The role of the crisis in the export and R&D adoption and their intensity

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Abstract

The last financial and economic crisis may have had some consequences on the export and R&D adoption. The first aim of this paper is to shed more light on the factors driven the export and R&D adoption behaviour during this period, disentangling the effects of the dropping demand and the credit crunch. Besides the adoption of the strategies, the crisis may have also affected to the relationship between the intensity of them. Therefore, the second aim of the study is to analyse the effects upon the export and R&D intensity relationship. For this purpose, Spanish manufacturing data drawn from the *Survey of Business Strategies* for the period 2000-2014 are used. By using both a probabilistic and a Heckman sample selection model, the results suggest that access to external funds is an important factor explaining export adoption, while availability of internal funds seems to be important for R&D. Second, once controlled by financial factors, R&D adoption it is countercyclical. Third, export adoption is not explained by demand conditions. Finally, for the intensity analysis, export and R&D appear as persistent strategies and from 2008 onwards there was a positive effect from R&D intensity to export intensity but not the opposite, confirming the asymmetries in the complementarity gains between export and R&D during the crisis period.

1. INTRODUCTION

Exporting firms are more productive than domestic firms (Peters et al., 2015; Bernard and Jensen, 1999; Greenaway and Kneller, 2007; Wagner, 2007; Wagner, 2012; among others) and firms with R&D are drivers of innovation (Becheikh et al., 2006; De Jong and Vermeulen, 2007; Cohen and Levinthal 1989; among others). Therefore, exporter and R&D status are characteristics of the most innovative and productive firms that will drive the economy. Both theoretically and empirically it is widely accepted the positive association between R&D and exporting. Within the theoretical literature Constantini and Melitz (2008), Atkeson and Burstein (2010), and Long et al. (2011) are some of the studies showing how trade liberalization creates incentives for firms' R&D investment, but also how firms increase their expected profits from exporting by investing in R&D. In the empirical literature, Aw et al. (2011), Becker and Egger (2013), Bernard and Jensen (1997) and Roper and Love (2002), among others, show how investment in innovative activities increase the propensity to export. Bustos (2011), Aw, Roberts and Xu (2008), Atkeson and Burstein (2010) or Costantini and Melitz (2007) are some of the studies showing the positive impact of exports on R&D. However, this positive effect may be not symmetric and depend on exogenous shocks. Vicente-Chirivella and Battisti (2017) showed that during the crisis period, for a sample of Spanish manufacturing firms, the probability of engaging in export strategies increased but not that of R&D strategies, and also that the crisis reduced the probability that exporting firms embark on R&D strategies but not the probability that R&D firms embark on export. Even though the results of this study confirm the changes in the export/R&D adoption because of the crisis, nothing is said about the channels causing these switches. On the one hand, from 2008 onwards economies were hit by a very important credit crunch which, given the importance of sunk costs involved in these two strategies, it may have influenced the export and R&D adoption. On the other hand, firms suffered a dramatic decrease in the internal demand which may have forced them to sell abroad to survive, forgetting about the R&D investment.

The first aim of this study is to shed more light on the factors driven the export and R&D adoption behaviour during the crisis period, disentangling the effects of the dropping demand and credit crunch.

Besides the adoption of strategies, if one wants to have the whole picture about the consequences of the crisis upon export and R&D, the analysis should be done not only for the extensive margin (percentage of exporting/R&D firms), but also for the intensity of these activities. Improvements in learning capabilities (Cohen and Levinthal, 1990), need to expand their markets to reach the return level that justify the high costs incurred in R&D investment

(Zahra et al., 2000) and higher competitiveness of knowledge-intensive firms (Suárez-Porto and Guisando-González, 2014) are theoretical reasons defending the positive effect of R&D intensity on export intensity. Learning-by-exporting effects are behind the theoretical explanation of the positive effect of export intensity on R&D intensity (Grossman and Helpman; 1991, 1993). However, as occurred in the adoption decision, exogenous shocks may have some consequences upon the (possible) reinforcement between export and R&D intensity. Therefore, the second aim of this study is to analyse what happened during the crisis period with the relationship between the intensity of these two activities.

In the empirical analysis, first discrete choice models for dynamic panel data are used to identify the factors explaining the export and R&D behaviour during the crisis. These firms' decisions are characterized depending on firms' internal and external measures of financial constraints, demand conditions and other controls. The potential simultaneity in the two firms' decisions is taken into account through the estimation of a bivariate probit. To allow the individual effect to be correlated with the regressors and to solve the 'initial conditions problem', the Wooldridge (2005) approach is applied. Regarding the intensity analysis, to avoid the sample selection bias, the Heckman (1979) procedure estimated by maximum likelihood was applied.

The data used in this study come from the *Survey of Business Strategies* (ESEE hereafter) for the period 2000-2014. ESEE is an annual panel survey representative of Spanish manufacturing firms by industry and size categories. The final working sample consists of around 13,000 observations corresponding to 1,229 firms.

The main results can be summarized as follows. First, financial factors explain export and R&D behaviour during the crisis period. Interestingly, these financial factors were not the same for the export and R&D decisions. While access to external funds appears as an important factor explaining export adoption, availability of internal funds seems to be the important one for R&D. Second, once controlled by financial factors, R&D adoption presents a countercyclical behaviour. Third, demand conditions are not significant in explaining export adoption. This result highlights the relevance of access to finance to promote exporting activities. Fourth, export and R&D appear as persistent strategies also when the analysis is done within an intensity framework. Fifth, from 2008 onwards there exists a positive effect from R&D intensity to export intensity but not the opposite. This last result confirms the asymmetries in the complementarity gains between export and R&D during the crisis period found by Vicente-Chirivella and Battisti (2017) also for the intensity of these activities.

The rest of the paper is organized as follow. Section 2 summarises the related literature and introduce the main hypotheses. In Section 3, data, variables used in the study and some descriptive statistics are showed. Section 4 is devoted to explain the methodologies and present the estimates of the different models for the Spanish manufacturing firms, besides some robustness checks. Finally, Section 5 concludes.

2. RELATED LITERATURE AND HYPOTHESES

Financial constraints and demand conditions are two key aspects that may affect export and R&D adoption decisions. The world financial and economic crisis started in 2008 supposed both a dramatic decrease in the availability of funds to finance firms' investments, but also a great drop in the internal demand. These two exogenous shocks could have significantly influenced the adoption of export and R&D strategies but also the relationship between the intensity of them.

The first of these two shocks starting in 2008 was the dramatic credit crunch that the economy suffered. Both export and R&D activities involve important sunk costs (Roberts and Tybout, 1997) that should be taken into account in the analysis of the adoption decision. Exporting companies have to investigate competition and foreign demand, establish marketing and distribution channels and adjust the characteristics of the products to meet or comply with foreign legislation, as well as quality and security of other countries tastes (Roberts and Tybout, 1999). Moreover, the development of R&D may involve not only the creation of a R&D department, purchasing specific physical assets, hiring skilled labour, but also to collect information on new technologies, organizational changes and adjustments to new technologies (Máñez et al., 2009; Máñez et al., 2015, among others). These high sunk costs, together with the high fixed costs to remain in the activity, make liquidity very important for participation in international markets and innovative activities (Melitz, 2003; Bellone et al., 2010; Manova, 2013 and Aw et al., 2011).

Recently, some theoretical models of heterogeneous firms have incorporated financial drivers. The pioneer model is Chaney (2016)[1], followed by Muûls (2008) and Manova (2013).[2] Chaney (2016) added to the model of international trade with heterogeneous firms of Melitz (2003)

[1] The first working paper of this study was in 2005.

