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Demand Drops and Innovation Investments: Evidence from the Great Recession in Spain

Alex Armand

University of Navarra

Pedro Mendi

University of Navarra

Navarra Center for International Development

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Alex Armand
University of Navarra

Pedro Mendi
University of Navarra

Abstract

Decreases in aggregate demand can influence the decision to invest in innovation. This paper focuses on this choice when reductions are heterogeneous across productive strata of the economy. To guide the empirical analysis, we model heterogeneous firms' decisions to invest in innovation. In our framework, firms are heterogeneous and demand shocks are exogenous. We show that drops in aggregate expenditure reduce the proportion of firms investing in innovation. We then study investment behaviour in a panel of Spanish innovative manufacturing firms. These firms are all investing in internal R&D in 2004 and are yearly surveyed until 2013. During the Great Recession, firms experienced large contractions in aggregate consumption, up to 10% of its pre-crisis trend. We proxy heterogeneous variation in demand with entry and exit rates in the productive stratum of each firm. Rates incorporate all firms in the stratum, including non-innovative firms. To support our identification strategy, we show that these rates are not capturing idiosyncratic unobservable characteristics among innovative firms. Higher exit rates are associated with reductions of 2 to 3% in the share of firms investing in innovation. The drop is larger for smaller firms, which also experience larger decreases in sales. These results are in line with our theoretical predictions. Our estimates are robust to the inclusion of indicators of time-varying credit constraints. For these constraints, we observe a marginal role among innovative firms.

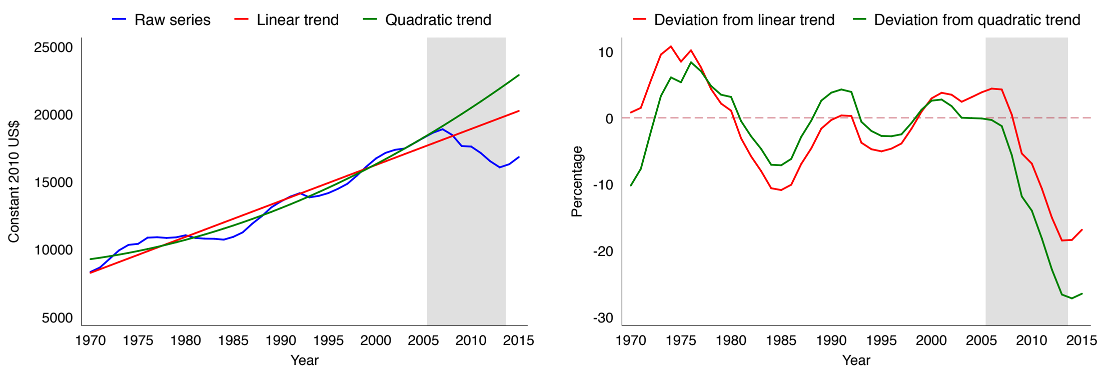
Keywords: R&D, Innovation, Firm entry, Firm exit, Great Recession.
JEL codes: L22, O31, O32.

***Armand**: University of Navarra and Navarra Center for International Development - Instituto Cultura y Sociedad, Edificio de Bibliotecas, 31009 Pamplona, Spain (e-mail: aarmand@unav.es); **Mendi**: University of Navarra, Department of Business, Edificio Amigos, 31009 Pamplona, Spain (e-mail: pmendi@unav.es). We would like to thank Philippe Aghion, Víctor Aguirregabiria, Andrés Barge-Gil, Estelle Cantillon, Luis Garicano, Monica Langella, Abel Lucena, Asier Mariscal and seminar/conference participants at the 9th MEIDE Conference, 43rd EARIE Annual Conference, XXXI Jornadas de Economía Industrial, Rimini Conference in Economics and Finance, LACEA/LAMES 2016, and SAEe 2016 for helpful comments. The authors gratefully acknowledge the financial support from the Ramón Areces Foundation.

1 Introduction

During the Great Recession in Spain, which began in 2008, the Spanish economy faced a sharp contraction in demand. Industrial production dropped by roughly 30%, and unemployment rose from 8% to 26% in 2013 (Bentolila et al., 2012). To illustrate how dramatic the decrease was, Figure 1 presents the series of household final consumption expenditure (in per capita terms) over the period 1970 to 2015.[1] The left panel presents the level of household final consumption expenditure, in constant prices, as well as the linear and quadratic trends of the series. The sharp decrease in consumption is apparent in this panel. This sudden drop is also illustrated in the right panel of Figure 1, which shows the deviation of consumption from its pre-crisis trend. An important consequence of this drop in demand was that during this period, a large number of firms ceased operations, resulting in a sharp increase in net exit rates across industries (García-Macia, 2016). This turbulent environment is likely to have affected firms' prospects for future returns on different types of investments. In particular, investment in innovation, riskier than many other investment categories, may be particularly affected. Indeed, according to the OECD, from 2008 to 2013, Business Enterprise R&D decreased in Spain by 14.5% in nominal terms. Yet, it is not clear how such a large reduction in demand distributed across different industries and size groups.

Figure 1: Household final consumption expenditure per capita, Spain 1970-2015



Note. The left panel presents the series of household final consumption expenditure, which is reported in constant prices (2010 US$) and in per capita terms (source: World Bank). It also presents the linear and the quadratic trend (source: authors' calculations). The right panel presents deviations from the linear and the quadratic trends. The linear trend series is computed using predicted values from a linear regression of the raw series on the year variable (re-scaled to have 1970 = 1) for the pre-crisis sample (1970-2008). The quadratic trend is computed using predicted values from a linear regression of the raw series on the year variable and its square.

In order to shed light on this issue, we analyse investment decisions in a panel of Spanish manufacturing firms. These firms were actively investing in internal R&D in 2004 and have been yearly surveyed until 2013.[2] We proxy heterogeneous variation in demand with the rate at which firms enter and exit the market. We exploit time, industry and firm size variation to supplement the

[1] The shaded area highlights the period 2005-13, which is the object of our empirical analysis, and that includes the Great Recession Years.

[2] The panel includes firms operating in the manufacturing sector and investing in internal R&D at the beginning of the period. The first restriction is based on the consideration that firms working in the agricultural and service sectors are facing different investment decisions in terms of technology. The second restriction is data-driven.

panel with stratum-specific rates. The rates incorporate all firms, including non-innovative firms. For our identification strategy, it is important to note that firms investing in internal R&D are the vast minority for small and medium firms.[3] The rates in the overall stratum are not explaining firm exit in our sample (see appendix A.2), nor are related to idiosyncratic firm-level characteristics driving innovation investments (see sections 4 and 5.2). This suggests that, conditional on all observable characterisitcs, we can identify the relationship between changes in the firm's environment and their innovation decision. Our results suggest that higher net exit rates relate negatively with innovation investments. Among smaller firms, this relationship is much stronger. These firms are also characterised by large drops in sales when exit rates are higher. This suggests a demand-driven effect on innovation. Our estimates are robust not only to time-invariant (unobservable) firm characteristics, but also to sector- and size- specific trends.

Understanding how different factors affect incentives to invest in innovation is essential, given the key role that innovation plays in the process of total factor productivity growth. While firm characteristics have been shown to influence the decision to engage in innovation (Argyres and Silverman, 2004; Cohen and Levinthal, 1990; Sadowski and Sadowski-Rasters, 2006), external factors have received less attention. Regarding the role of the business cycle on R&D expenditures, theoretical arguments are mixed (Barlevy, 2007; Arvanitis and Woerter, 2014; Min, 2011). Pro-cyclicality is supported by a relaxation of liquidity and credit constraints during expansions. Counter-cyclicality is instead justified by the lower opportunity cost of R&D during recessions. Empirical evidence focuses instead on financial constraints introduced by recessions. Using a panel of French firms, Aghion et al. (2012) find that liquidity constraints are an important determinant of R&D expenditures. Garicano and Steinwender (2016) argue that the Great Recession in Spain affected longer-duration investments. The mechanism behind this change is the reduced access to finance. Yet, they do not observe large effects on R&D investments. This suggests these results might apply more to less-productive (non-innovative) firms.[4]

Fewer studies have instead focused on the role of aggregate demand during recessions. We contribute to the existing literature by studying how variation in the net exit rate in the stratum where a firm operates can affect its decisions to invest in innovation. To motivate our empirical analysis, we model heterogeneous firms' decision to invest in innovation. In our framework, firms differ in their marginal costs of production, and each firm produces one of a large number of product varieties that have the same elasticity of substitution (Melitz, 2003; Dixit and Stiglitz, 1977).[5] Both output levels and incentives to invest in cost-reducing innovation activities negatively

[3] In the manifacturing sector, the share of firms investing in R&D is around 12% among Small and Medium Enterprises (with 10 to 249 employees) and around 62% for large firms (more than 250 employees). Source: Spanish National Statistics Institute (INE).

[4] In section 5.2 we show that our estimates are robust to within-firm estimation, as in Garicano and Steinwender (2016). The methodology is presented in section 4. While we focus only on innovation investments and on investments in tangible goods, we cannot observe the same pattern in our sample. Their identification strategy relies on the existence of a homogeneous effect of demand shocks on different types of investment. Following a decrease in demand, this assumption may turn out to be problematic since the degree of competition in the industry may increase. Thus marketing expenses may decrease by less, or even increase, relative to innovation expenses.

[5] In the international trade literature, other contributions that adopt this modelling approach are Bustos (2011); Hallak and Sivadasan (2013). Guadalupe et al. (2012) use a similar setting to explain innovation and foreign ownership. Yeaple

correlate with their marginal costs. In this setting, drops in aggregate expenditure reduce the proportion of innovative firms. This depends on firm's productivity, the relationship being stronger for less productive firms.

The Great Recession had deep consequences in the composition of many industries in Spain (García-Macia, 2016). Yet, we cannot guarantee that exit rate variation is fully capturing demand heterogeneity. Lack of finance could also have aggravated exit rates. To isolate this channel, we exploit time and stratum variation using financial ratios. We select ratios capturing (median) liquidity and credit constraints in each stratum. The inclusion of these controls does not affect the relationship between net exit rates and investment. We cannot argue that credit constraints played a central role among innovative firms. Their superior ability to access credit could support this result. Furthermore, the negative relationship between rates and investment is deeper when deviations from trend in aggregate consumption are larger. We do not find evidence of changes in financing, nor important changes in perceptions. If anything, firms became more worried about the lack of demand.[6]

The remainder of the paper is organized as follows. Section 2 presents the theoretical model that motivates the empirical analysis. Section 3 describes the data used in this paper. Section 4 discusses the empirical strategy, whose results are presented in Section 5. Finally, Section 6 presents some concluding comments.

2 Theoretical framework

This section presents a model of the decision to engage in production and innovation activities in an economy with heterogeneous firms. We follow the framework provided by the seminal work of Dixit and Stiglitz (1977). Firms have heterogeneous productivity, which translates into differences in marginal costs and production levels among firms (Melitz, 2003; Bustos, 2011). Firms face a fixed cost for entering the market and can increase their productivity by paying a fixed innovation cost. While Melitz (2003) takes into consideration an infinitely-repeated game and analyses the derivation of a steady state equilibrium, we start from a steady state equilibrium and discuss the short-run impact of unexpected, exogenous changes in some of the determinants of the equilibrium. Ours is a partial equilibrium approach, as in Hallak and Sivadasan (2013); Guadalupe et al. (2012).

2.1 Model setup

The demand side of the economy is characterized by a representative consumer who spends an exogenously given amount E in each period and has preferences over a continuum of goods,

(2005) considers an alternative modelling approach where firm heterogeneity is generated by heterogeneous employees.

[6]Net exit rates may capture alternative channels. They may signal the probability of exit of incumbent firms, affecting expected returns. But we do not observe large effects on perceived constraints. They also alter the degree of competition in the industry where the firm operates. Yet, the direction of the effect of competition on innovation is still controversial (Schumpeter, 1942; Arrow, 1962; Vives, 2008).

indexed by ω and represented by a constant elasticity of substitution (CES) utility function:

$$U = \left[\int_{\omega \in \Omega} q(\omega)^{\rho} d\omega \right]^{1/\rho} \tag{1}$$

where Ω is the measure of existing products. The optimal expenditure decision on variety ω is:

$$r(\omega) = E \left[\frac{p(\omega)}{P} \right]^{1-\sigma} \tag{2}$$

where $\sigma = \frac{1}{1-\rho} > 1$ is the elasticity of substitution between any two goods and the aggregate price index P is defined by $\left[\int_{\omega \in \Omega} p(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}}$. Therefore, the producer of each variety faces an effective demand equal to $q(\omega) = E \cdot P^{\sigma-1} p^{-\sigma}$, where σ is the absolute value of the price elasticity of demand.

The economy consists of a single industry characterized by a free-entry monopolistic competition, where each firm produces a single differentiated good under increasing returns to scale and using a single factor of production. We assume there is a large pool of potential entrants that do not know their specific marginal costs ex-ante (Melitz, 2003; Bustos, 2011). Potential entrants are heterogeneous in their marginal cost of production, c^i, which is assumed to be a random draw from a continuous distribution with p.d.f. $h(\cdot)$ on the support $[\underline{c}, \overline{c}]$, and c.d.f. $H(\cdot)$. Active firms may choose to pay a fixed cost f^I to acquire a technology that reduces the firm's marginal cost by $\varepsilon > \underline{c}$. We will see below that the decision to invest in innovation will depend on the initial draw from the marginal cost distribution.