[2] See Egger and Kesina (2013) and Minetti and Zhu (2011) for a discussion of the theoretical models.

financial constraints, to conclude that they prevent some firms from exporting due to the fixed costs that this entails. If a firm is experiencing financial constraints, the extra costs to access foreign markets are not affordable and therefore only those firms with sufficient internal funds will be able to export.[3] Muûls (2008) incorporated external funding to the original model of Chaney (2016) to conclude, for Belgium manufacturing firms, that the lower the financial constraints that companies face, the higher the probability of exporting.[4] Besides, the author also find evidence supporting the idea that financial constraints not only have an effect on the extensive margin (percentage of exporting firms) but also upon the intensive margin (volume of exports). Finally, Manova (2013) showed that more constrained firms are less likely to participate in export markets, and in case they do, they export less. That is, financial constraints would affect both the decision to export and the amount exported by companies already exporting. The first empirical work analysing the link between financial constraints and exports, using firm-level data, was Greenaway, Guariglia and Kneller (2007). They find no evidence that firms enjoying better ex-ante financial health are more likely to start to export but they find that participation in export markets improves firms' ex-post financial health (in the case of continuous exporters, but no for starters).[5] Later on Wagner (2014b), using as a proxy for financial constraints credit rating of German manufacturing companies, finds that the higher the credit quality of the company (associated with less restriction on liquidity) the higher the likelihood that it exports, and the higher the share of exports in total sales.[6] Forlani (2010), using data from the balance sheets of Italian SMEs, builds two indexes measuring the short term and long term financial situation of a firm. Using these indexes, he predicts whether companies have difficulty obtaining external funding and, therefore, if they are financial constrained. The results showed that internal resources are an important factor for firms' internationalization, especially for those that are financial constrained. Further, Damijan and Kostevc (2011) argue that access to finance is crucial to start and boost exports (extensive margin), as well as it is particularly important for small firms to improve their intensive margin (number of products).

[3] According to the model, financial constraints are only binding for firms with intermediate productivity, since firms with high productivity will always generate enough internal funds to afford the sunk costs and for firms with low productivity exporting is not profitable.

[4] Bellone et al. (2010) obtain the same results for a sample of France manufacturing firms.

[5] One possible explanation to these results is that, in the sample they use, the average number of employees is more than 200 for non-exporters and more than 300 for exporting firms. That is, the sample contains a considerable share of large firms which are not the most likely to be affected by financial constraints.

[6] As the author pointed out, the results have to be taken with caution because smaller firms are underrepresented (as the credit-rating score is not available for these firms).

All in all, using different variables (and approaches) to measure internal and external financial constraints, liquidity constrained firms have more difficulties to start exporting. Wagner (2014) offers an exhaustive survey of the empirical works in the field.[7]The stylized fact is that *"financial constraints are important for the export decisions of firms: exporting firms are less financially constrained than non-exporting firms. Studies that look at the direction of this link usually report that less constrained firms self-select into exporting, but that exporting does not improve financial health of firms"* (Wagner, 2014, p. 1479).

Regarding R&D, because of information asymmetries (Brealey, Leland and Pyle, 1977), high sunk costs (Arrow, 1962) and lack of collaterals (Lev, 2001; and Berger and Udell, 1990), theoretical models have also predicted a negative effect of credit constraints on R&D adoption. The existence of imperfect capital markets hinders the uptake of funding by companies to carry out investments, especially if it comes to investment in R&D. As Arrow suggested in 1962, an additional difficulty to finance R&D is the appropriability of the returns of that investment. The inventors of new knowledge do not fully appropriate of the rents generated by R&D, since knowledge is a right of not exclusive consumption. Therefore, the returns to investments in knowledge are difficult to estimate, leading to greater difficulty in finding funds for that activity. In addition, there are many reasons, explained in what follows, that hinder access to external financing to meet the costs involved in R&D. In the first place, it should be noted that asymmetric information problems are more noticeable in R&D projects than in other more current investments. Such projects are usually very novel and, therefore, they are hardly understood by those who are not specialists in the field. As a result, those who must provide the funds for a project have many difficulties in calculating the probability of success. This situation may create moral hazard and adverse selection problems, as was suggested by Jensen and Meckling (1976) and Stiglitz and Weiss (1981). Secondly, the returns linked to high technology projects are highly uncertain as R&D projects have a low probability of success (Brealey, Leland and Pyle, 1977; and Carpenter and Petersen, 2002). Third, innovation investment generates a large number of intangible assets that cannot be used as collateral to the lender (Lev , 2000 ; Berger and Udell, 1990). Fifty per cent, or more, of expenditures on R&D are wages and salaries of highly skilled workers, and they generate some intangible assets which in the future will bring benefits to the company (Hall, 2002). However, at the time of carrying out investment, the collateral that the firm can offer is practically zero. Since the value of these projects are within the human capital if researchers decide to change companies or are made redundant, the project loses much of its

[7] 32 empirical studies that cover 14 different countries plus 5 multy-country studies.

value. Fourth, companies have no incentives to explain in detail its R&D projects, as they might be because of concerned about imitation by competitors (Bhattacharya and Ritter, 1983), which make more difficult to estimate the expected future profits. Finally, the fact that R&D projects are long-term investments make them more risky because when innovative companies are facing financial problems their market value, based on future options, quickly falls (Cornell and Shapiro, 1988).

Due to the reasons explained above one could expect a negative relationship between credit constraints and R&D. Moreover, due to the added difficulty of obtaining external financing to fund R&D, one might think that companies may prefer funding R&D through internal funds rather than external funds and, therefore, this type of investment would be more sensitive to internal funding measures such as cash flow. However, empirical studies show mixed results for both, internal and external financing measures. On the one hand, the early works in the field did not find any relationship between internal funds and R&D (Scherer, 1965; Mueller, 1967; and Elliott 1971).[8] On the other hand, Himmelberg and Petersen (1994), Mulkay, Hall and Mairesse (2001) and Hall (1992) found a positive and significant correlation between cash flow and investments in R&D. However, there exist a number of works that, although admitting a correlation between internal resources and investment in R&D, introduced some exceptions. Hao and Jaffe (1993) split the sample between small and large firms and concluded that financial constraints affect the former but not the latter. Similarly, Harhoff (1998) found a weak correlation for both small and large companies, although this effect does not appear significant when the Euler equation was used. Bond, Harhoff and Van Reenen (2005) argue that financial constraints may affect the decision to perform R&D but not to the level of it. They conclude that cash flow may be important for a company when deciding whether to invest in R&D in the UK but not for choosing the level of this investment. Finally, Brown, Fazzari and Petersen (2009), for a sample of high-tech companies, conclude that cash flow is relevant for young companies while having little impact on mature companies. Similarly to export works, in addition to the studies using cash flow as a proxy for external financial constraints, there are those that use a direct indicator built through survey data. Mancusi and Vezzulli (2014) for Italian SMEs, built a financial indicator using a question that asked firms if they would want additional funding to which they obtained, at the prevailing interest rate, with their main bank. Companies that answered affirmatively were considered financial constrained. The conclusion from this study was that financial constrained companies are less likely to engage in R&D projects. Savignac (2008),

[8] Himmelberg and Petersen (1994) argue that the results of these works are becasue in the sample they only considered large firms, which usually have more cash flow than they need to carry out such investments.

Hajivassiliou and Savignac (2011), Tiwari, Mohnen, Palm and Loeff (2007) and Efthyvoulou and Vahter (2016) also use data collected through a survey to construct a direct indicator to identify companies that are financial constrained. In the case of Savignac (2008) and Hajivassiliou and Savignac (2011) it was found that financial constraints reduce the likelihood of firms to undertake innovative activities. While in the case of Tiwari et al. (2007), the conclusion is that financial constraints affect the decision of how much spend on R&D. Finally, Efthyvoulou and Vahter (2016) studied the effects of financial constraints upon innovation success for 11 Western and Eastern European countries and found that financial constraints are strongly negatively related to innovation performance. Besides, they also conclude that lack of internal funds it is more important than limited access to external funds.[9] Aghion et al. (2012) defined financial constrained companies as those that appear in a list of the French banking system, in which companies have not been able to fulfil the obligations of a loan (defaulting companies), since these companies, a priori, will face more difficulties to get a loan in the future. Their findings suggest that the percentage of R&D investment on total investment is less countercyclical when companies are more financial constrained. [10]

Overall, in light of these results, unlike what was concluded for exports, the empirical evidence is ambiguous and far from conclusive.