We consider a steady state in the infinitely-repeated game with the following stages in every period. Firstly, a mass M^e of potential entrants enter the industry and pay the fixed cost of entry f^e. After entry, existing firms decide whether to undertake the innovation investment f^I and whether to incur into the fixed production cost f. Then production takes place, loans are paid back, and profits are realized. After profit are realized, a fraction δ of the mass of active firms in the previous period, M, exits. All fixed costs are financed via within-period loans whose interest rate r is exogenously given.

Among those firms that enter in each period, the firms with the lowest productivity exit the market immediately since it is not profitable to stay in the market and start producing as the fixed production cost, f, is non-sunk. The rest of the firms decide on whether to invest in innovation, which would reduce their marginal cost of production, and start producing. Assuming $MC(c, \varepsilon)$ represents the firm's marginal cost with a cost reduction ε induced by investment in new technologies, the optimal pricing rule is given by:

$$p(c, \varepsilon) = \frac{MC(c, \varepsilon)}{\rho} \tag{3}$$

where $MC(c, \varepsilon) = c - \varepsilon$ if the firm invests in innovation, and $MC(c, 0) = c$ if the firm does not do so. Since we assume that the marginal cost is constant, the firm's gross profits, not taking into consideration production and/or innovation costs, are given by:

$$\pi(c,\varepsilon) = \frac{r\left[MC(c,\varepsilon)\right]}{\sigma} \tag{4}$$

where $r(\cdot)$ is given by equation 2.

The steady state equilibrium is characterized by the mass of active firms, M, the mass of entrants in every period M^e, such that $p_{in}M^e = \delta M$, the distribution of active firms $\mu(\cdot)$, and the cut-off levels c^* and c^I such that for $c > c^*$ firms decide not to produce, for $c \in \left[c^I, c^*\right]$ firms produce but do not invest in innovation, and for $c < c^I$ firms invest in innovation. The cut-off value c^* is the type that is strictly indifferent between incurring the fixed production cost f and exiting, whereas the cut-off value c^I is just indifferent between investing in the cost-reducing technology and not doing so. This result is based on the fact that prices are decreasing in marginal costs (equation 3) and, since $\sigma = \frac{1}{1-\rho} > 1$ (equations 2 and 4), revenues and profits are inversely proportional to prices. For any two firms characterized by marginal costs c_1 and c_2, profits are equal to:

$$\pi(c_2) = \pi(c_1) \cdot \left(\frac{c_2}{c_1}\right)^{1-\sigma} \tag{5}$$

Therefore, the cut-off value c^I satisfies the following condition:

$$\pi\left(c^I - \varepsilon\right) = \pi\left(c^I\right) + f^I = \pi\left(c^I\right) \cdot \left(\frac{c^I - \varepsilon}{c^I}\right)^{1-\sigma}. \tag{6}$$

2.2 Market exit and innovation decision

Taking this steady state equilibrium as a starting point, we consider the effect of exogenous changes to the fixed cost of entry f^e, the interest rate r, and aggregate expenditure E. We assume that the exogenous shock to the fixed entry cost is announced at the beginning of the period, prior to the potential entrants' entry decisions. In contrast, the shocks to the interest rate and to expenditure are announced after entry takes place, that is, once the mass of potentially active firms is determined. The effects on innovation and net exit rates of these shocks are expressed in Propositions 2, 3, and 4. First, Lemma 1 presents a result that will be useful for our propositions.

Lemma 1. *Let* c^I *be the value of the marginal cost such that equation 6 is satisfied. If firm profits when the marginal cost is* c^I *are changed by an amount* x*, then the threshold value* c^I *shifts to the right (left) if* $x > 0$ (< 0).

Proof. From equation 6 we can observe that $\pi\left(c^I - \varepsilon\right)$ equals $\pi\left(c^I\right)$ times a factor that is greater than one, since $1 - \sigma < 0$. Let the subscript 1 denote profits before the shift, and the subscript 2 denote profits after the shift. Then, we can express $\pi_1\left(c^I-\varepsilon\right)$ and $\pi_2\left(c^I-\varepsilon\right)$ as:

$$\begin{aligned}\pi_1\left(c^I-\varepsilon\right) &= \pi_1\left(c^I\right)+f^I=\pi_1\left(c^I\right)\cdot\left(\frac{c^I-\varepsilon}{c^I}\right)^{1-\sigma}\\ \pi_2\left(c^I-\varepsilon\right) &= \left[\pi_1+x\right]\cdot\left(\frac{c^I-\varepsilon}{c^I}\right)^{1-\sigma}>\pi_1\left(c^I-\varepsilon\right)+x\end{aligned}$$

Since $\pi_2\left(c^I-\varepsilon\right)-\pi_1\left(c^I-\varepsilon\right)>\pi_2\left(c^I\right)-\pi_1\left(c^I\right)$, we can then conclude that:

$$\pi_2\left(c^I-\varepsilon\right)-\pi_2\left(c^I\right)>\pi_1\left(c^I-\varepsilon\right)-\pi_1\left(c^I\right)=f^I$$

If $x>0$, then the firm whose marginal cost is c^I is strictly better off investing in innovation. Therefore, there will be a range of values $c>c^I$ such that firms with these marginal cost still find it profitable to invest in innovation. For this reason, the threshold value c^I is now greater. Using a similar argument, we can conclude that the threshold value c^I is lower if $x<0$. □

Lemma 1 shows is that, in order to study how incentives to innovate change following an exogenous shock, we only need to study whether profits change at the initial cut-off value c^I. If profits increase, then so do incentives to innovate, in the sense of the threshold value begin greater. Propositions 2, 3, and 4 state what the effects of an increase in entry costs, an increase in the interest rate, and a decrease in expenditure are on entry and innovation rates.

Proposition 2. *An increase in the fixed entry cost, f^e, increases the cut-off value c^I.*

Proof. Notice that every period a total δM firms exit the industry. In the steady state, these are replaced by a mass of firms $p_{in}M_e$, where p_{in} is the ex-ante probability of entry, and each entrant expects to make a discounted profit that equals the initial value of the entry cost, f_1^e. If the entry cost increases to $f_2^e>f_1^e$, then it must be the case that the mass of entrants, M^e decreases, and that the cut-off value c^* increases. To see this, recall that once the fixed entry cost is paid, it is sunk, and entrants behave in the same way as any incumbent firm, therefore, c^* can not decrease. If this cut-off value stayed the same and M^e did not decrease, then the net profits of the firm whose marginal cost is c^* would be zero, and hence the expected profits of an entrant would be as in the steady state, that is, f_1^e, below the new fixed entry cost. As a consequence, c^* and profits of the incumbent firms (those that entered prior to the increase in the entry cost) increase. Then, from Lemma 1, the cut-off value c^I also increases. □

Proposition 3. *An increase in the interest rate r decreases the cut-off values c^* and c^I.*

Proof. Given our assumption on timing, the interest rate increase does not affect the entry cost f^e. It is easy to see that the increase in r increases the fixed production cost as well as the fixed innovation cost, f^I. Let c_1^* denote the cut-off value that determines exit before the change in r. Since the fixed production cost increases, the firm whose marginal cost is c_1^* is now making negative profits, and therefore decides not to produce. This lowers the cut-off value to $c_2^*<c_1^*$. Now, since the firms that decide not to produce are the least efficient ones, the price index

decreases, thus lowering profits for all firm types. To see this, notice that the total number of firms that remain after the change in the cut-off value from c_1^* to c_2^* is $\frac{H(c_2^*)}{H(c_1^*)}$. Therefore, the new price index is given by:

$$P_2 = \left[M \cdot \frac{H\left(c_2^*\right)}{H\left(c_1^*\right)} \right]^{\frac{1}{1-\sigma}} \left[\int_{\underline{c}}^{c_2^*} \left(\frac{c}{\rho} \right)^{1-\sigma} \frac{h(c)}{H\left(c_2^*\right)} dc \right]^{\frac{1}{1-\sigma}}$$

which is smaller than the price index before the change in the cut-off value, P_1, which is given by:

$$P_1 = [M]^{\frac{1}{1-\sigma}} \left[\int_{\underline{c}}^{c_1^*} \left(\frac{c}{\rho} \right)^{1-\sigma} \frac{h(c)}{H\left(c_1^*\right)} dc \right]^{\frac{1}{1-\sigma}}$$

Therefore, since $P_2 < P_1$, profits per variety decrease. From Lemma 1, this reduces the incentives to invest in innovation of the firm whose marginal cost is c^I. Therefore, the cut-off value c^I is now smaller and hence a smaller proportion of firms invest in innovation. This result is consistent with empirical findings observed by Aghion et al. (2012); Garicano and Steinwender (2016). □

Proposition 4. *A decrease in aggregate expenditure E decreases both c^* and c^I.*

Proof. A decrease in expenditure E translates into a downward shift in the demand function, and hence profits across all types. Therefore, the profits of the firm whose marginal cost is c^* are now less than f, and thus the new cut-off value c^* moves to the left. From Lemma 1, the cut-off value c^I is also lower after the decrease in expenditure. □

In absence of demand or interest rates shocks, our model predicts that an increase in net exit rates originating from an increase in the fixed entry cost will increase the proportion of firms that innovate. Negative demand shocks create a simultaneous increase in the net exit rate and a decrease in innovation rates. Exit following an increase in the interest rate or a reduction in expenditure affects more inefficient firms. The impact on innovation will be strongest among these firms. If we assume that firm size proxy for productivity, our model predicts a heterogeneous relationship between exit rates and size.

The model can be easily extended to a setting in which firms can decide to invest in different types of innovation investment. For instance, firms may invest in internal and external R&D to lower their cost of production. Contracting for external R&D might cost f^E, bringing about a reduction in marginal cost of ε^E. We could think of internal R&D as having a two-sided effect. On the one hand, it may be an alternative to external R&D. On the other hand, it may also complement external R&D. Whether internal R&D is a substitute for or a complement to external R&D depends on the level of investment in internal R&D. We could assume that there are two possible investment levels on internal R&D: f_1^I and f_2^I, with $f_2^I > f_1^I$. If the firm invests in internal R&D and the level of investment is f_1^I, the reduction in cost is $\varepsilon^I > \varepsilon^E$. This is regardless of whether the firm has also invested on external R&D. In this case, internal R&D substitutes for external R&D. Internal

R&D complements external R&D if the level of investment is f_2^I. This reflects the two roles of internal R&D: being a source of innovations as well as enhancing external knowledge (Cohen and Levinthal, 1990).

3 Data

This paper makes use of data from different sources. We combine the PITEC dataset, which provides detailed information about innovation inputs and outputs of Spanish firms, with data about market characteristics and sectoral ratios. We describe each source in this section.

3.1 The PITEC database

The PITEC (*Panel de Innovación Tecnológica*) database is a panel of Spanish firms surveyed yearly by the Spanish National Statistics Institute (INE). The dataset contains detailed information on firms' characteristics and on all inputs and outputs related to innovation. It includes activities in R&D, purchase of services, other activities linked to innovation, factors limiting investments in R&D, intellectual property rights, and innovations in production processes and products. The dataset provides also information on sales and on gross investments in tangible goods. The questionnaire is comparable with the Community Innovation Survey, implemented in many other European countries (see for instance Archibugi et al., 2013; Ballot et al., 2015; Cassiman and Veugelers, 2006, 2002; Mohnen and Roller, 2005; van Beers et al., 2008).

We select all firms active in the manufacturing sector and investing in internal R&D in 2004. Firstly, while the dataset includes firms in all sectors, we focus on the manufacturing sector in line with most empirical studies. [7] The reason to exclude services industries is that the role of formal internal R&D is less relevant. In addition, the purchase of external services related to innovation might present deep differences compared to manufacturing. Secondly, the selection of firms that invest in R&D in 2004 is data-driven. This selection allows us to have a comparable panel for both small and large firms for the whole period. [8] Thirdly, we select only firms that are active for the whole period 2004-2013. We therefore exclude firms exiting the market. This restriction is based on the decision to study the behaviour of firms conditional on being active in the market. In this way, we can focus solely on investment decisions. In appendix A.2 we discuss in detail market exit for the firms we exclude. The cumulative hazard estimates tend to be rather small compared to the rest of the economy. This suggests that we are focusing on a relatively stable group of firms.

Firms are classified according to their main activity. The database provides an industrial classification based on the CNAE-93 for the period 2003-2008 and CNAE-09 from 2008 on. These are used by the Spanish National Institute of Statistics. In the absence of a direct conversion of the two classifications, we uniform them over time and use indicators for macro sectors. Table 1

[7] We exclude from the sample firms in the "Repair and installation of machinery and equipment" sector and firms switching from manufacturing to services and vice-versa when CNAE-09 is introduced.

[8] We select the period 2004-2013 since the database provides information for large firms (in excess of 200 employees) for the period 2003-13 and for a panel of smaller firms for the period of 2004-13. To analyse both, we restrict the sample to the periods where information for both is available.

presents the list of selected sectors and their aggregation code into macro-sectors. The table also provides the correspondence between the CNAE-93 and CNAE-09 industry classifications.