The second exogenous shock that the Spanish economy suffered from 2008 onwards, which may have had some consequences on the export and R&D strategies, was the very important decline in the domestic demand. Traditionally, exports behaviour has been explained through two main drivers; the evolution of foreign demand and the evolution of the price competitiveness of the country. However, a growing number of studies have recently pointed out that such determinants are only able to explain part of the export performance (Fagan et al., 2005; di Mauro and Forster, 2008; Dieppe et al. 2012; Belke et al., 2014; Esteves and Rua, 2015). Belke et al. (2014) and Esteves and Rua (2015) are two studies supporting the domestic demand as one of the possible drivers of exports. The theoretical idea behind these papers is that, due to the limited production capacity of firms in the short-term, during periods of growing domestic demand, firms will work at full capacity and, therefore, will not be willing to pay the high sunk

[9] They also do the analysis differentiating between the prduction and services sectors and between exporters and non-exporters. Their results indicate that financial constraints have more pronounced negative effects in the production sector and for non-exporters.

[10] Although the mainstream, based on the opportunity cost theory, defend the countercyclicality of R&D investment, there are also alternative theoretical models that explain the procyclicality of R&D expenditure. For example, the empirical studies of Barlevy (2007) and Comin and Gertler (2006) found that R&D expenditures show a procyclical pattern. Aghion et al. (2010), Aghion et al. (2012), López-García et al. (2013) and Beneito et al. (2015) are also studies showing that when firms are credit constrained the counter cyclicality of R&D is reversed.

costs involved in exports. Nevertheless, when the economy is hit by a negative demand shock and firms are producing at very low capacities, the free resources may be used to increased their efforts towards international markets. After the negative shock, more firms will be willing to pay the sunk costs and substitute domestic sales by exports, since the costs of excess capacity would be higher than the entry costs and the low expectations for the domestic demand may push firms to export as the only way to survive. The same idea applies to incumbent exporters. Under unfavourable internal economic conditions, exporter firms will remain in international markets to avoid repaying the entry costs (Máñez et al., 2008; Bernard and Jensen, 2004; Campa, 2004; among others). Empirical studies have already supported this negative relationship between internal demand and exports. Esteves and Rua (2015) found a negative link between the lagged domestic demand developments and export performance for the Portuguese economy. They also found an asymmetric effect depending on the cycle, being stronger when domestic demand declines. In the same vein, Belke et al. (2014), using firm-level data for Spain, Portugal, Italy, France, Ireland and Greece, conclude that domestic demand is relevant for the dynamics of exports, especially for Spain, Portugal and Italy, and more significant during more extreme stages of the business cycle.[11] Despite the results of the studies mentioned above, a positive correlation between domestic and exports sales is also plausible. Two are the main channels which could cause this positive effect. First, international trade allows firms to get in touch with new technologies, processes or techniques not available in their home markets, expanding firms' capabilities (Álvarez and Robertson, 2004).[12]These efficiency improvements will positively affect both export, but also domestic sales. Second, the increase in international sales will improve the financial situation of the firm generating higher cash flow that may be used to finance domestic operations (Berman et al. 2015).

Considering the above results one can conclude that internal demand conditions is one of the factors that could determine the strategic decision of firms to export, although it is not clear enough whether this relationship is positive or negative. At the same time, and given the importance of liquidity for start exporting, the effects of internal demand upon export adoption may be weak or even insignificant during credit constraints periods.

[11] Ahn and McQuoid (2012), Soderbery (2014) and Blum et al. (2011) are studies finding this negative link between domestic and export sales using firm-level data for countries outside Europe.

[12] This new knowledge acquired by the firm because of its export activity has been labelled "learning-by-exporting" and it has been widely studied in the applied industrial organization research. See for example Golovko and Valentini (2014), Love, Roper and Vahter (2014), Álvarez and Robertson (2004), Salomon and Shaver (2005) or Salomon and Jin (2008).

With regards to the effects of the business cycle upon R&D, although the mainstream defends the countercyclicality of R&D, there are also studies showing the procyclicality of R&D investments. The arguments for R&D spending to be countercyclical rest on two main ideas. First, the opportunity cost theory (Hall, 1991; Aghion and Saint-Paul, 1998) states that firms can allocate their resources to current production or to productivity-enhancing activities (R&D). Therefore, during expansive cycles (characterized by a strong demand) devote resources to R&D activities would mean detracting resources from current production, which would imply high opportunity costs for firms. That is the reason why during growth periods it will be optimal for firms use their resources to current production, while during recessions, given the decrease in the opportunity costs of R&D, will be optimal allocate these resources to R&D activities. Second, according to the Schumpeterian view of business cycles, recessions give the opportunity to the market for correcting inefficiencies and for encouraging firms to reorganize and innovate (Schumpeter 1939). However, these two mechanisms imply that firms can borrow funds for innovation unlimitedly, and that may not be the case during a period where firms are facing credit constraints. When external financing is limited, firms can only financing innovation projects through cash flows, which during recessions usually decrease. Therefore, during downturns credit constrained firms may follow a procyclical R&D investment pattern. Empirical studies at the firm level as Aghion et al. (2012), for a sample of French firms, or López-García et al. (2013), for a sample of Spanish firms, have corroborated the procyclicality of R&D investment for credit constrained firms.[13] Beneito et al. (2015) also find this prociclicality for credit constrained firms, but this effect is alleviated in family owned firms and in firms that are group-affiliated.

Considering the works mentioned above, it seems that empirical evidence is still not conclusive and the procyclicality or countercyclicality of R&D may depend not only on the cycle but also on the availability of funds.

After reviewing the theoretical and empirical research in the field four are the main conclusions. First, due to the added difficulty on obtaining external financing to fund R&D (even more during a period of scarce funds in the economy) this type of investment should be only sensitive to internal funding. Thus, because during the crisis firms' internal funds dramatically decreased the following hypothesis is formulated:

HYPOTHESIS 1: Cash flow significantly affected to the decrease in R&D adoption.

[13] Ouyang (2011) also finds this procyclical pattern of R&D at the industry level for a panel of twenty U.S. manufacturing industries during the period 1958-1998.

Second, from 2008 onwards the percentage of exporting firms importantly increased, however due to the important sunk costs involved for participating in international markets, access to external funds should help to this internationalisation. Therefore:

HYPOTHESIS 2: From 2008 onwards the probability of exporting was higher for firms with higher access to external funds.

Third, given that the procyclicality of R&D may be caused by financial factors, once we control for these factors, R&D should be countercyclical. Therefore:

HYPOTHESIS 3: During the crisis period R&D adoption followed a countercyclical pattern.

Finally, even if during the crisis period firms may be producing at very low capacities, without access to external funds internationalisation is not possible. Therefore:

HYPOTHESIS 4: During the crisis period demand conditions did not explain export adoption.

The second part of the paper aims to analyse the synergies between export and R&D. Research in the field have generally followed two strategies to study these synergies. First, evaluate the effects on the likelihood of adoption of one strategy given that the other strategy was already adopted (Esteve-Pérez and Rodríguez, 2013; Vicente-Chirivella and Batistti, 2017). Second, evaluate the complementarity effects of export and R&D on performance, either sales or productivity growth (Golovko and Valentini, 2011; Aw et al., 2007; Peters et al., 2015). Differently from these studies, in the present paper the analysis of the (possible) reinforcement between export and R&D will be done through the effects on the intensity of these activities. That is, how the intensity of R&D affects to the intensity of export and vice versa.