Table 1: List of industries and macro-sectors

Manufacturing sector	**CNAE-93**	**CNAE-09**	**Macro sector**
Food, beverages, and tobacco	2, 3	3	1
Textiles	4	4	2
Wearing apparel	5	5	2
Leather and footwear	6	6	2
Wood and cork	7	7	3
Paper and paper products	8	8	4
Printing and reproduction of recorded media	9	9	4
Chemical products	11	10	5
Pharmaceutical products	12	11	5
Rubber and plastics	13	12	3
Other non-metallic mineral products	14, 15	13	6
Manufacture of basic metals	16, 17	14	6
Fabricated metal products	18	15	6
Computer, electronic and optical products	20, 22, 23, 24	16	7
Electrical equipment	21	17	7
Other machinery and equipment	19	18	8
Motor vehicles, trailers and semi-trailers	25	19	9
Building of ships and boats	26	20	9
Aircraft, spacecraft and machinery thereof	27	21	9
Other transport equipment	28	22	9
Furniture	29	23	4
Other manufacturing	30, 31	24	4

Note: Fabricated metal products excludes machinery and equipment. We remove the sector "Repair and installation of machinery and equipment" since it was classified as a service activity under CNAE-93. The PITEC database identifies 56 industries up to 2008, and 44 industries from 2008 on, when the CNAE-09 classification system was introduced.

Table 2 presents summary statistics of selected firms by firm size. We include the whole period 2004-2013. Firms with any innovation input ranges from 60% to 91% depending on their size. Since all firms are investing at the beginning of the period, this suggests that the propensity to stop investing is much larger among smaller firms. This pattern is similar when we distinguish between internal and external investments. Larger firms also tend to have a larger number of patent applications, to be part of a group, and to be active in the rest of the world. Among firms in the first quartile, only 11% form part of a group and 48% is active beyond the European market. Among larger firms, these shares are 80% and 84%. The share of female workers is uniform among firms, at around 25-27% of workers.

3.2 Industrial Survey, net exit rates and financial ratios

We supplement the PITEC database with industry-level information. We match each industry with aggregated data from the Industrial Survey (*Encuesta Industrial de Empresas*), which is managed by INE. We have included information about profits and their growth rates, inventory variation, total sales, personnel expenditures, total employment, hours worked, and investment in tangible assets.

Table 2: Firm characteristics, by firm size quartile

	Size quartile			
	1st quartile	2nd quartile	3rd quartile	4th quartile
Firm invested in innovation	0.60	0.76	0.82	0.91
	(0.49)	(0.43)	(0.38)	(0.28)
R&D	0.54	0.69	0.78	0.87
	(0.50)	(0.46)	(0.42)	(0.34)
Buy	0.31	0.42	0.47	0.64
	(0.46)	(0.49)	(0.50)	(0.48)
Log expenditure on innovation	6.69	8.90	10.18	12.54
	(5.56)	(5.19)	(4.86)	(4.21)
Sales	14.11	15.51	16.55	18.10
	(1.04)	(0.76)	(0.76)	(1.15)
Subsidiary of foreign MNC	0.01	0.04	0.14	0.30
	(0.10)	(0.20)	(0.34)	(0.46)
Share of female employees	0.26	0.25	0.26	0.27
	(0.22)	(0.20)	(0.20)	(0.20)
Producing biotechnologies	0.05	0.03	0.03	0.06
	(0.21)	(0.18)	(0.17)	(0.25)
Active in Local market	0.96	0.97	0.96	0.92
	(0.21)	(0.17)	(0.19)	(0.27)
Active in Spanish market	0.93	0.97	0.97	0.98
	(0.25)	(0.16)	(0.17)	(0.15)
Active in Other EU market	0.66	0.85	0.91	0.93
	(0.47)	(0.36)	(0.29)	(0.25)
Active in Rest of the World	0.48	0.69	0.78	0.84
	(0.50)	(0.46)	(0.41)	(0.37)
Part of group of firms	0.11	0.22	0.45	0.80
	(0.31)	(0.41)	(0.50)	(0.40)

Note. Standard deviations in parenthesis. Size quartiles are determined over the sample distribution of the number of employees. "R&D" indicates the share of firms performing internal R&D, while "Buy" refers to purchase of external R&D, machinery or licensing. "Innovation inputs" instead refer to either R&D or Buy.

To proxy for variation in demand in specific strata of the economy, we supplement each firm with sector- and size-specific entry and exit rates. The information is provided by the Central Business Register (CBR), also managed by INE. The CBR provides information on registrations of companies, on companies remaining operational, and on exiting companies. This information is disaggregated by main economic activity and by number of employees. [9]

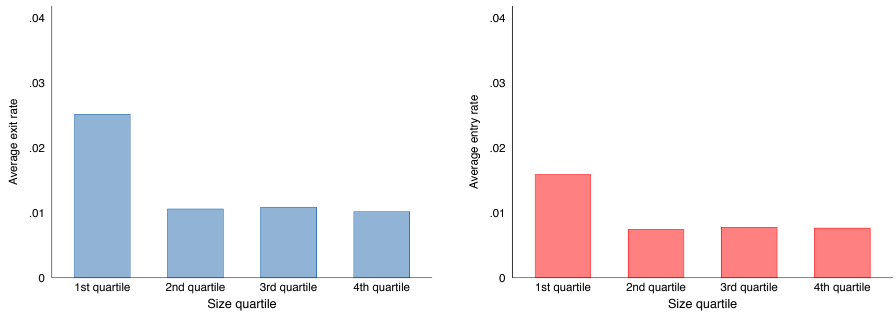
Matched data allows analysing entry and exit rates in the stratum where innovative firms operate. Figure 2 shows the average exit and entry rate by size quartile. In the first quartile, exit rates are much larger compared to higher quartiles (3% versus 1%).[10] This pattern is similar for the entry rate with smaller firms characterized by a larger entry rate (around 2% versus 1% for larger firms). Entry and exit rates are positively correlated, with correlation equal to 0.70 for firms in the first quartile and 0.36 for other firms (see appendix A.1). This is in line with evidence showing that exit and entry rates depend on firm characteristics, with smaller and younger firms having

[9] Entry and exit rates are available for the following groups: between 1 and 5 employees; between 6 and 9 employees; between 10 and 19 employees; 20 or more employees. Each firm is then matched using the number of employees and their main sector of activity.

[10] We distinguish between *small firms*, defined as firms in the first quartile of the size distribution, and *large firms*, defined as firms in the second, third and fourth quartiles.

higher exit rates, and tend to be positively correlated within strata of the economy (Malerba and Orsenigo, 1996; Abbring and Campbell, 2010; Dunne et al., 1988). It is central to control for time-invariant unobserved firm characteristics to consistently estimate the coefficient associated with net exit rate.

Figure 2: Average exit and entry rates, by size quartile



Note. The left (right) panel shows the distribution of exit (entry) rates by firm quartile. Exit and entry rates are computed at size- and industry- stratum and are averaged over different quartiles. Exit and entry rates are defined in section 3.2. Size quartile is determined on the basis of the distribution of number of employees in a specific year.

Since the Great Recession characterise most of our period of interest, we focus on net exit rates. We define these as the change in the number of firms operating at year t in industry j and in size group s. The change is relative to the initial number of firms operating in the stratum. We hypothesize that this captures how reductions in aggregate demand affect firms in each stratum. If Δ_{jst} is the decrease in the number of firms at year t for a firm in industry j and of size group s, the net exit rate is defined by:

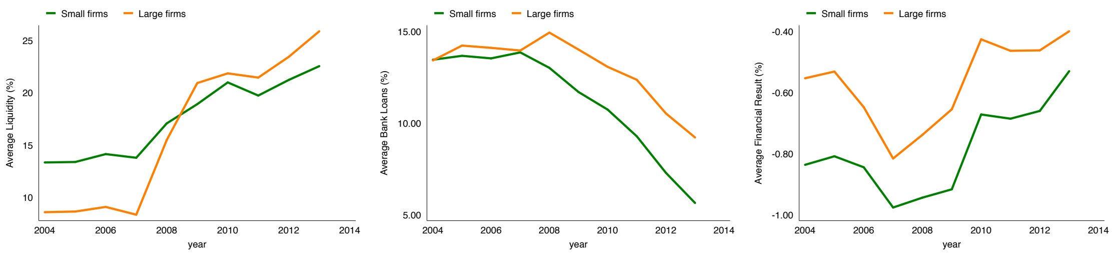
$$netexit_{jst} = \frac{\Delta_{jst}}{n\_sur_{jst-1} + n\_entry_{jst-1}} = \frac{n\_exit_{jst} - n\_entry_{jst}}{n\_sur_{jst-1} + n\_entry_{jst-1}} \quad (7)$$

where n_sur_{jst}, n_entry_{jst} and n_exit_{jst} are the number of firms surviving, entering and exiting industry j in size group s in year t, respectively. The sum $n\_sur_{jst-1} + n\_entry_{jst-1}$ equals the total number of firms in the industry-size group at the beginning of year t. The net exit rate matched with sampled firms has an average of 0.30%, with a minimum of -3.45% and a maximum of 8.90% (see appendix A.2). In the empirical part, we standardize the net exit rate using the whole period of analysis. One standard deviation corresponds to an increase in the net exit rate by around 0.79%. It is important to note that we are matching exit rates that includes all firms. We do not discriminate between innovative and non-innovative firms. We do so to capture the situation of the whole stratum, rather than just innovative firms only. In appendix A.2, we show that our sample is a relatively stable share of the market. In addition, net exit rate does not drive market exit in our sample.

With available data we can only proxy for the heterogeneous variation in demand in each stratum. It is therefore difficult to conclude that this variation is solely captured by net exit rates. It is also possible that liquidity and credit constraints, associated with periods of stronger recession, could be driving market exit (see Aghion et al. 2012; Garicano and Steinwender 2016). To capture these constraints, we complement our dataset with sectoral ratios of non-financial firms at stratum level. The information is provided by the RSE database. It is managed by the Bank of Spain, the Central Business Register and the European Committee of Central Balance Sheet offices. We match each firm with the median value of different financial ratios within their sector and sales group.[11]

We select financial ratios that could proxy for liquidity and credit constraints. Firstly, to proxy for liquidity constraints, we make use of the quick ratio. It is the ratio between current assets (measured by cash and short term financial assets) and current liabilities (measured by short-term debt). This ratio captures a firm's ability to meet its short-term obligations with its most liquid assets. A higher ratio indicates availability of liquid assets and a lower presence of liquidity constraints. The average ratio is equal to 17%. In section 5, we standardise the ratio (with one standard deviation being equal to 9.4%) and we indicate it by *Liquidity*. Secondly, to proxy for credit constraints, we make use of the ratio between bank loans and total liabilities. We indicate it by *Bank Loans*. An increase in the ratio captures a reduction in credit constraints associated with banks. The average ratio is equal to 13%, with one standard deviation equal to 6.5%. Thirdly, we control for the burden of financial expenses, normalised by net revenue. We indicate this ratio by *Interest burden*. A higher ratio shows a higher cost associated with financial activities, such as interests. In our sample, this ratio has an average of 13.2% with standard deviation of 4.85%. Figure 3 presents the time series of the average of these indicators, as matched with the sampled firms.

Figure 3: Liquidity, bank loans and financial burden, 2004-2013



Note. Average Liquidity is computed as the average ratio between cash plus short term financial assets and current liabilities. Average Bank Loans is computed as the average ratio between bank loans and total assets. Average Financial Burden is computed as the average ratio between financial expenses and net income. Ratios are matched at sector and sales group levels. Small (large) firms are defined as firms in the first (second-fourth) quartile of the size distribution.

Both liquidity and bank loans are relatively constant before the beginning of the recession in 2008. Liquidity is higher among smaller firms, while bank loans are comparable across firms. It is surprising that, once the recession hits the economy, strata where sampled firms operate become more liquid. Bank loans instead drop significantly. Larger decreases are among smaller firms.[12]

[11] Firms are classified in four sales groups: less than 2 million euros, between 2 million and 10 million euros, between 10 million and 50 million euros, and more than 50 million euros. These groups are used to match firms within each sector.

[12] The drop in bank loans following 2007 is mainly driven by a sharp reduction on short term bank loans, compensated by an initial increase in the medium-long term bank loans and a drop after 2009. See appendix A.7.

4 Empirical strategy

Time and firm-level variation in innovation investment and market conditions allows us to exploit a fixed effect estimation method.[13] In the estimation, we can control for time-invariant unobservable firm characteristics. This is particularly important in our setting as it eliminates the possibility that firms in a given sector could be affected by different market conditions due to the peculiar characteristics of the firm or the sector where they operate that are unobserved. In other words, we reduce identification issues to the possibility that net exit rates are correlated with idiosynchratic shocks. Given the large number of controls and the fact that we compute exit rates for all firms, this possibility is remote.

To measure the relationship between the contemporaneous variation in net exit rates, $netexit_{it}$, and the decision/outcome of firm i at time t, y_{it}, we estimate the following specification:

$$y_{it} = \alpha_0 + \alpha_N netexit_{it} + \mathbf{X}_{it}\beta + \sum_{t=2}^{T}\gamma_t d_t + \sum_{j=2}^{T}\sum_{t=2}^{J}\omega_{tj}d_t s_j + c_i + u_{it} \tag{8}$$

where $\mathbf{X}_{it}$ is a matrix of time-varying firm characteristics[14], d_t are year fixed effects, s_i are macro-sector dummy variables (as specified in Table 1), c_i captures unobserved time-invariant firm characteristics and u_{it} are idiosyncratic error terms. Our parameter of interest is α_N. It captures the change in the outcome variable due to the variation in the number of firms operating in the firm's stratum, once we control for the available observable characteristics and for firm-specific unobservable characteristics c_i. In our preferred specification, we also introduce a set of interaction terms between year and macro-sector dummies. This allows to control for unobservable macro-sector characteristics that are year-specific. We estimate equation 8 using fixed effects estimation.