Both from a theoretical but also from an empirical point of view it is widely accepted the positive effect of R&D in export and vice versa. On the one hand, investment in R&D increase the propensity to export (Aw et al., 2011; Becker and Egger, 2013; Bernard and Jensen, 1997 and Roper and Love, 2002) as the introduction of a successful innovation may boost productivity growth (Crépon and Duget, 1997; Verspagen, 1997, Gu and Tang, 2004; Huergo and Jaumandreu, 2004; Parisi et al., 2006; Rochina-Barrachina et al., 2010; Máñez et al., 2009), and this improvement in productivity allows firms to *self-select* into international markets (Greenaway and Kneller, 2007; Wagner, 2007; Delgado et al., 2002 or Máñez et al., 2005). At the same time, and independently of the increase in productivity, the novel (or better quality) product developed can increase the foreign demand pushing the firm to internationalisation by selling this good abroad (Hitt, Hoskisson and Kim, 1997). On the other hand, as mentioned before, international trade promotes firms' learning and, thus, positively contribute to the returns of the R&D investments. Acknowledging this positive effect between the two strategies, a key aspect in this relationship is how affect the intensity of R&D to the intensity of export and vice versa. From a theoretical point of view three are the main reasons that justify a positive

effect of R&D intensity on export intensity. As suggested by Cohen and Levinthal (1990), investment in R&D is an important process that expands organizational knowledge and learning capabilities over time. Therefore, internationalisation may be driven by the firm's efforts to leverage its improvements in organizational knowledge and learning capabilities (Dunning, 1993; Kotha et al., 2001; Lu and Beamish, 2001). The higher the R&D investment the greater the organizational knowledge and learning capabilities improvements, factors that may drive not only internationalisation, but also international expansion by increasing exporting as the proportion of total sales (Eriksson et al., 1997). Second, since investment in knowledge is an expensive strategy, knowledge-intensive firms may need to expand their markets in order to reach the return level that justify the high costs incurred (Zahra et al., 2000). Finally, because of the better capabilities and efficiency of knowledge-intensive firms, they will be more competitive and therefore will reach better results in international markets (Suárez-Porto and Guisando-González, 2014). Considering the learning-by-exporting effects, it can also be argued that the export intensity influences the R&D intensity. Theories of *endogenous innovation and growth* (Romer, 1990; Grossman and Helpman, 1991; Young, 1991 or Aghion and Howitt, 1998) are consistent with the concept of learning-by-exporting. Firms operating abroad are exposed to a richer source of knowledge compared with those that only operate nationally. This new knowledge acquired beyond the national borders enhance firm's capabilities and therefore can foster increased R&D investment within firms. The higher the export intensity the greater the contact with new knowledge and, thus, the higher the R&D intensity. Hobday (1995) using a technology-gap model shows that innovation rates are accelerated by firm's exporting activities. Despite these arguments, a key aspect which will allow firms to take advantage of the positive learning-by-exporting effects is that firms must possess sufficiently advanced internal R&D allowing them to absorb the new knowledge (Griffith et al., 2004; Cohen and Levinthal, 1990). If this is not the case, these positive effects may either not arise or even be negative for the R&D intensity, creating a substitution effect.

Empirical evidence in the field is still far from conclusive though. Filatotchev and Piesse (2009) analyse the effects of R&D intensity upon export intensity for new listed firms in 4 European countries and found that R&D intensity is an important antecedent factor for internationalisation of sales and vice versa. However, they run a simple Granger test to verify the direction of causality and find that if R&D expenditures are increased by 1%, there is an expected increase in international sales of 1.3%. While, if international sales are increased by 1%, R&D expenditures increase by only 0.005%. They conclude then that causality runs from R&D expenditures to internationalisation, and not the other way round. Barrios et al. (2003)

using Spanish data found that firms export more the higher their R&D intensity and, also, that this effect is greater when firms are exporting to EU/OECD countries.[14]A part from the studies using R&D intensity, there also exists works proxying *innovation intensity* by other variables. Sterlacchini (2001) in a study for Italian manufacturing firms, use the percentage of R&D employees and find a positive effect upon export shares. Lachenmaier and Wößmann (2006) in a cross section study for German manufacturing firms, apply a Tobit specification with instrumental variables and found that the innovation expenditure positively affects to the export share. However, we can also find studies that find not significant effects between the intensity of the two strategies. Aw et al. (2007), using a panel dataset for Taiwanese electronics industry, found no significant effects neither from R&D intensity to export intensity nor the other way round. The same not significant effect is found by Girma et al. (2008) for their study using British and Irish firms. Becchetti and Rossi (2000) for Italian firms find that R&D intensity increases neither the probability of being an exporter nor the share of exports on sales.

Wagner (2007) offers an exhaustive survey of empirical works analysing the relationship between exports and productivity and concludes that evidence regarding learning-by-exporting is mixed and therefore not conclusive. Therefore, more research needs to be done to understand the relationship between export and R&D intensity and whether the effects from export to R&D are the same than from R&D to export. Vicente-Chirivella and Battisti (2017) show that during the crisis period the probability of engaging in export strategies increased but not that of R&D strategies, and also that the crisis reduced the probability that exporting firms embark on R&D strategies but not the probability that R&D firms embark on export. That is, there was an asymmetry in the sequential adoption between export and R&D. The same may occur with the intensity of these activities. Consequently, the following hypothesis is formulated:

HYPOTHESIS 5: During the crisis period R&D intensity positively affected export intensity but not the opposite.

3. DATA AND DESCRIPTIVES

For this study yearly data from the *Survey of Business Strategies* (ESEE) are used. ESEE is an annual panel survey representative of Spanish manufacturing firms by industry and size

[14] The theory behind the higher effect for EU/OECD countries is that in order to be able to compete in those countries firms should improve first their own technology, while exporting to less advanced countries would not be that challenge because firms will not need to improve their own technology in advance.

categories. The sample analysed in this study covers the period 2000-2014. This dataset provides exhaustive information at the firm level on: firm's activity; sales; R&D expenditure; demand conditions; foreign trade; and accounting data. ESEE excluded firms with less than 10 employees. Firms with 10 to 200 employees were randomly sampled, holding around 5% of the population in the first year that the survey was carried out. All firms with more than 200 employees were requested to participate, obtaining a participation rate around 70% during the first year. To minimise attrition, new firms with the same sampling criteria as in the base year have been annually incorporated, so that the sample of firms remains representative over time.[15]

Sampling out those firms' observations that fail to supply relevant information about all the variables involved in the analysis the final sample used in this paper consists of around 13,000 observations corresponding to 1,229 firms. As the first year of the sample is needed to set up the variables solving the initial conditions problem and the explanatory variables are lagged one period, the estimation is carried out for the period 2002-2014.

The dependent variables in this paper are *Export, R&D, Export intensity* and *R&D intensity*. The former has been defined as a dummy variable that takes on value 1 for firms that have exported during the current year. The same procedure was followed to set up the R&D variable. Regarding export and R&D intensity, the former is the value of exports over total sales. While the latter is defined as the total R&D expenses over total sales. Among the explanatory variables, demand conditions and internal and external constraints are those of most interest in this study. To measure the demand conditions two dummy variables were built. *Expansive demand*, that takes on value 1 for firms declaring to face an expansive demand, and *Recessive demand*, taking on value one for firms declaring to face a recessive demand.[16]As can be seen in Figure 1 the percentage of firms declaring to face a recessive demand dramatically increased from 2008 onwards (which coincides with the beginning of the financial and economic crisis).