To check whether net exit rates, as computed in the paper, are capturing idiosyncratic shocks, we follow Garicano and Steinwender (2016) identification procedure. Specifically, for each firm, we look at multiple investments and we jointly estimate the following specification:

$$\begin{aligned} y_{ict} &= \alpha_0 + \alpha_N netexit_{it} + \alpha_C netexit_{it} \times innov_{ict} + \alpha_I innov_{ict} + \\ &\quad + \mathbf{X}_{it}\beta + \sum_{t=2}^{T}\gamma_t d_t + \sum_{j=2}^{T}\sum_{t=2}^{J}\omega_{tj}d_t s_j + c_i + u_{ict} \end{aligned} \tag{9}$$

where y_{ict} is the investment of firm i on category c at time t, $innov_{ict}$ is an indicator variable equal to 1 if the observation refers to the category "investment on innovation" (which is capturing the category fixed effect), $\mathbf{X}_{it}$ is a matrix of time-varying firm characteristics, c_i captures unobserved

[13] We present all our results using linear fixed effects method, even in presence of binary outcomes. Our conclusions are robust to non-linear methods. See appendix A.4.

[14] Time-varying controls includes indicators for the firm being a subsidiary of a foreign multinational, active in biotechnology activities, belonging to a group of firms, and presence in the local, national, EU and other foreign markets and the share of female employees. It also includes sector-level controls such as the logarithms of profits, hours worked, positive variation in inventory, and the growth in these three variables compared to the year before. For profits and the variation in inventory, we censor negative values at zero and compute the logarithms as the variable plus one.

time-invariant firm characteristics and u_{it} are idiosyncratic error terms. We also introduce a set of controls as in our main specification.

We estimate equation (9) using first only firm fixed effects and then firm-by-year fixed effects. Since the latter captures firm-specific time-varying unobservable characteristics, the equality of α_C in the two specifications provides supportive evidence on the validity of our identification strategy for equation (8). In section 5.2 we indeed show that our estimates are not affected by using within-firm estimation and controlling for firm-by-year fixed effects.

Our analysis focuses only on firms that do not exit the market in the period 2004-2013. We do not focus on the direct relationship between net exit rates and the timing of firm exit from the market. If we estimate a survival model where our outcome of interest is market exit, we find that hazard ratios associated to net exit rates are not statistically different from 1. This suggests that net exit rates computed among all firms, innovative and non-innovative, are not affecting the probability of exiting the market among these firms. See appendix A.2 for a detailed discussion.

5 Results

In this section we focus on the firm's decision to invest on innovation and how this decision varies when net exit rates are higher in the firm's stratum of the economy. We analyse both the extensive margin (section 5.1), i.e. whether a firm invests in these inputs, and the intensive margin (section 5.2), i.e. how large are the investments in these inputs. We then discuss potential mechanisms at play.

5.1 Extensive margin

We start by looking at the decision to invest in any innovation activities. We consider internal R&D and buy strategies. The latter includes external R&D, acquisition of machinery that embodies new technology, or disembodied technology in the form of licensing. Columns 1-4 in table 3 report estimated coefficients for equation 8. The dependent variable is an indicator variable equal to one if the firm invested in innovation at time t and zero otherwise. In all specifications we estimate the model using firm-level fixed effects. To test for the robustness of estimates, we include different sets of controls. In column 1, we include a set of year dummies. In column 2, we control for industry-level characteristics and for macro-sector fixed effects. In column 3, we add firm-level controls, and proxies for liquidity and credit constraints. In column 4, we control for sector-specific trends by introducing a set of interaction terms between year and macro-sector indicators. We also control for size-by-sector fixed effects, where size is reported in quartiles and is allowed to change over time for each firm. We report the full list of controls used in each specification in section 4.

The propensity to invest decreases in strata where net exit rates are higher. A one standard deviation increase in the net exit rate induces a decrease of around 2 percentage points. Controlling only for firm and year fixed effects leads to a slightly higher coefficient. This shows that controls only marginally pick up the effect of the net exit rate on other dimensions. We also extend equation

8 by controlling for contemporaneous firm-level sales. The coefficient on net exit rate is robust to this control. Higher sales have only a small compensation effect (see appendix A.3).

Controlling for proxies of liquidity and credit constraints does not affect our estimates. Liquidity is playing an important role in explaining the decision to invest. A one standard deviation increase translates into a 4% increase in the share of firms investing. We do not find evidence of large effects of bank loans on the decision to invest in innovation. The coefficient on bank loans is small and mainly driven by buy strategies. The positive coefficient suggests that investing firms are more able to access credit during recessions.

To rule out the existence of within-sector common shocks that are not accounted by controls, we predicted the error component using our preferred specification (column 4). We then computed intra-sector correlation. For the idiosyncratic error term u_{it}, it is smaller than 0.001. This suggests that additional sector- and time-specific common shocks not captured by net exit rates are not present. Intra-sector correlation for c_i is instead equal to 0.12. Unobservable time-invariant firm characteristics present patterns that are similar for firms operating in the same sector.

It is also possible that our result could be measuring sector-wide variation. The sector-level net exit rates are only partially correlated with sector-size-level net exit rates. The correlation is equal to 0.51.[15] Controlling for the sector-level net exit rate is not affecting the coefficient on the stratum-level exit rate. See appendix A.5.

Since smaller firms are active in strata with higher exit and entry rates, we check whether the reduction in investments is driven by firm size. In column 5, we restrict the sample to small firms, while in column 6, we consider only large firms. The negative coefficient on net exit rates is mainly driven by small firms.

We extend our analysis by looking at different components of the innovation investment. We distinguish between internal R&D (column 7) and buy strategies (column 8). This is an important distinction since internal R&D investments are typically characterized by a longer time horizon. They are also subject to a higher degree of uncertainty than external sources (Pindyck, 1991). Net exit rate has a negative and statistically significant coefficient on the probability to engage in R&D. For buy strategies, the coefficient is instead not significant . If we assume that firm's size is positively correlated with productivity and that R&D and buy strategies are complementary, both findings are consistent with the model presented in section 2.

Since the recession characterise most of the 2004-13 period, we study how this relationship varies with aggregate demand reductions. We first introduce in our estimating model a pre-post comparison. We interact the net exit rate with a dummy variable equal to 1 if the period of observation is post-2007 and 0 otherwise. We then study heterogeneity in terms of the deviation in aggregate expenditure. We define it as the percentage decrease of aggregate expenditure in per capita terms for Spain (in constant 2010 US$) from its quadratic pre-crisis trend.[16]

[15] We also test whether exit rates in the panel are affecting investments in innovation. The correlation between this measure and the overall net exit rate is even smaller and equal to 0.31. The coefficient on the overall net exit rate is robust to the inclusion of exit rates in the panel.

[16] We present the results with aggregate consumption for Spain. We predict the trend using a linear regression of the raw data on the time variable and its square. We use the pre-crisis sub-sample (1970-2007) and we rescale 1970 to

Table 3: Effect of net exit rate on innovation investment

	Firms investing in R&D in 2004							
Dependent variable:	Any investment in innovation (R&D and/or Buy)						Invested in...	
							R&D	Buy
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sub-sample	All firms	All firms	All firms	All firms	Small firms	Large firms	All firms	All firms
	FE	FE	FE	FE	FE	FE	FE	FE
Net exit rate	-0.025***	-0.023***	-0.018***	-0.019***	-0.016***	0.005	-0.019***	-0.005
	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	(0.005)	(0.003)	(0.003)
Profits (sector)		0.000	-0.001*	-0.001	0.001	0.001	-0.000	0.001
		(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Hours worked (sector)		0.048***	0.039***	0.028**	0.014	0.034***	0.019	0.017
		(0.011)	(0.010)	(0.012)	(0.027)	(0.012)	(0.012)	(0.016)
Liquidity (strata)			0.044***	0.037***	0.040***	0.010**	0.028***	0.018***
			(0.004)	(0.004)	(0.010)	(0.004)	(0.004)	(0.005)
Bank loans (strata)			0.002**	0.002***	-0.001	0.001	0.001	0.003***
			(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Financial burden (strata)			-0.004***	-0.004***	0.000	-0.004***	-0.003***	-0.004***
			(0.001)	(0.001)	(0.004)	(0.001)	(0.001)	(0.001)
Observations	30696	30696	30696	30696	7848	22848	30696	30696
rho	0.476	0.494	0.480	0.453	0.511	0.505	0.508	0.384
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Macro-sector FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector-level controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-varying controls	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Time-by-Macro-sector FE	No	No	No	Yes	Yes	Yes	Yes	Yes
Size-by-Macro-sector FE	No	No	No	Yes	No	No	Yes	Yes

Note: Standard errors in parenthesis are clustered at firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variables are an indicator variable for any investment in innovation (columns 1-4), for investments in internal R&D (column 5) or purchase of external R&D, machinery or licensing (column 6). The net exit rate is defined at the sector- and size- stratum where the firm is operating (see section 3.2) and is standardized over the whole period. The full list of controls is specified in section 4. Rho is the share of the overall variance explained by the firm-level unobserved fixed effect.

Table 4 presents results for any innovation investment (columns 1-4), for investment in R&D (column 5) and in buy strategies (column 6). The reduction in investment happens in strata where exit rates are higher, but only in periods when negative deviations from the trend are larger. For each percentage decrease from trend, one standard deviation increase in net exit rate reduces the propensity to invest by 0.2 percentage points. When consumption is at trend level, the coefficient is positive, but not significant.

We can also extend our analysis by keeping entry and exit rates separate. When aggregate consumption is not deviating from trend, higher entry rates have an opposite effect compared to exit rates. Both effects are significant and tend to sum up to zero (see appendix A.1). This is again in line with our theoretical model.

Table 4: Net exit rates and aggregate trends

	Firms investing in R&D in 2004					
Dependent variable:	Any investment in innovation (R&D and/or Buy)				Invested in...	
					R&D	Buy
	(1)	(2)	(3)	(4)	(5)	(6)
	FE	FE	FE	FE	FE	FE
Net exit rate	0.007	0.008*	0.002	0.004	0.002	0.007
	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)
Net exit rate * Post-2007	-0.043***	-0.038***				
	(0.006)	(0.006)				
Net exit rate * Reduction from trend			-0.002***	-0.002***	-0.002***	-0.001***
			(0.000)	(0.000)	(0.000)	(0.000)
Observations	30696	30696	30696	30696	30696	30696
rho	0.453	0.453	0.453	0.453	0.508	0.384
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Macro-sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Time-varying controls	Yes	Yes	Yes	Yes	Yes	Yes
Time-by-Macro-sector FE	No	Yes	No	Yes	Yes	Yes
Size-by-Macro-sector FE	No	Yes	No	Yes	Yes	Yes

Note: Standard errors in parenthesis are clustered at firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variable is an indicator variable for any investment in innovation, such as internal R&D, purchase of external R&D, machinery or licensing. The net exit rate is defined at the sector- and size- stratum where the firm is operating (see section 3.2) and is standardized over the whole period. The full list of controls is specified in section 4. % reduction from trend is defined as the percentage decrease of aggregate expenditure in per capita terms (in constant 2010 US$) from its quadratic pre-crisis trend. Rho is the share of the overall variance explained by the firm-level unobserved fixed effect.

5.2 Intensive margin

In this section, we focus on the amount spent on any innovation activity. This includes internal R&D, external R&D, machinery and licensing. We present estimates for equation 8 in table 5.[17] In columns 1-3, we concentrate on all firms, while in columns 4-6, we restrict the sample to firms that have not stopped investing in innovation over the period of analysis.

Innovation investments drop in strata where exit rates are higher. The reduction is larger when the recession is deeper. When aggregate consumption decreases by 1%, a one standard deviation increase in net exit rates is associated with a decrease of around 2 percentage points

1. Raw data were obtained from the World Bank DataBank. Our conclusions are robust to using the European or the World aggregate consumption. See appendix A.6.

[17]Expenditures are reported in logarithms after adding one unit. Results are robust to outcomes in levels.

in innovation expenditure. In line with our theoretical model, when aggregate consumption is at its trend level, firms tend to increase expenditure. However, the coefficient is not statistically significant. When we restrict the sample, the coefficients are much smaller and only the interaction term is significant.[18]

Table 5: Effect of net exit rate on innovation expenditures

	Firms investing in R&D in 2004					
Dependent variable:	Overall expenditure on innovation (R&D + Buy expenditures)					
Sub-sample:	All firms			Firms always investing		
	(1)	(2)	(3)	(4)	(5)	(6)
	FE	FE	FE	FE	FE	FE
Net exit rate	-0.256***	-0.208***	0.020	-0.002	-0.006	0.024
	(0.033)	(0.036)	(0.048)	(0.012)	(0.015)	(0.020)
Net exit rate * Reduction from trend			-0.018***			-0.003**
			(0.003)			(0.002)
Profits (sector)	0.004	-0.002	-0.007	0.002	0.003	0.002
	(0.009)	(0.012)	(0.012)	(0.003)	(0.004)	(0.004)
Hours worked (sector)	0.489***	0.243*	0.242*	-0.064	-0.115**	-0.118**
	(0.126)	(0.137)	(0.137)	(0.051)	(0.056)	(0.056)
Liquidity (strata)		0.368***	0.347***		-0.007	-0.007
		(0.046)	(0.045)		(0.013)	(0.013)
Bank loans (strata)		0.026***	0.026***		-0.001	-0.001
		(0.009)	(0.009)		(0.003)	(0.003)
Financial burden (strata)		-0.043***	-0.040***		0.000	0.001
		(0.011)	(0.011)		(0.003)	(0.003)
Observations	30696	30696	30696	14069	14069	14069
rho	0.565	0.517	0.517	0.810	0.782	0.782
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Macro-sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Time-varying controls	Yes	Yes	Yes	Yes	Yes	Yes
Time-by-Macro-sector FE	No	Yes	Yes	No	Yes	Yes
Size-by-Macro-sector FE	No	Yes	Yes	No	Yes	Yes

Note: Standard errors in parenthesis are clustered at firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variables are overall expenditures on innovation (including R&D and Buy strategies), reported in logarithms. The net exit rate is defined at the sector- and size- stratum where the firm is operating (see section 3.2) and is standardized over the whole period. The full list of controls is specified in section 4. Rho is the share of the overall variance explained by the firm-level unobserved fixed effect.

To check whether net exit rates, as computed in the paper, are capturing idiosyncratic shocks, we use within-firm estimation by using two investments at time t, as in Garicano and Steinwender (2016) identification procedure (see equation 9 in section 4). We focus on the investment on innovation and the investment on tangible goods, which are the two investment categories available in the dataset. Investments are reported in logarithms. Table A12 presents estimates for equation (9) under different specifications. We focus on columns 4 and 5. Column 4 is our preferred specification in the paper, while in column 5 we introduce firm-by-year fixed effects. If firm-specific time-varying unobservable characteristics or shocks are correlated with net exit rate we would expect the coefficient on the interaction between net exit rate and the innovation investment dummy variable to change significantly across the two specification. We can observe instead that our estimate is not changing. This supports the evidence that net exit rate, as computed in

[18]Estimating the model using a Tobit-type specification does not affect our conclusions. See appendix A.4.

the paper, is not capturing idiosyncratic variation that is not already captured by our controls.[19] Disaggregating further the innovation investment (for example, distinguishing between internal and external R&D) and running a similar estimation procedure lead to the same conclusion.

Table 6: Within-firm comparison across investment types

Dependent variable:	Firms investing in R&D in 2004 Investment in category c at time t (in logarithm) (1) FE	(2) FE	(3) FE	(4) FE	(5) FE
Net exit rate	-0.254***	-0.236***	-0.185***	-0.210***	
	(0.037)	(0.037)	(0.037)	(0.039)	
Net exit rate * Innovation	-0.019	-0.019	-0.019	-0.019	-0.019
	(0.047)	(0.047)	(0.047)	(0.047)	(0.046)
Liquidity (strata)			0.325***	0.276***	
			(0.040)	(0.042)	
Bank loans (strata)			0.032***	0.035***	
			(0.007)	(0.007)	
Financial burden (strata)			-0.044***	-0.040***	
			(0.008)	(0.009)	
Observations	61392	61392	61392	61392	61392
Firm FE	Yes	Yes	Yes	Yes	No
Year FE	Yes	Yes	Yes	Yes	No
Macro-sector FE	No	Yes	Yes	Yes	No
Sector-level controls	No	Yes	Yes	Yes	No
Time-varying controls	No	Yes	Yes	Yes	No
Time-by-Macro-sector FE	No	No	No	Yes	No
Size-by-Macro-sector FE	No	No	No	Yes	No
Category FE	Yes	Yes	Yes	Yes	Yes
Firm-by-Year FE	No	No	No	No	Yes

Note: Standard errors in parenthesis are clustered at firm level (columns 1-4) and at firm-by-investment level (column 5). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variable is the value of investment in category c at time t. We make use of two categories: investment on innovation and investment on tangible goods. Innovation is a dummy variable equal to 1 if the category is "investment on innovation". The net exit rate is defined at the sector- and size- stratum where the firm is operating (see section 3.2) and is standardized over the whole period. The full list of controls is specified in section 4.

5.3 Demand versus credit constraints

We have so far recorded that increases in net exit rates are associated with reductions in innovation investments. The reduction in innovation investments could have indeed been related to demand shocks. Yet, it could also be capturing additional financial constraints that are not captured by our controls. To test this hypothesis, we focus on other outcome variables, such as sales, financing and perceptions.

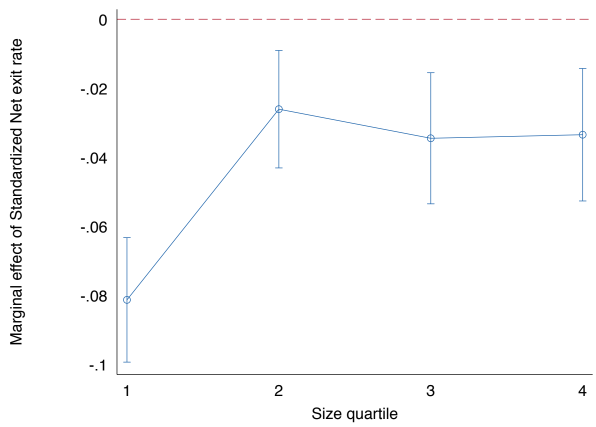
Variations in sales are closely associated with changes in aggregate demand. In our sample, sales among smaller firms follow aggregate consumption very closely (see appendix A.3). The year-level correlation of the two series during the period 2004-13 is equal to 0.91 (0.97 if we restrict the period to the 2008-2013 recession). This relationship is less clear for larger firms. In this case, the correlation between the two series drops to 0.60 (0.62 if we restrict the period to the

[19] We also notice that by focusing on these two investments, we cannot observe any statistically significant difference in the way higher net exit rates translate in lower investments across investment categories. This suggests that, with respect to the investment categories we focus on, Garicano and Steinwender (2016) results do not fully apply in our setting.

recession). It is not surprising that aggregate expenditure shocks have a larger impact on smaller firms, as we also observe changes in investment behaviour.

During the recession, reduction in sales were also heterogeneous. Overall, higher exit rates are associated with a sharp decrease in sales. A one standard deviation increase in the net exit rate is linked with a reduction in sales by around 7 percentage points (see appendix A.3). Since reductions in investments are mainly associated with small firms, we study how this coefficient changes when interacting it with size quartile dummies. Figure 4 plots the marginal effects of net exit rates on firms' sales at different quartiles of the size distribution. The marginal effect for smaller firms is large and negative. A one standard deviation increase translates into a reduction of around 8 percentage points. For in the second, third and fourth quartile, the effect is smaller and homogeneous across groups. This is also in line with the homogeneity in the average net exit rates among these firms.

Figure 4: Marginal effects of net exit rate on firm's sales, by size quartile



Note. Coefficients are estimated using Fixed Effects estimation for equation 8 and using interaction terms between net exit rates and indicator variables for firms' size quartile. The net exit rate is defined at the sector- and size- stratum where the firm is operating (see section 3.2) and is standardized over the whole period. The coefficients are estimated including the full set of controls, including time fixed effects, firm and industry time-varying controls and time-by-sector fixed effects.

At least among innovative firms, the link between net exit rates and heterogeneity in demand reduction is robust. To explore an alternative channel, we focus on lack of financing. [20] We study whether firms are shifting their source of R&D financing. Since this information is restricted to investing firms, we select only the ones that, in the period, always invest in innovation. We identify four different sources: internal, external (from other firms and banks), public and foreign funding. Table A.7 presents estimates of equation 8 where the dependent variables are the shares of the investment from each source. Firms tend to allocate higher shares to external funding, but the coefficient is small and only significant at 10%. The link between higher exit rates and shifts in the sources of innovation financing is therefore weak.[21]

We cannot control whether financing is an issue for the firms that have already stopped their

[20] We do not observe evidence of investment diversification. This is true within innovation investments and across investments. Higher exit rates are linked to a reduction in all types of investments, including tangible goods. See

Table 7: Effect of net exit rate on the sources of financing innovation investments

	Firms investing in R&D in 2004			
Sub-sample:	Firms always investing			
Dependent variable:	Percentage of total investment in R&D financed by the source...			
	Internal	External	Public	Foreign source
	(1)	(2)	(3)	(4)
	FE	FE	FE	FE
Net exit rate	-0.002	0.004*	-0.003	-0.001
	(0.004)	(0.002)	(0.003)	(0.001)
Profits (sector)	0.001	-0.000	-0.001	-0.000
	(0.001)	(0.000)	(0.001)	(0.000)
Hours worked (sector)	0.013	-0.000	-0.016**	-0.003
	(0.008)	(0.002)	(0.007)	(0.004)
Liquidity (strata)	-0.006*	0.002	-0.001	0.001
	(0.004)	(0.001)	(0.003)	(0.001)
Bank loans (strata)	0.000	-0.000	-0.000	0.000
	(0.001)	(0.000)	(0.001)	(0.000)
Financial burden (strata)	-0.001	0.000	0.000	0.000
	(0.001)	(0.000)	(0.001)	(0.000)
Observations	14069	14069	14069	14069
rho	0.461	0.353	0.424	0.605
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Macro-sector FE	Yes	Yes	Yes	Yes
Sector-level controls	Yes	Yes	Yes	Yes
Time-varying controls	Yes	Yes	Yes	Yes
Time-by-Macro-sector FE	Yes	Yes	Yes	Yes
Size-by-Macro-sector FE	Yes	Yes	Yes	Yes

Note: Standard errors in parenthesis are clustered at firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variables is the share of the overall investment on innovation that is financed by each source. External includes other firms and banks. The net exit rate is defined at the sector- and size- stratum where the firm is operating (see section 3.2) and is standardized over the whole period. The full list of controls is specified in section 4. Public funding includes European Union funding. Rho is the share of the overall variance explained by the firm-level unobserved fixed effect.

investment. We therefore focus on the firm's perceptions about the constraints to innovation investment. We make use of a set of 10 questions focusing on these constraints.[22] For each topic, we averaged answers within each sub-group and re-scaled them in a 0-1 scale. The value 1 represents the highest importance.

We group constraints into four categories: liquidity and credit constraints, lack of knowledge, market-related constraints, and lack of demand. Figure 5 shows the time series of averages for these indexes. We distinguish between small and large firms. In general, firms responded to the recession in the first part by reporting liquidity, credit and market-related constraints with increased importance. Their importance reduces towards the end of the period, probably reflecting responses in interest rates. These constraints are more important for smaller firms, while lack of

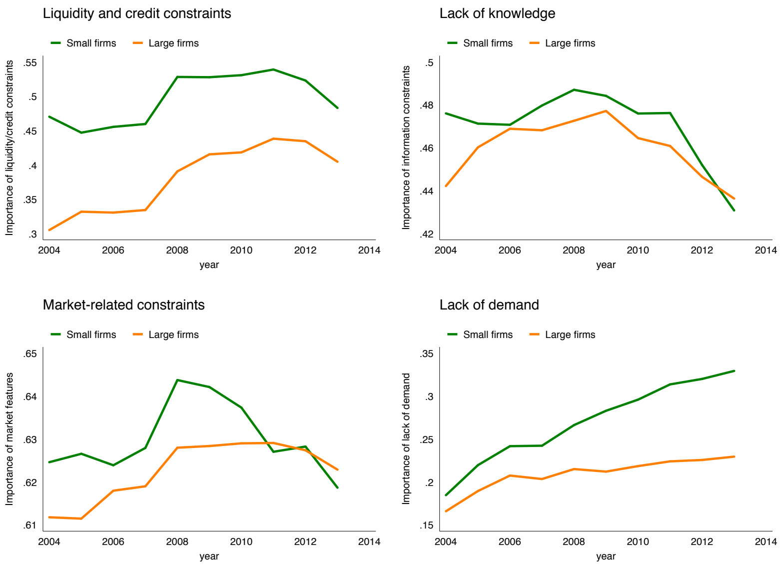
appendix A.9.

[21] We also estimate equation 8 by interacting net exit rates with the short-term interest rate for Spain. Variation in interest rates seems to also capture variation in aggregate demand. When an interaction term with aggregate demand is also introduced, the coefficient becomes insignificant. See appendix A.7.

[22] For each question, a firm's representative had to rank on a scale from 1-4 the importance of each element for the firm, from high to not relevant. The exact text of the question reads as follows: "*How important were the following factors hindering innovation activities or influencing the decision not to innovate?*". Appendix A.8 presents a description of individual components of each index, descriptive statistics and estimates for the coefficient on net exit rates for each individual answer.

knowledge is decreasing over the period and is very similar across firm size. Lack of demand is instead always increasing.

Figure 5: Aggregate trends in importance of constraints for innovation



Note. For each topic, the dependent variable is built by averaging answers within the sub-group and rescaling them in a 0-1 scale, with 1 representing the highest relevance. Appendix A.8 presents a description of individual components.

To understand whether perceptions are also heterogeneous across strata, we again look at net exit rates. Firms active in high-exit strata might update their perceptions differently. For example, if credit is perceived as a stronger constraint, it could suggest the presence of credit constraints. Table 8 presents estimates for equation 8. Higher exit rates are significantly associated with an increase in the importance of lack of demand. On the other hand, we do not observe any significant coefficient for other constraints. This again suggests that net exit rates are capturing heterogeneous variation in demand. It also indicates that credit constraints were not particularly relevant for innovative firms.

6 Conclusions

The Great Recession in Spain has had a dramatic effect on the Spanish economy. Large reductions in aggregate consumption have affected not only the overall economy, but have also created deep differences across productive sectors. We hypothesise that a higher net exit rate proxies for higher reductions in demand. We have analysed whether higher stratum-specific rates are associated with innovation investment. Since small firms are more likely to be hit by involuntary exit, our theoretical framework also predicted the effect to be stronger among smaller firms.