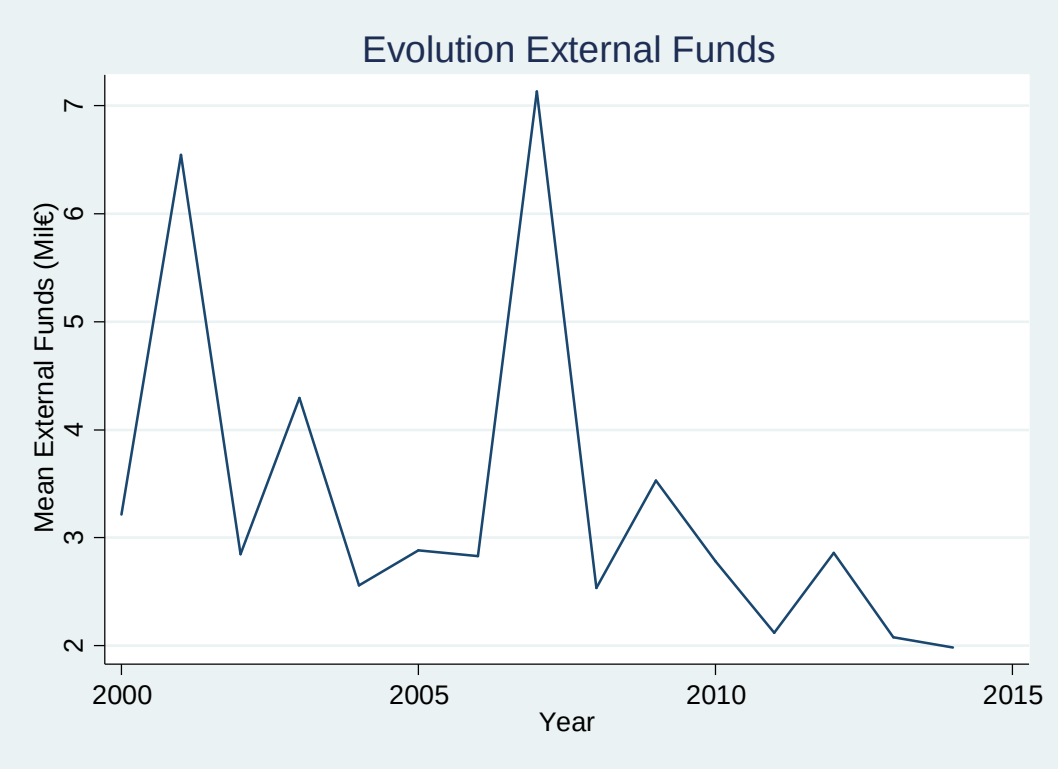
[15] See https://www.fundacionsepi.es/investigacion/esee/spresentacion.asp for further details.

[16] The baseline case are firms declaring a stable demand.

Figure1- Evolution percentage of firms declaring facing a recessive demand

With regards to the financial situation, in Spain bank loans are the most common form of external financing for firms and constitute the bulk of firms' financial debt (Schiantarelli and Sembenelli, 2000). Reason why in this paper it has been considered that one of the most relevant variables when analysing liquidity constraints is the financial volume borrowed by firms. Following Beneito et al. (2015), using company's balance sheet information, a variable is constructed that aims to measure the access to external funding by firms (*External funds*). First, the volume of firms' new long-term debt is calculated as debts the firm has borrowed in a given year both from banks and from other long-term lenders. Then, to avoid contamination from changing macroeconomic policies, in the link between the volume of debt and tighter financial constraints, in the estimation specifications the financial volume variable will be introduced as the deviation of the current firm's borrowed volume with respect to the average volume borrowed by manufacturing firms in the same year, industry and size. Positive values of this variable would correspond to firms that may have access to higher volumes of external debt and, therefore, are less external constrained. Figure 2 shows the evolution of access to external funds during the period analysed.

Figure2- Evolution of acceess to external funds



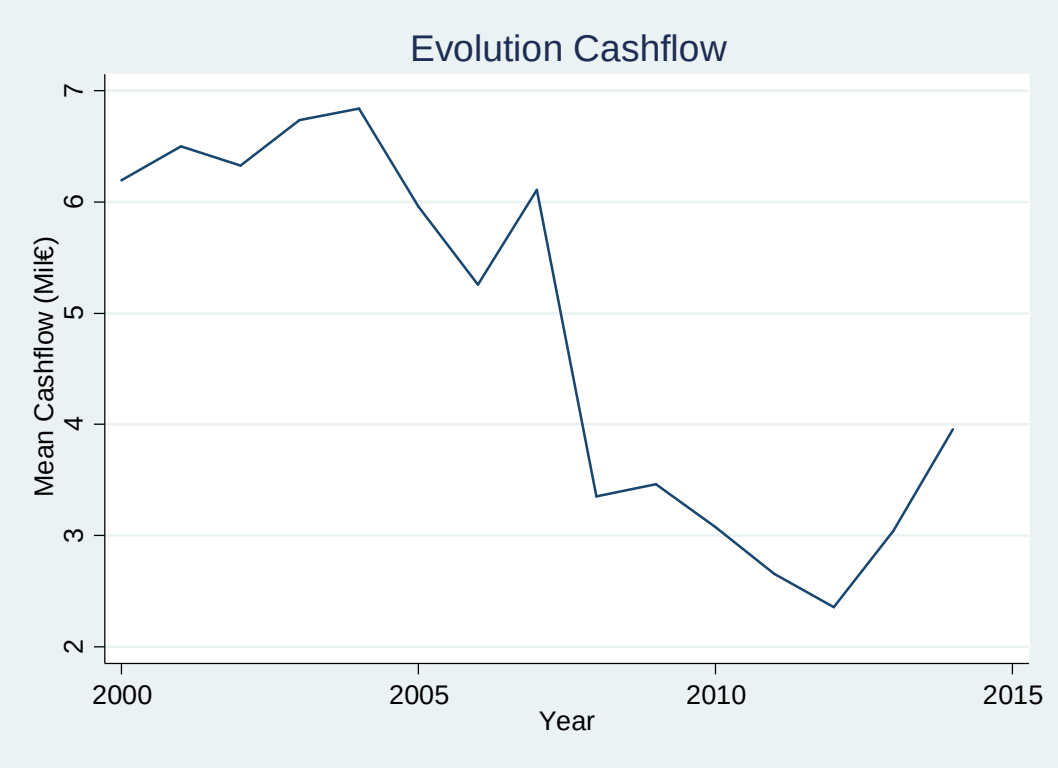
When a company does not have access to external financing, internal funds may be of great importance in order to carry out its investments. Therefore, cash flow is the second measure used in this study to capture internal financial constraints (*Cash flow*). Many studies have used cash flow-related measures as proxies for internal financial constraints. Manole and Spatareanu (2010) and Buch et al. (2010) use cash flow as an internal restriction measure. Stiebale (2011), Ito and Terada-Hagiwara (2011) and Berman and Héricourt (2010) are also works that use the cash-flow ratio on assets, or capital, as a measure of internal restrictions of companies. Bellone et al. (2010) construct an index to measure financial constraints and among the variables, the ability of companies to generate cash flow is used.[17]

For this work, the cash flow of each company and year is obtained as firm's sales minus the sum of purchases, external services, and labour costs. Then, this variable is expressed in real terms, using an industrial price index to deflate cash flow in nominal terms. The next step is to calculate the average of cash flow per sector and year. Finally, the deviation with respect to the average by sector and year is obtained. Thus, negative values should correspond to firms facing tight

[17] Other studies using cash flow (or its asset ratio) as a measure of firms' internal financing are, among others, Himmelberg y Petersen (1994), Ughetto (2008), Brown et al. (2009), and Hutchinson y Xavier (2006).

internal financial constraints; while positive values should correspond to firms with a large availability of internal funds. Figure 3 shows the evolution of cash flow.

Figure3- Evolution of cash flow



Since positive sign of both *External funds* and *Cash flow* corresponds to firms with a large availability of external or internal funds, a positive sign for the estimate of these two variables is expected.

Table 1 presents descriptive statistics for both dependent variables and the main explanatory variables involved in the study for the whole period, before the crisis and during the crisis. The two exogenous shocks mentioned above are clearly unambiguous comparing column 2 and 3. Both internal (cash flow) and external funds importantly decrease during the crisis period. Furthermore, the percentage of firms declaring facing a recessive demand dramatically increased from almost 19% before the crisis to more than 45% during the crisis period. Regarding export and R&D strategies, there were also significant changes both in the extensive but also in the intensive margin (mainly for export). The percentage of R&D firms remained practically steady before and during the crisis, with a difference of 2 percentage points. The same applies for the intensity of R&D. However, in the case of exporters, the increase in this percentage was more than 4 percentage points during the crisis and the export intensity notably increased too.

Table1-MEAN AND STANDARD DEVIATION

VARIABLES	Whole period	Pre-crisis	Crisis
Cash flow	5.91 (25.89)	7.48 (29.46)	4.63 (22.50)
External funds	3.37 (82.72)	4.52 (118.54)	2.44 (31.24)
% Recesive demand	33.36 (15.36)	18.90 (2.46)	45.13 (10.71)
% R&D firms	35.46 (1.37)	36.42 (1.30)	34.66 (0.81)
% Exporting firms	65.94 (3.38)	63.33 (1.06)	67.91 (3.19)
R&D intensity	0.63 (2.05)	0.63 (2.35)	0.64 (1.76)
R&D intensity for exporters	1.04 (2.92)	0.98 (2.73)	1.10 (3.10)
R&D intensity for non-exporters	0.24 (1.66)	0.25 (1.45)	0.22 (1.88)
Export intensity	21.04 (27.69)	18.96 (26.03)	22.72 (28.86)
Export intensity for R&D firms	34.52 (29.42)	32.28 (28.28)	37.08 (30.46)
Export intensity for non-R&D firms	13.26 (23.16)	11.54 (21.35)	15.07 (24.80)
Observations	12,999	5,832	7,167

Notes:
Cash flow and External funds are in millions of € and deflated by the producer price index
Standard deviations in parentheses

Besides the demand and financial variables, a number of variables commonly used in the related literature are also employed as controls. It still remains controversial whether market power encourages or inhibits firms from embarking on R&D activities and internationalisation. To capture the degree of competition, two variables are introduced in estimation. *Market share*, measuring the firm's market share in its main market. And a set of dummy variables capturing the number of competitors with significant market share in the firms' main market: 10 or less competitors, from 11 to 25 competitors, more than 25 competitors, and atomistic market, this latter for firms declaring having no competitors with significant market share *(Number of competitors 0–10, Number of competitors 10–25 and Number of competitors >25,* being atomistic the baseline). One more control variable used in this study is *Size* (measured as the logarithm in the number of employees). Large firms usually have larger internal funds than SMEs, and have better access to financial markets (Damijan and Kostevc, 2011). Moreover, SME's are usually more risk averse, which may make them to refuse taking external debt to finance exporting or innovation ventures.[18] Finally, large firms may enjoy economies of scale, which would allow them to increase the profitability of export and innovative activities. For all these reasons, a positive effect of size on the probability of export and/or performing R&D is expected. A variable measuring the good performers (*Labour productivity*) is also included as a control variable. If the self-selection hypothesis holds, those firms which have a better

[18] As can be seen in Bernard et al. (2007, 2009), Eaton et al. (2008), and Damijan et al. (2010), while large firms usually export to many countries and a large number of products, small firms usually only export to one or two countries and a small number of products, being then more vulnerable to foreign market failure.

performance should be more likely to export (perform R&D). *Foreign* participation is also included as control variable. Finally, export and R&D activities involve important sunk costs that should be taken into account in the analysis of the decision to export (performing R&D). Because of the lack of a direct measure of sunk costs, the lagged export and R&D status in the respective choice equations have been used as a proxy of sunk costs. Industry and year dummies are used in all regressions.

Table 2 provides detailed information on all the variables involved in the estimations.

Table 2- Variables definiton

Export	Dummy variable taking value 1 if the firm exports, and 0 otherwise
R&D	Dummy variable taking value 1 if the firm invests in R&D, and 0 otherwise
Export intensity	Value of exports over total sales
R&D intensity	Total expenses in R&D over total sales
External funds	Firms' volume of new long-term debt with respect to the average volume borrowed by manufacturing firms in the same year, industry and size.
Internal funds	Firms' Cash-Flow with respect to the average by industry and year
Expansive demand	Dummy variable taking value 1 if the firm declares to face an expansive demand
Recessive demand	Dummy variable taking value 1 if the firm declares to face a recessive demand
Market share	The firm's market share in its main market (in %).
Number of competitors 0–10	Dummy variable taking value 1 if the firm asserts to have less than (or equal to) 10 competitors with significant market share in its main market, and 0 otherwise
Number of competitors 10–25	Dummy variable taking value 1 if the firm asserts to have more than 10 and less than (or equal to) 25 competitors with significant market share in its main market, and 0 otherwise
Number of competitors >25	Dummy variable taking value 1 if the firm asserts to have more than 25 competitors with significant market share in its main market, and 0 otherwise
Size	Log of the number of the firm's employees.
Labour productivity	Output per employee.
Foreign	Dummy variable taking value 1 if the firm's capital is participated by a foreign enterprise.
Public sales	Dummy variable taking value one if more than 25% of firm sales go to the public sector and zero otherwise
High skill labour	Proportion of engineers and graduates in the firm's labour force.
Med skill labour	Proportion of technical engineers, experts and qualified assistants in the firm's labour force.
Appropriability	Ratio of the total number of patents over the total number of firms that assert to have achieved innovations in the firms industrial sector (20 sectors of the two-digit NACE-93 classification) (in %)

Age	Log of the number of years since the firm was born.
Year dummies	Dummy variables taking value 1 for the corresponding year, and 0 otherwise
Industry dummies	Industry dummies accounting for 20 industrial sectors of the NACE-93 classification

4. ESTIMATION RESULTS

4.1 Empirical model

To test the influence of credit constraints and demand conditions upon the decision of embarking on R&D and/or export strategies by firm i in time t during the different years of the crisis period, discrete choice models for panel data are employed. The equation for these models is as follow:

$$Y_{it}^{*j} = \beta X'_{it} + u_{it}^{j} \ (1)$$

where the dependent variable (Y^{*j}_{it}) is a latent (unobservable) variable representing the increase in the relative discounted utility derived from adopting each one strategy j = Export, R&D and X_{it} is a vector of explanatory factors. As this variable is unobservable, the dependent variable is proxied by a binary variable (y^{j}_{it}) that takes value one if the relative utility associated to the strategy is positive, namely:

y^{j}_{it} =1 if Y^{*j}_{it} >0

y^{j}_{it} =0 if Y^{*j}_{it} <0

By using a probabilistic approach, it is tested if the demand and financial variables have any impact on the likelihood of adoption of the strategy under consideration. In particular, to test whether the financial and economic crisis has had any effect on the export and R&D decisions, through demand and financial conditions, the baseline specification is sequentially estimated by including interaction terms between the financial constraints and demand conditions variables and 6 different time dummies. A dummy variable that takes on value 1 for years beyond 2008, a dummy year that takes on value 1 for years beyond 2009. The same procedure is followed for years beyond 2010, 2011,2012 and 2013. In that way, it can more precisely be estimated how demand conditions and financial constraints have affected to export and R&D decisions during the different years of the crisis.