Bearing these considerations in mind, we analyse a panel of Spanish manufacturing firms yearly surveyed from 2004 to 2013. Variation in net exit rates indeed captures firms' choices of investment. The average effect is driven by smaller firms in the sample. The magnitude of these

Table 8: Effect of net exit rate on perceived constraints to innovation investments

Dependent variable:	**Firms investing in R&D in 2004** Degree of importance of...			
	Liquidity/Credit constraints	Lack of demand	Lack of knowledge	Market-related constraints
	(1)	(2)	(3)	(4)
	FE	FE	FE	FE
Net exit rate	-0.003	0.005**	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Profits (sector)	-0.001	0.000	0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Hours worked (sector)	-0.001	0.004	-0.003	-0.009
	(0.010)	(0.011)	(0.008)	(0.009)
Liquidity (strata)	0.004	-0.010***	0.002	-0.000
	(0.003)	(0.003)	(0.003)	(0.003)
Bank loans (strata)	-0.000	-0.000	0.000	0.001
	(0.001)	(0.001)	(0.000)	(0.000)
Financial burden (strata)	0.002***	0.002**	0.001*	0.001**
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	30696	30696	30696	30696
rho	0.507	0.423	0.510	0.489
Firm FE	Yes	Yes	Yes	Yes
Time-varying controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Sector-level controls	Yes	Yes	Yes	Yes
Time-by-Macro-sector FE	Yes	Yes	Yes	Yes
Size-by-Macro-sector FE	Yes	Yes	Yes	Yes

Note: Standard errors in parenthesis are clustered at firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. For each topic, the dependent variable is an index built by averaging answers within the sub-group and rescaling them in a 0-1 scale, with 1 representing the highest relevance. The net exit rate is defined at the sector- and size- stratum where the firm is operating (see section 3.2) and is standardized over the whole period. The full list of controls is specified in section 4. Rho is the share of the overall variance explained by the firm-level unobserved fixed effect.

changes are not small. Roughly 0.8% increase in the net exit rate leads to a reduction of around 2 percentage points in the share of firms investing in innovation. We suggests that this is mainly linked to large deviations in aggregate demand. The reduction in investment in higher in periods when the reduction from trend is larger. At the same time, higher rates are associated with large reductions in sales. These are again concentrated among smaller firms.

The empirical results presented in the received literature point at the central importance of private investments in innovation for the whole economy. This makes the study of private and public responses that could support R&D investments during recessions a relevant matter. This empirical evidence is complemented by our results. These suggest that, since most of the decrease in innovation-related investments occurs among smaller firms, this type of firms should be particularly targeted in periods of low demand.

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Appendices to "Demand Drops and Innovation Investments: Evidence from the Great Recession in Spain"

A Additional analysis

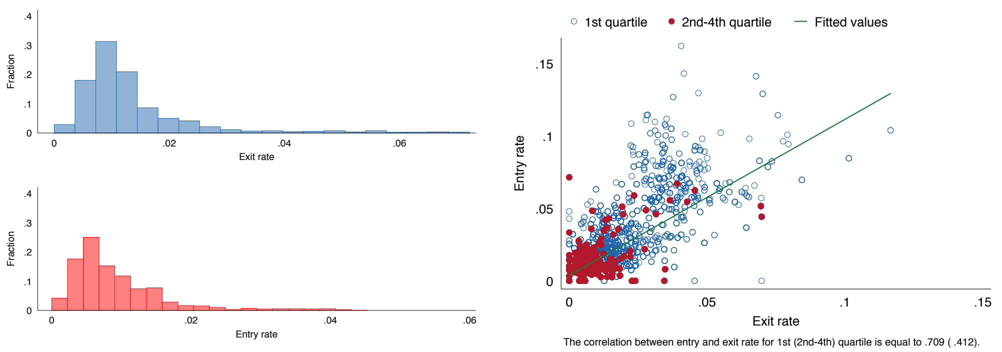
A.1 Exit versus entry rate

Our analysis can be extended to understand whether the exit and entry rates have distinctive roles. Starting from equation 7, we can decompose the net exit rate in its two main components:

$$exit_{jst} = \frac{n\_exit_{jst}}{n\_sur_{jst-1} + n\_entry_{jst-1}} \quad ; \quad entry_{jst} = \frac{n\_entry_{jst}}{n\_sur_{jst-1} + n\_entry_{jst-1}}$$

where $exit_{jst}$ and $entry_{jst}$ are the exit and entry rate at year t for a firm in industry j and of size group s. The left panel of figure A1 shows the distribution of the exit and the entry rate across the sampled firms. The unit of observation is the firm, therefore these variables measure the individual exposure to different exit and entry rates. Exit and entry rates show a very similar distribution, with exit rates presenting higher values, but being more concentrated around zero. The right panel in figure A1 presents a scatter plot for the entry and exit rates in the period of study and a linear prediction. Again, observations are at firm level to capture variation on entry and exit rates at our main unit of observation.

Figure A1: Distribution of exit and entry rate and correlation



Note. The left panel shows the distribution of the exit rate, while the right panel shows the distribution of the entry rate. The dotted line represent the mean of the distribution. Size quartile is determined on the basis of the distribution of number of employees in a certain year. Exit and entry rates are computed at sector- and size- stratum and are averaged over different quartiles of the size distribution (see section 3.2). Fitted values are computed using a linear regression of the entry rate on the exit rate. Source: author's calculations using the Spanish Central Business Register.

To look at entry and exit rates separately, we extend equation 8 by introducing exit ($exit_{it}$) and entry ($entry_{it}$) rates separately. Table A1 presents estimates of this specification when the dependent variable is the decision to invest on innovation. Overall, firm exit, but not entry, is associated with a reduction on the probability of investing in innovation. This might be due to the fact that we are mainly focusing on a period of deep recession. To this purpose, in columns 4-6, we estimate equation 8, but interacting entry rate with the percentage reduction of aggregate household consumption expenditure for its trend. In periods when the aggregate household expenditure is not deviating from its trend, higher entry rates have an opposite coefficient compared to exit rates, and these tend to sum up to zero.

Table A1: Effect of exit and entry rates on innovation investments

	Firms investing in R&D in 2004					
Dependent variable:	Overall expenditure on innovation (R&D + Buy expenditures)					
	(1)	(2)	(3)	(4)	(5)	(6)
	FE	FE	FE	FE	FE	FE
Exit rate	-0.040***	-0.032***	-0.032***	-0.033***	-0.028***	-0.025***
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.005)
Entry rate	0.002	-0.001	0.000	0.024***	0.017***	0.021***
	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)
Entry rate * Reduction from trend				-0.002***	-0.002***	-0.002***
				(0.000)	(0.000)	(0.000)
Observations	30696	30696	30696	30696	30696	30696
rho	0.488	0.475	0.453	0.490	0.477	0.455
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Macro-sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Time-varying controls	No	Yes	Yes	No	Yes	Yes
Time-by-Macro-sector FE	No	No	Yes	No	No	Yes
Size-by-Macro-sector FE	No	No	Yes	No	No	Yes

Note: Standard errors in parenthesis are clustered at firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variables are indicator variables for investments in internal R&D (columns 1-3) or purchase of external R&D, machinery or licensing (columns 3-6). Exit and entry rates are defined in section 3.2 and are standardized over the whole period. They are computed at the industry and stratum level where the firm is operating. The full list of controls is specified in section 4. Rho is the share of the overall variance explained by the firm-level unobserved fixed effect.

A.2 Exit analysis

Table A2 presents descriptive statistics for this variable for the sampled firms. Rates are multiplied by 100, while they are standardized in the main text.

Table A2: Descriptive statistics of net exit rates

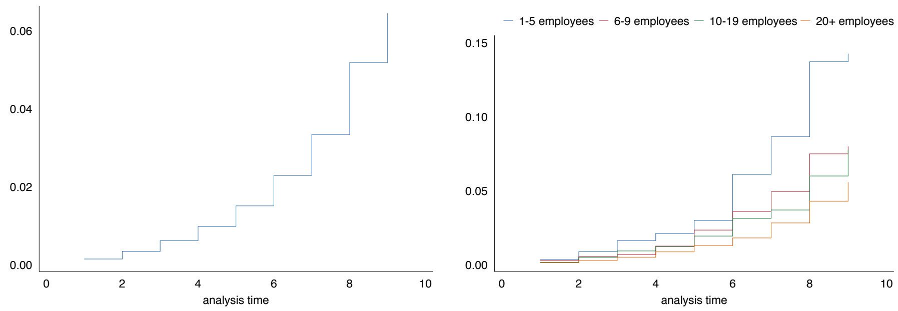
	(1)	(2)	(3)	(4)	(5)
	Mean	Median	Std.Dev.	Min	Max
Net exit rate	0.30	0.23	0.75	-3.45	8.90
Net exit rate (Year == 2004)	-0.11	-0.17	0.62	-1.69	4.54
Net exit rate (Year == 2005)	0.14	0.11	0.79	-2.86	4.01
Net exit rate (Year == 2006)	-0.00	0.09	0.58	-3.45	4.79
Net exit rate (Year == 2007)	0.14	0.00	0.90	-2.67	7.14
Net exit rate (Year == 2008)	0.48	0.44	0.71	-2.27	8.90
Net exit rate (Year == 2009)	0.83	0.75	0.75	-0.43	7.23
Net exit rate (Year == 2010)	0.43	0.41	0.52	-0.50	4.05
Net exit rate (Year == 2011)	0.42	0.43	0.62	-1.29	6.08
Net exit rate (Year == 2012)	0.44	0.47	0.69	-2.56	7.31
Net exit rate (Year == 2013)	0.17	0.20	0.78	-3.45	4.05

Note: The rates are multiplied by 100. The net exit rates is defined at the sector- and size- stratum where the firm is operating.

One possible claim is that net exit rates and contemporaneous investments are drivers of exit rates in our target population. To analyse this potential channel, we selected all firms that are in the initial sample (i.e. that are investing in R&D in 2004 and are active in the manufacturing sector), but keeping the firms that exit the market during the period of interest. We can therefore study directly how the probability of exit has evolved over time among firms initially sampled.

We define firm exit by whether a firm is declared in the dataset as both temporary or indefinitely closed. Our outcome of interest is a dummy variable equal to 0 if the firm is active in the market at time t, 1 if the firm exits at time $t+1$ and missing for every period following exit. Figure A2 presents estimates of the Nelson-Aalan cumulative hazard estimates on the probability of exiting the market for the whole sample (left panel) and by firm size (right panel). First, we can note that overall the cumulative hazard estimates tend to be rather small, showing that we are focusing on a pretty stable market in terms of exit rates. Secondly, as expected, hazard estimates are dependent on size, with smaller firms having higher hazard estimates. This difference becomes evident only during the period of crisis, whereas before there was little difference between smaller and larger firms.

Figure A2: Nelson-Aalan cumulative hazard estimates for market exit



Note. The left panel shows the Nelson-Aalan cumulative hazard estimates for the whole sample of firms investing in R&D in 2005, while the right panel presents the same estimates by firm size (number of employees). Time 0 is set to year 2005.

We check whether the variation in net exit rates explains the timing of exit among these firms. Table A3 presents estimates of different survival models estimating the role of our measure of net exit rate on market exit. In columns 1-3, we estimate a Cox proportional hazards model, while in columns 4-6 we present estimates for a random-effect parametric model assuming an exponential survival distribution. Hazard ratios are presented. In the estimation, we always control for firm-level and industry-level time-varying controls and for industry fixed-effects. Since we cannot control for firm fixed-effects, we add firm-level averaged controls (controls are averaged over the period of reference and includes average sales) and sector-level averaged controls. The latter are therefore specific to the firms originally investing in R&D, rather than the whole sector. Time-fixed effects are excluded due to collinearity with time variable in the survival model. In column 2-3 and 5-6, we add a control for whether the firm invested in innovation at time t.

Net exit rate have an hazard ratio not statistically different from 1. Adding controls specific to investment in innovation, sales and competitor's behaviour at time t does not affect our estimates. In columns 2 and 4, we add a control for whether the firm invested in innovation at time t, while in columns 3 and 6, we also control for firm-level sales and average investment in innovation in the firm's stratum. The latter is computed as average log-expenditure among other firms in the same

Table A3: Parametric survival model for the probability of market exit

	Firms investing in R&D in 2004					
Failure event:	Temporary or Permanent market exit at time $t+1$					
	(1)	(2)	(3)	(4)	(5)	(6)
Model:	Cox	Cox	Cox	Parametric	Parametric	Parametric
Distributional assumption:	-	-	-	Exponential	Exponential	Exponential
Net exit rate	0.992	0.986	0.982	1.040	1.026	0.982
	(0.036)	(0.036)	(0.042)	(0.036)	(0.036)	(0.039)
Firm invested in innovation at time t		0.532***	0.559***		0.438***	0.475***
		(0.048)	(0.051)		(0.040)	(0.044)
(Log)Sales at time t			0.412***			0.367***
			(0.029)			(0.033)
Average investment in innovation			1.176***			1.079***
			(0.023)			(0.019)
Observations	31803	31803	31799	31803	31803	31799
Firm random effects	No	No	No	Yes	Yes	Yes
Firm FE	No	No	No	No	No	No
Year FE	No	No	No	No	No	No
Firm-level time-varying controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm-averaged controls	Yes	Yes	Yes	Yes	Yes	Yes
Sector-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Sector-level time-varying controls	Yes	Yes	Yes	Yes	Yes	Yes

Note: Estimates are hazard ratios. Robust standard errors are presented in parenthesis. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The survival indicator is a dummy variable equal to 0 if the firm is active in the market at time t, 1 if the firm exit at time $t+1$ and missing for every period following exit. The net exit rate is defined at the sector- and size- stratum where the firm is operating (see section 3.2) and is standardized over the whole period. Share of competitors investing is the share of other firms (excluding the firm to which we assign the value) in the same sector and size stratum that are investing in any innovation activity. Firm-averaged controls are computed by averaging firm-level time-varying controls over the time. Sector-level time varying controls are computed by averaging firm-level time-varying controls at sector level. The full list of controls is specified in section 4.

sector-size stratum of the firm. This variable aims at capturing competitors' behaviour. Once controlling for the set of variables we can control for, we can conclude that net exit rates in the firm's stratum are not driving exit among firms in the specific market that is under analysis.