The model is estimated by maximum likelihood assuming a Normal non-linear cumulative distribution function as well as random effects. Although the fixed effect model would have had the advantage of allowing the explanatory variables to be correlated with the individual effects, it would have had the shortcoming of eliminating a large number of observations. To allow the

individual effect to be correlated with the regressors and to solve the 'initial conditions problem', the Wooldridge (2005) approach is applied.[19] Following this method, the unobserved individual effects (α_i) is conditioned on the initial values of the dependent variable (y_{i1}) and the individual mean of the time-varying covariates ($\bar{x}_i$), allowing for correlation between the individual effect and the observed characteristics:

$$\alpha_i = \alpha_0 + \alpha_1 y_{i1} + \alpha_2 \bar{x}_i + a_i$$

and therefore:

$$y_{i,t}^{j} \begin{cases} 1 \; if \; \theta_0^j y_{it-1}^J + \theta_1^j y_{it-1}^r + \beta^j X_{it-1} + \gamma^j Z_{it-1} + \omega DC + \delta^j Q_{it-1} + \\ \alpha_0 + \alpha_1 y_{i1} + \alpha_2 \bar{x}_i + a_i + \mu_t + S_i + u_{it}^j \geq 0 \\ 0 \; Otherwise \end{cases} \quad (2)$$

where θ_0 identifies the significance of the sunk costs, $\theta_1$accounts for firms' expected profits from exporting to be affected by firms' R&D decisions and vice versa, X_{it-1} is a vector of variables controlling for firms' internal and external financial constraints and demand conditions, $Z_{it-1}$is a vector of control variables, ω identifies the overall crisis effects, δ the differential effects of the financial and demand conditions variables during the different years of the crisis, plus the usual vector of year (μ_t) and industry dummies (S_i) and u_{it} is the error term. Moreover, due to interdependences in the export and R&D decisions the error terms of the two equations are likely to be correlated. Hence, following Battisti et al. (2015) a bivariate probit that is estimated via the maximum likelihood is used. The resulting latent bivariate model is specified as:

$$\begin{cases} y_{i,t}^{Export} = \theta_0^{Export} y_{i,t-1}^{Export} + \theta_1^{Export} y_{i,t-1}^{R\&D} + \beta^{Export} X_{it-1} + \gamma^{Export} Z_{it-1} + \omega DC + \delta^{Export} Q_{it-1} + \\ \alpha_i + \mu_t + S_i + u_{it}^{Export} \quad (3a) \\ y_{i,t}^{R\&D} = \theta_0^{R\&D} y_{i,t-1}^{R\&D} + \theta_1^{R\&D} y_{i,t-1}^{Export} + \beta^{R\&D} X_{it-1} + \gamma^{R\&D} Z_{it-1} + \omega DC + \delta^{R\&D} Q_{it-1} + \\ \alpha_i + \mu_t + S_i + u_{it}^{R\&D} \quad (3b) \end{cases}$$

As mentioned above the second aim of this paper is analysing the (possible) reinforcement between export and R&D intensity, especially during the crisis period. Methodologically, one concern that arises when the objective is to examine the effects on export and/or R&D intensity

[19] The initial conditions problem arises when the first observation for each firm in a panel does not coincide with the first year of this firm. That is, when we do not have information about firms from the very beginning. Since the first observation for each firm is affected by the same process that will affect the variable from the first year of the observation period, this variable would be endogenous.

is the sample selection bias. To solve this problem, the Heckman (1979) sample selection bias model was applied. That is, first the probability of exporting/performing R&D is estimated, and then, for those firms exporting/performing R&D, the intensity of these strategies is calculated. The two equations are:

$$y_{i,t}^{j} = \beta X_{it}^{'} + u_{it}^{j} \qquad (4a)$$

$$d_{i,t}^{j} = 1\left\{\gamma w_{it}^{'} + \varepsilon_{it}^{j} > 0\right\} \qquad (4b)$$

Equation $4a$ is the interest equation and equation $4b$ is the participation equation.[20]

4.2 Results

The first aim of this study is to analyse the importance of financial constraints and demand conditions upon export and R&D adoption decisions during the crisis period. To start with, the significance of financial and demand variables is tested over the whole period. As can be seen in column 1 and 2 in Table 3, within the financial constraints and the demand measures only cash flow is significant for the R&D decision. Furthermore, as was found by Vicente-Chirivella and Battisti (2017), export and R&D are persistent strategies (see $Export_{t-1}$ in column 1 and $R\&D_{t-1}$ in column 2) and sequential adoption is highly significant both in the export and in the R&D decision adoption (see $Export_{t-1}$ in column 2 and $R\&D_{t-1}$ in column 1).

To analyse how financial constraints and demand conditions have affected to the probability of export/R&D adoption strategies during the various years of the crisis period, six crisis dummy variables were set up. The first crisis dummy variable takes on value 1 for years beyond 2008. The second crisis dummy variable takes on value 1 for years beyond 2009. The other 4 crisis dummy variables were set up in the same way for years 2010, 2011, 2012 and 2013. In this way, the crisis effects for the different years of the crisis can be evaluated. Besides the overall effects of the crisis on export/R&D adoption decision, the 'extra' effect of financial constraints and demand conditions on the probability of exporting/performing R&D was also tested. In this case, 4 interaction terms between the various crisis dummy variables and the financial and demand conditions variables were introduced in the model. For example, the variable 'Internal crisis08' picks up the 'extra' effect of internal financial constraint variable upon export and R&D decisions from 2008 onwards. The variable 'Expansive demand crisis09' picks up the 'extra' effect of being a firm with an expansive demand on the export/R&D probability from 2009 onwards, etc. The main conclusions from these regressions are as follow. First, regardless the analysis is done from

[20] The explanatory variables included in the participation and interest equation are the same included in the bivariate probit, with the only difference that in the interest equation the lagged export and R&D status is substituted by the lagged export and R&D intensity.

2008 onwards, from 2009 onwards, etc. the crisis positively affected to the likelihood of exporting (see *Crisis* in columns 3, 5, 7, 9, 11 and 13). The same result was found in Vicente-Chirivella and Battisti (2017). Second, cash flow always positively affects to the probability of performing R&D, but there is not an extra effect because of the crisis. Third, from 2009 onwards the interaction term between the crisis and the external financial constraint variable it is always positive and significant. This result would indicate that, even though when the analysis is done for the whole period this variable is not significant, because of the crisis firms with higher volume of new long-term debt with respect to the average volume borrowed by manufacturing firms in the same year, industry and size, have a higher probability of exporting. In other words, the probability of exporting it is higher for firms less external financial constrained (see *External crisis* in columns 5, 7, 9, 11 and 13).[21]Finally, regarding the demand variables, during three consecutive years of the crisis (2009, 2010 and 2011) firms facing an expansive demand had a lower probability of performing R&D. This result would be in line with the countercyclicality of R&D. Besides the demand and financial constraints results, the persistence and sequential adoption of export and R&D are also fulfilled in these regressions (see $Export_{t-1}$ and $R\&D_{t-1}$).

[21] This result is reinforced some years of the crisis due to the negative effect of External crisis on the R&D likelihood (years 2008, 2009 and 2011).