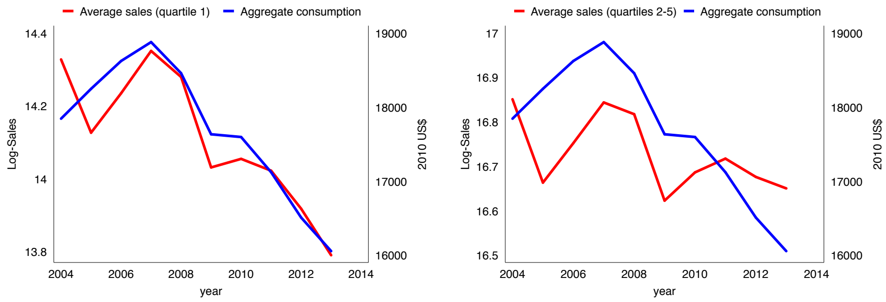
A.3 Understanding sales during the Great Recession

We begin by looking at the relationship between changes in sales over time and changes in aggregate consumption. Figure A3 compares the series of total aggregate household consumption (in per capita terms) and the average sales for the firms we observe in our sample. We focus on firms in the first quartile (left panel) and firms from the second to the fourth quartile (right panel). We can observe that aggregate consumption is moving very closely with sales for smaller firms, while this relationship is weaker for larger firms.

We then look at the relationship between net exit rates and sales by estimating equation 8 under different set of controls. Results are presented in Table A4. Similarly to innovation expenditures, we look separately at firms that stop their investment on innovation (columns 1-3) versus firms that are investing every year (columns 4-6).

Table A5 presents estimates of equation 8, when controlling for firm-level sales. In columns 2-3 and 5, we control for average sales in the firm's sector, but excluding for the firm's size stratum. In columns 5 and 6, we also introduce an interaction term between net exit rate and sales. We take these results as indicative, since this estimation strategy can present issues if sales

Figure A3: Relationship between average sales and aggregate household consumption



Note. Household consumption is the series of household final consumption expenditure reported in constant prices (2010 US$) and in per capita terms (source: World Bank). Sales are averaged for each year among all manufacturing firms, including the firms in the first quartile (left panel) and the firms in the second-fourth quartiles (right panel). To allow for a comparable variation of sales for firms in the the two groups, we have fixed the left y-axis with a same range of 0.5.

Table A4: Effect of net exit rate on firm-level sales

	Firms investing in R&D in 2004					
Dependent variable:	Firm's sales (in logarithms)					
Sub-sample:	All firms			Firms always investing		
	(1)	(2)	(3)	(4)	(5)	(6)
	FE	FE	FE	FE	FE	FE
Net exit rate	-0.066***	-0.067***	0.005	-0.012	-0.021*	-0.016
	(0.007)	(0.007)	(0.009)	(0.008)	(0.011)	(0.015)
Net exit rate * Reduction from trend			-0.006***			-0.001
			(0.001)			(0.001)
Observations	30694	30694	30694	14069	14069	14069
rho	0.946	0.926	0.928	0.955	0.943	0.943
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Macro-sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Time-varying controls	Yes	Yes	Yes	Yes	Yes	Yes
Time-by-Macro-sector FE	No	Yes	Yes	No	Yes	Yes
Size-by-Macro-sector FE	No	Yes	Yes	No	Yes	Yes

Note: Standard errors in parenthesis are clustered at firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variables are firm's sales, reported in logarithms. The net exit rate is defined at the sector- and size- stratum where the firm is operating (see section 3.2) and is standardized over the whole period. Year FE include a set of year dummies. The full list of controls is specified in section 4. Rho is the share of the overall variance explained by the firm-level unobserved fixed effect.

are correlated with idiosyncratic unobservable characteristics or shocks. Higher sales tend to reduce the negative coefficient of net exit rates. At the same time, we observe that highest average sales in the rest of the sector are reducing the propensity to invest in innovation, both conditional or unconditional from firm-level sales. We observe however that, while sales largely explains investments in innovation, the coefficient on net exit rate is robust to controlling for sales.

A.4 Non-linear estimation methods

Firstly, when estimating whether the firm is investing in innovation using a binary outcome as dependent variable, we focused on an unobserved effects linear probability model. Since fixed effects linear models can suffer from an incidental parameter problem when T is small (Wooldridge, 2010), we introduce a Correlated Random Effects (CRE) Probit model to explain the probability

Table A5: Effect of net exit rate on innovation investment, controlling for sales

Dependent variable:	**Firms investing in R&D in 2004** Any investment in innovation (R&D and/or Buy)				
	(1)	(2)	(3)	(4)	(5)
	FE	FE	FE	FE	FE
Net exit rate	-0.014***	-0.017***	-0.013***	-0.126***	-0.124***
	(0.003)	(0.003)	(0.003)	(0.020)	(0.020)
(Log)Sales	0.073***		0.070***	0.070***	0.067***
	(0.007)		(0.007)	(0.007)	(0.007)
(Log)Sales (sector, excluding stratum)		-0.034***	-0.026***		-0.026***
		(0.007)	(0.007)		(0.007)
Net exit rate * (Log)Sales				0.008***	0.008***
				(0.001)	(0.001)
Observations	30694	30685	30683	30694	30683
rho	0.470	0.451	0.469	0.467	0.467
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Macro-sector FE	Yes	Yes	Yes	Yes	Yes
Sector-level controls	Yes	Yes	Yes	Yes	Yes
Time-varying controls	Yes	Yes	Yes	Yes	Yes
Time-by-Macro-sector FE	Yes	Yes	Yes	Yes	Yes
Size-by-Macro-sector FE	Yes	Yes	Yes	Yes	Yes

Note: Standard errors in parenthesis are clustered at firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variable is an indicator variable for any investment in innovation, such as internal R&D, purchase of external R&D, machinery or licensing. The net exit rate is defined at the sector- and size- stratum where the firm is operating (see section 3.2) and is standardized over the whole period. The full list of controls is specified in section 4. Rho is the share of the overall variance explained by the firm-level unobserved fixed effect.

of the firm i to invest in innovation at time t, i.e. $p(y_{it} = 1|netexit_{it}, \mathbf{Z}_{it}, c_i)$:

$$p(y_{it} = 1|netexit_{it}, \mathbf{Z}_{it}, c_i) = \Phi[\alpha_0 + \alpha_N netexit_{it} + \mathbf{Z}_{it}\beta + c_i] \quad (10)$$

where $\Phi()$ is the standard normal cumulative distribution function and $\mathbf{Z}_{it}$ is a matrix containing all observable characteristics (both constant and variable over time) of each firm. While in a pure random effects model the conditional distribution of c_i is independent from observable characteristics, CRE framework allows dependence between c_i and observable characteristics, but it is restricted. In fact, c_i is assumed to be equal to $\psi_0+\psi_1\overline{netexit_i}+\overline{\mathbf{Z}}_i\lambda+a_i$, where $a_i|(netexit_{it}, \mathbf{Z}_{it})$ is distributed $Normal(0, \sigma^2)$. In columns 1-3 of Table A6, we estimate average marginal effects of the net exit rate on the probability to invest in innovation using three different methods: Pooled OLS, Fixed Effects and CRE Probit model.

Secondly, when looking at the intensive margin of innovation investment, we estimated equation 8 restricting the sample to only firms investing in innovation (any type) during the whole period of interest. The objective being to estimate the impact of the net exit rate on a particular groups of firms that are always investing in innovation. One alternative is to look at overall effect on all firms, but in this case we would face a corner solution problem. We therefore estimate the effect of the net exit rate on overall expenditure on innovation using a CRE tobit model censored at 0 and we compare it with a pooled OLS estimate and a Fixed Effects estimate. Columns 4-6 in Table A6 present the results for the average marginal effects under these three models.

Table A6: Effect of net exit rate on innovation investment: robustness to estimation method

	Firms investing in R&D in 2004					
Dependent variable:	Any investment in innovation			Overall expenditure on innovation		
	(1)	(2)	(3)	(4)	(5)	(6)
Estimation method:	Pooled OLS	Fixed Effects	CRE Probit	Pooled OLS	Fixed Effects	CRE Tobit
Net exit rate	-0.047***	-0.018***	-0.014***	-0.639***	-0.202***	-0.256***
	(0.003)	(0.003)	(0.003)	(0.034)	(0.033)	(0.022)
Observations	30696	30696	28296	30696	30696	30696
Firm FE	No	Yes	No	No	Yes	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Macro-sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Time-varying controls	Yes	Yes	Yes	Yes	Yes	Yes
Time-by-Macro-sector FE	No	No	No	No	No	No
Size-by-Macro-sector FE	No	No	No	No	No	No

Note: Robust standard errors in parenthesis. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variables are an indicator variable for any investment in innovation, such as internal R&D, purchase of external R&D, machinery or licensing (columns 1-3), and overall expenditures on innovation (including R&D and Buy strategies), reported in logarithms (columns 4-6). The net exit rate is defined at the sector- and size- stratum where the firm is operating (see section 3.2) and is standardized over the whole period. The full list of controls is specified in section 4.

A.5 Robustness to exit rates computed at different levels of aggregation

We build sector-level net exit rates and estimate how increases affect innovation investment. Similarly, we build exit rates in the sector and stratum of the firm using the PITEC database and selecting only firms that were investing in internal R&D in 2005. Since we do not observe entry rates in the panel, we can compute only exit rates. Estimates for equation 8 using these two variables are reported in Table A7. The sector-level measure is capturing part of the effect at the stratum level, but it is very small and never significant, while the effect on the stratum-level exit rate is unaffected. In contrast, an increase in both the overall sector-size stratum and the panel sector-size stratum has a negative effect on the propensity to invest in innovation, but the coefficient on the overall net exit rate is robust to the inclusion of exit rates in the panel. Investment decisions seems to be affected by variation in net exit rates that are in proximity of firm's activity, both in terms of type of activity and firm size. However, we can note that exit rates in the overall stratum and among innovative firms are possibly capturing two independent effects with the same direction.

A.6 Different aggregate shocks

In the main text we have focused on deviations from the pre-crisis trend in household consumption for Spain only. However, we can focus on deviations at different levels. Similar to Spain, we have computed deviations from the quadratic trend for the European Union and for the whole World for the same period. Figure A4 presents a comparison for Spain, European Union and the World in terms of total per capita household expenditure (left panel) and in terms of deviations from the quadratic trend (right panel). As expected the series are highly correlated (at least for Spain and the European Union), but Spain presents the highest deviations from trend.

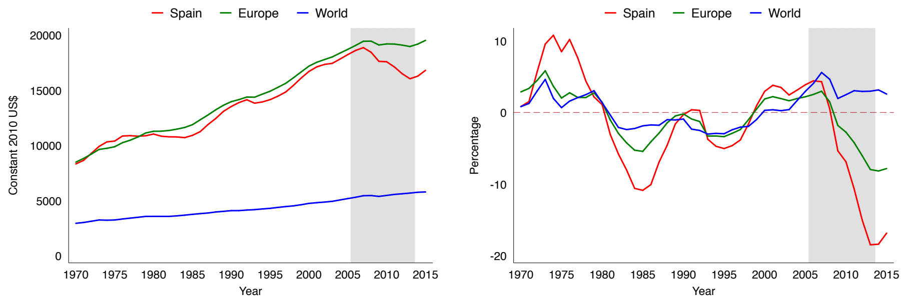
We proceed by estimating equation 8 by interacting the net exit rate with the percentage de-

Table A7: Effect of net exit rate at different levels of aggregation on innovation investment

	Firms investing in R&D in 2004				
Dependent variable:	Any investment in innovation (R&D and/or Buy)				
	(1)	(2)	(3)	(4)	(5)
	FE	FE	FE	FE	FE
Net exit rate (sector)	-0.003	0.008			0.012
	(0.006)	(0.006)			(0.009)
Net exit rate		-0.020***		-0.016***	-0.017***
		(0.003)		(0.003)	(0.003)
Exit rate (stratum, computed in panel)			-0.012***	-0.011***	-0.011***
			(0.002)	(0.002)	(0.002)
Exit rate (sector)					-0.005
					(0.012)
Observations	30696	30696	29431	29431	29431
rho	0.456	0.453	0.492	0.489	0.490
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Macro-sector FE	Yes	Yes	Yes	Yes	Yes
Sector-level controls	Yes	Yes	Yes	Yes	Yes
Time-varying controls	Yes	Yes	Yes	Yes	Yes
Time-by-Macro-sector FE	Yes	Yes	Yes	Yes	Yes
Size-by-Macro-sector FE	Yes	Yes	Yes	Yes	Yes

Note: Standard errors in parenthesis are clustered at firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variables is an indicator variable for any investment in innovation, such as internal R&D, purchase of external R&D, machinery or licensing. The net exit rate is defined at the sector- and size- stratum where the firm is operating (see section 3.2) and is standardized over the whole period. Year FE include a set of year dummies. The full list of controls is specified in section 4. Rho is the share of the overall variance explained by the firm-level unobserved fixed effect.

Figure A4: Household final consumption expenditure per capita



Note. The left panel presents the series of household final consumption expenditure, which is reported in constant prices (2010 US$) and in per capita terms (source: World Bank). The right panel presents deviations from the quadratic trends.

crease from the trend in aggregate household consumption expenditure computed at different levels. Table A8 presents the results for the investment in any innovation activity (columns 1-3), and for the investment in internal R&D (columns 4-6). The choice of the level at which we compute deviations from trend marginally affects the estimates, but does not affect its direction.

A.7 Innovation investments and financing

In aggregate terms, the period 2004-2013 was characterized by a deep variation in terms of financing. If we look at the share of bank loans (normalized by total assets) in the sector-sale group of our sampled firms, we can observe that following 2007 there has been a sharp reduction in short term bank loans which continued throughout the period (see figure A5). In terms of medium-long

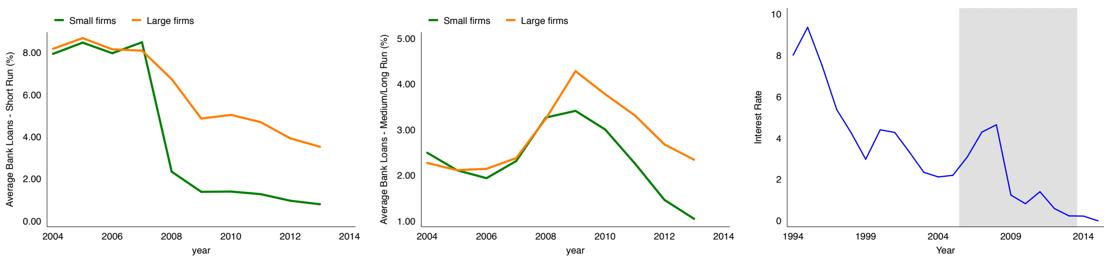
Table A8: Effect of net exit rate under different measures of aggregate shocks

	Firms investing in R&D in 2004					
Dependent variable:	Any investment in innovation (R&D and/or Buy)			Invested in...		
				R&D	R&D	R&D
	(1)	(2)	(3)	(4)	(5)	(6)
	FE	FE	FE	FE	FE	FE
Net exit rate	0.001	0.000	-0.011***	-0.001	-0.002	-0.011***
	(0.005)	(0.005)	(0.004)	(0.006)	(0.006)	(0.004)
Net exit rate * % reduction from trend	-0.001***			-0.001***		
	(0.000)			(0.000)		
Net exit rate * % reduction from trend (Europe)		-0.003***			-0.002***	
		(0.001)			(0.001)	
Net exit rate * % reduction from trend (World)			-0.006***			-0.005***
			(0.002)			(0.002)
Observations	24155	24155	24155	24155	24155	24155
rho	0.512	0.512	0.513	0.569	0.569	0.569
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Macro-sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Time-varying controls	Yes	Yes	Yes	Yes	Yes	Yes
Time-by-Macro-sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Size-by-Macro-sector FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors in parenthesis are clustered at firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variables are an indicator variable for any investment in innovation (columns 1-4), for investments in internal R&D (column 5) or purchase of external R&D, machinery or licensing (column 6). The net exit rate is defined at the sector- and size- stratum where the firm is operating (see section 3.2) and is standardized over the whole period. The full list of controls is specified in section 4. Rho is the share of the overall variance explained by the firm-level unobserved fixed effect.

term bank loans, we can instead observe an increase following 2007 and a sharp decrease after 2009.

Figure A5: Short Term versus Medium-Long Term Bank Loans



Note. The left and middle panels show the average Bank Loans, computed as the average ratio between bank loans in short term (left) and medium-long term (middle) and total assets. Data is matched at sector and sales group levels. Small (large) firms are defined as firms in the first (second-fourth) quartile of the size distribution for a given year. The right figure presents the series of short-term interest rates for Spain (source: OECD).

We study how the coefficient on net exit rates can be heterogeneous in terms of aggregate changes in the short-term interest rates for Spain. These are defined as the "rates at which short-term borrowings are effected between financial institutions or the rate at which short-term government paper is issued or traded in the market. Short-term interest rates are generally averages of daily rates, measured as a percentage. Short-term interest rates are based on three-month money market rates where available. Typical standardized names are money market rate and treasury bill rate" (source: OECD). The right panel in figure A5 presents the series of short-term interest rates from 1994 to 2014.

We estimate equation 8 by interacting the net exit rate first with the short-term interest rate and then by adding also an interaction with the percentage decrease from the trend in aggregate household consumption expenditure. Table A9 presents these results.

Table A9: Innovation investments, net exit rate and interest rates

	Firms investing in R&D in 2004					
Dependent variable:	Any investment in innovation (R&D and/or Buy)		Invested in... R&D		Buy	
	(1)	(2)	(3)	(4)	(5)	(6)
	FE	FE	FE	FE	FE	FE
Net exit rate	-0.035***	0.008	-0.032***	0.012	-0.013***	0.007
	(0.005)	(0.010)	(0.005)	(0.010)	(0.005)	(0.012)
Net exit rate * Short-term IR	0.009***	-0.001	0.007***	-0.003	0.005**	-0.000
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)
Net exit rate * Reduction from trend		-0.002***		-0.002***		-0.001*
		(0.000)		(0.000)		(0.001)
Observations	30696	30696	30696	30696	30696	30696
rho	0.453	0.453	0.508	0.508	0.384	0.384
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Macro-sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Time-varying controls	Yes	Yes	Yes	Yes	Yes	Yes
Time-by-Macro-sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Size-by-Macro-sector FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors in parenthesis are clustered at firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variables are an indicator variable for any investment in innovation (columns 1-2), for investments in internal R&D (columns 3-4) or purchase of external R&D, machinery or licensing (columns 5-6). Exit and entry rates are defined in section 3.2 and are standardized over the whole period. They are computed at the industry and stratum level where the firm is operating. The full list of controls is specified in section 4. Rho is the share of the overall variance explained by the firm-level unobserved fixed effect.

A.8 Perceptions

We make use of a set of 10 questions focusing on the constraints to innovation. Table A10 presents all questions related to perceived importance of factors influencing innovation investments and how these are divided to capture different sub-groups of constraints. For each of these topics a firm's representative had to rank on a scale from 1-4 the importance of each element for the firm. For each topic we build an index by averaging answers within sub-group and by rescaling these variables in a 0-1 scale, with 1 representing the highest importance. The column sub-group identifies how each variable was aggregated into an index.

Table A11 presents descriptive statistics for each variable. In addition, it presents estimates for the coefficient on net exit rates using equation 8 and the full set of controls.

A.9 Investment diversification

Table A12 presents estimates of equation 8 where the dependent variables are three indicator variables: "R&D and Buy" is equal to one if the firm is investing in both activities at time t and zero otherwise, and "R&D or Buy" is equal to one if the firm is investing in R&D or in Buy strategies, but not on both. In columns 1-3, we present the estimates for all firms, while in columns 4-6 we restrict the sample to firms always investing in innovation. We do not observe evidence of diversification behavior by firms, both within innovation investments and across investments. Higher

Table A10: Categories and questions related to perceived constraints to innovation

Sub-group	Variable	Description
Liquidity / Credit	face1	Lack of funds within the company or group
	face3	High costs of innovation
	face2	Lack of external financing to the company
Knowledge	faci1	Lack of qualified staff
	faci2	Lack of information about technology
	faci3	Lack of information about markets
	otrofac2	Uncertain demand for innovative goods and services
Market	otrofac1	Market dominated by established companies
	faci4	Difficulty in finding partners for cooperation in innovation
Demand	otrofac4	Lack of demand for innovation

Table A11: Descriptive statistics and effect of net exit rates on attitudes

Factor of relevance for innovation	Statistics		Effect of net exit rates	
	(1) Mean	(2) Std.Dev.	(3) Coeff.	(4) Std.Err.
Lack of funds within the company or group	0.59	0.32	-0.002	0.003
Lack of external financing to the company	0.58	0.34	-0.005	0.003
High costs of innovation	0.61	0.33	-0.003	0.003
Lack of qualified staff	0.45	0.29	0.001	0.002
Lack of information about technology	0.43	0.27	0.003	0.002
Lack of information about markets	0.44	0.28	0.002	0.002
Difficulty in finding partners for cooperation in innovation	0.37	0.32	0.003	0.003
Market dominated by established companies	0.54	0.33	-0.001	0.003
Uncertain demand for innovative goods and services	0.58	0.32	0.000	0.003
Lack of demand for innovation	0.17	0.24	0.005**	0.002

Note: Standard errors are clustered at firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Each variable is defined on a scale 0-1, where 1 represents highest relevance. Columns 1-2 reports mean and statistics of each variable. Columns 3-4 reports estimates of the effect of exit rates estimated using 8 using the full set of controls (time fixed effects, firm- and industry-level time-varying controls, sector fixed effects and time-by-sector fixed effects). The full list of controls is specified in section 4. The net exit rate is defined at the sector- and size- stratum where the firm is operating (see section 3.2) and is standardized over the whole period.

exit rates reduce all types of investments, including investments in tangible goods. On the other hand, exit rates do not affect the way firms diversify between internal and external investments if we restrict to firms always investing in innovation. Among these firms we only observe a small decrease in the probability to invest on tangible goods at time t when net exit rates are larger.

B Variable description

We present additional information about the variables selected for the analysis. Table B13 presents the list of variables used and a short description. In order to preserve data confidentiality, some of the firm characteristics, such as capital investment or sales, have been partially anonymized. This process consists on a ranking of the values of the variable in question and computation of the averages of three or five consecutive observations, depending on the specific variable. For a given firm, the actual realization of the variable in question has been replaced by this average. Given the large number of observations, this anonymization process is expected not to introduce significant measurement error.

Table A12: Effect of net exit rate on diversification of investment

	Firms investing in R&D in 2004					
Dependent variable:	Decision to invest in...					
	R&D and Buy	R&D or Buy	Tangible goods	R&D and Buy	R&D or Buy	Tangible goods
Sub-sample:	All firms			Firms always investing		
	(1)	(2)	(3)	(4)	(5)	(6)
	FE	FE	FE	FE	FE	FE
Net exit rate	-0.004	-0.015***	-0.022***	-0.005	0.005	-0.006
	(0.003)	(0.004)	(0.003)	(0.006)	(0.006)	(0.005)
Profits (sector)	0.001	-0.001	-0.000	0.001	-0.001	-0.000
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)
Hours worked (sector)	0.008	0.020	-0.004	-0.016	0.016	-0.031**
	(0.015)	(0.017)	(0.012)	(0.021)	(0.021)	(0.014)
Liquidity (strata)	0.009*	0.028***	0.025***	0.003	-0.003	0.011**
	(0.005)	(0.006)	(0.005)	(0.007)	(0.007)	(0.005)
Bank loans (strata)	0.002*	0.001	0.004***	0.002	-0.002	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Financial burden (strata)	-0.004***	0.000	-0.003***	-0.002	0.002	-0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	30696	30696	30696	14069	14069	14069
rho	0.413	0.326	0.359	0.458	0.458	0.369
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Macro-sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Time-varying controls	Yes	Yes	Yes	Yes	Yes	Yes
Time-by-Macro-sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Size-by-Macro-sector FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors in parenthesis are clustered at firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variables are: "R&D and Buy" is an indicator variable equal to one if the firm is investing in both at time t and zero otherwise, "R&D or Buy" is an indicator variable equal to one if the firm is investing in R&D or in Buy strategies, but not on both, "Tangible goods" is an indicator variable equal to one if the gross investment in tangible goods is positive. The net exit rate is defined at the sector- and size- stratum where the firm is operating (see section 3.2) and is standardized over the whole period. The full list of controls is specified in section 4. Rho is the share of the overall variance explained by the firm-level unobserved fixed effect.

Table B13: Variable definitions

Variable	Description
any_inv	Dummy that takes value 1 if the firm has innovation inputs in t, 0 otherwise
r_n_d	Dummy that takes value 1 if the firm did internal R&D in t, 0 otherwise
buy	Dummy that takes value 1 if the firm purchased new embodied or disembodied technology or purchased external R&D in t, 0 otherwise
stdnetexit	Standardized net exit rate in t, by sector and size group
stdentry	Standardized exit rate in t, by sector and size group
stdexit	Standardized exit rate in t, by sector and size group
stdentry	Standardized exit rate in t, by sector and size group
q_size	Quartile in the size distribution in t, by sector
forsub	Dummy that takes value 1 if the firm is a subsidiary of a foreign multinational, 0 otherwise
employees	Logarithm of the number of employees in t-1
local	Dummy that takes value 1 if the firm sells in the local market from t-2 to t, 0 otherwise
national	Dummy that takes value 1 if the firm sells in the national market from t-2 to t, 0 otherwise
eumkt	Dummy that takes value 1 if the firm sells in any EU market from t-2 to t, 0 otherwise
othermkt	Dummy that takes value 1 if the firm sells in any other foreign market from t-2 to t, 0 otherwise
female	Percentage of female employees in t-1
patnum	Number of patent applications in t-1
lnhours	Logarithm of the industry total number of hours worked in t
lntaninvest	Logarithm of the industry total tangible investment in t
gr_profits	Growth rate of the industry total profits in t
cifra	Business sales in t