Table 3

	BIPROBIT WOOLDRIDGE (2005)													
VARIABLES	(Export) Whole period	(R&D) Whole period	(Export) 2008	(R&D) 2008	(Export) 2009	(R&D) 2009	(Export) 2010	(R&D) 2010	(Export) 2011	(R&D) 2011	(Export) 2012	(R&D) 2012	(Export) 2013	(R&D) 2013
Export $_{t-1}$	2.683***	0.248***	2.675***	0.244***	2.670***	0.247***	2.670***	0.245***	2.673***	0.247***	2.668***	0.241***	2.673***	0.241***
	(0.0657)	(0.0752)	(0.0658)	(0.0752)	(0.0658)	(0.0754)	(0.0659)	(0.0755)	(0.0658)	(0.0753)	(0.0659)	(0.0751)	(0.0660)	(0.0748)
R&D $_{t-1}$	0.182***	2.276***	0.183***	2.255***	0.178**	2.253***	0.175**	2.251***	0.174**	2.253***	0.184***	2.256***	0.183***	2.255***
	(0.0702)	(0.0494)	(0.0697)	(0.0492)	(0.0697)	(0.0491)	(0.0699)	(0.0491)	(0.0698)	(0.0491)	(0.0699)	(0.0491)	(0.0698)	(0.0491)
Cash-Flow $_{t-1}$	-0.0181	0.0582***	-0.0372	0.0503**	-0.0314	0.0535**	-0.0219	0.0553**	-0.0147	0.0535**	-0.0217	0.0571***	-0.0244	0.0616***
	(0.0258)	(0.0204)	(0.0283)	(0.0235)	(0.0272)	(0.0226)	(0.0272)	(0.0221)	(0.0264)	(0.0220)	(0.0258)	(0.0213)	(0.0257)	(0.0210)
External funds $_{t-1}$	0.000938	0.000652	0.00108	0.00303*	-2.55e-05	0.00199*	-6.69e-05	0.00126	7.25e-05	0.00146	0.000385	0.000668	0.000420	0.000573
	(0.00181)	(0.000665)	(0.00199)	(0.00176)	(0.00169)	(0.00120)	(0.00161)	(0.00107)	(0.00169)	(0.00107)	(0.00182)	(0.000671)	(0.00183)	(0.000664)
Expansive demand $_{t-1}$	0.105	-0.0499	0.113	0.000148	0.132	0.0156	0.123	0.0177	0.117	-0.00102	0.126	-0.0287	0.127	-0.0350
	(0.0745)	(0.0554)	(0.0922)	(0.0685)	(0.0863)	(0.0646)	(0.0836)	(0.0628)	(0.0821)	(0.0618)	(0.0797)	(0.0595)	(0.0781)	(0.0579)
Recessive demand $_{t-1}$	0.0140	-0.0314	0.0907	0.0980	0.108	0.0234	0.0347	-0.0118	0.00716	0.00658	0.0349	0.00234	0.0325	-0.0124
	(0.0638)	(0.0555)	(0.0980)	(0.0803)	(0.0859)	(0.0718)	(0.0790)	(0.0655)	(0.0717)	(0.0612)	(0.0697)	(0.0587)	(0.0663)	(0.0568)
Crisis			0.117*	0.0620	0.176**	0.0358	0.238***	0.0869	0.313***	0.0260	0.267***	0.120*	0.241**	0.0987
			(0.0702)	(0.0619)	(0.0745)	(0.0631)	(0.0740)	(0.0657)	(0.0795)	(0.0656)	(0.0823)	(0.0658)	(0.0956)	(0.0741)
Internal crisis			0.0233	0.0104	0.0143	0.00528	0.000875	0.00366	-0.0110	0.00779	0.0135	0.000251	0.0287	-0.0346
			(0.0216)	(0.0200)	(0.0232)	(0.0200)	(0.0232)	(0.0212)	(0.0247)	(0.0208)	(0.0273)	(0.0230)	(0.0298)	(0.0279)
External crisis			-0.000163	-0.00299*	0.0122**	-0.00246**	0.0129**	-0.00154	0.0133*	-0.00197*	0.0174**	-0.000772	0.0179**	-0.000287
			(0.00218)	(0.00178)	(0.00565)	(0.00121)	(0.00602)	(0.00110)	(0.00772)	(0.00111)	(0.00741)	(0.000942)	(0.00737)	(0.00126)
Expansive demand crisis			0.00227	-0.102	-0.0447	-0.179*	-0.0242	-0.219**	-0.0239	-0.192*	-0.0769	-0.113	-0.143	-0.126
			(0.121)	(0.0940)	(0.127)	(0.0971)	(0.132)	(0.103)	(0.142)	(0.110)	(0.158)	(0.121)	(0.179)	(0.149)
Recessive demand crisis			-0.137	-0.209**	-0.196**	-0.115	-0.107	-0.0836	-0.0247	-0.143	-0.104	-0.170*	-0.121	-0.155
			(0.108)	(0.0916)	(0.0993)	(0.0872)	(0.0966)	(0.0876)	(0.104)	(0.0909)	(0.116)	(0.0955)	(0.136)	(0.116)
Constant	-1.488***	-2.607***	-1.987***	-2.725***	-2.003***	-2.723***	-1.974***	-2.718***	-1.950***	-2.722***	-1.975***	-2.702***	-1.980***	-2.694***
	(0.265)	(0.215)	(0.233)	(0.187)	(0.233)	(0.187)	(0.234)	(0.187)	(0.234)	(0.187)	(0.233)	(0.187)	(0.233)	(0.186)
Observations	13,093	13,093	13,093	13,093	13,093	13,093	13,093	13,093	13,093	13,093	13,093	13,093	13,093	13,093

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

As mentioned above, the second part of the paper aims to analyse the synergies between export and R&D intensity and whether these synergies are symmetric or asymmetric.

Methodologically two are the main concerns that should be considered. First, a possible problem of sample selection bias. Second, the initial conditions problem. The former was solved using the Heckman (1979) sample selection bias specification (estimated by maximum likelihood).[22] The latter using the Wooldridge (2005) approach. Results are showed in Table 4.

Table 4

HECKMAN WOOLDRIDGE (2005) CRISIS				
VARIABLES	(1) Export Volume	(2) Export Adoption	(3) R&D Volume	(4) R&D Adoption
Export intensity $_{t-1}$	0.796***		-0.00206	
	(0.00989)		(0.00210)	
R&D intensity $_{t-1}$	0.250**		0.717***	
	(0.108)		(0.0172)	
Export $_{t-1}$		2.731***		0.240***
		(0.0695)		(0.0873)
R&D $_{t-1}$		0.177*		2.261***
		(0.0950)		(0.0554)
Cash-Flow $_{t-1}$	0.298	-0.0378	0.136***	0.0440
	(0.200)	(0.0354)	(0.0431)	(0.0297)
External funds $_{t-1}$	0.00076	0.00040	-0.00009	0.00007
	(0.00150)	(0.00254)	(0.00023)	(0.00038)
Expansive demand $_{t-1}$	-0.171	0.137	0.0115	-0.107
	(0.545)	(0.112)	(0.112)	(0.0806)
Recessive demand $_{t-1}$	0.0611	-0.0570	0.211**	-0.105
	(0.457)	(0.0820)	(0.0959)	(0.0676)
Number of competitors 0–10 $_{t-1}$	-0.756	-0.0256	-0.349**	-0.00114
	(0.718)	(0.126)	(0.168)	(0.106)
Number of competitors 10–25 $_{t-1}$	0.850	-0.0588	-0.282	0.0148
	(0.845)	(0.149)	(0.195)	(0.125)
Number of competitors >25 $_{t-1}$	-0.334	-0.139	-0.203	-0.126
	(1.061)	(0.173)	(0.255)	(0.150)
Public sales $_{t-1}$	-1.860	0.390	-0.0514	0.295
	(2.134)	(0.373)	(0.397)	(0.346)
High skill labor $_{t-1}$	-0.0159	-0.000389	0.00420	-0.00127
	(0.0527)	(0.00991)	(0.00995)	(0.00792)
Med skill labor $_{t-1}$	0.0346	-0.0149**	-0.00694	0.00375

[22] First of all, it should be checked whether the use of a Heckman specification it is justified. To do so, STATA provides at the bottom of the output the likelihood-ratio test. This test indicates that the two equations are not independent and therefore that it is appropriate estimate the model using the Heckman approach.

	(0.0292)	(0.00578)	(0.00558)	(0.00459)
Appropriability $_{t-1}$	-0.000753	0.00995	-0.0148***	-0.000197
	(0.0133)	(0.0192)	(0.00496)	(0.00224)
Market share $_{t-1}$	0.00147	0.000657	0.00214	-0.000680
	(0.0159)	(0.00310)	(0.00317)	(0.00229)
Age $_{t-1}$	3.047*	0.565**	0.126	-0.0263
	(1.562)	(0.262)	(0.351)	(0.226)
Size $_{t-1}$	-1.216	0.155	0.226	0.283**
	(0.844)	(0.140)	(0.195)	(0.119)
Foreign $_{t-1}$	-0.232	0.0850	0.145	-0.0502
	(1.207)	(0.307)	(0.223)	(0.176)
Labour productivity $_{t-1}$	-0.000297	0.000553	-3.34e-05	-0.000166
	(0.00138)	(0.000372)	(0.000382)	(0.000246)
Group $_{t-1}$	-0.432	-0.150	0.105	0.0765
	(0.838)	(0.185)	(0.158)	(0.121)
Export intensity status	0.134***		0.00296	
	(0.0101)		(0.00215)	
R&D intensity status	-0.0647		0.0320***	
	(0.0671)		(0.00998)	
Export status		0.745***		0.0243
		(0.0738)		(0.0840)
R&D status		0.189**		0.473***
		(0.0915)		(0.0558)
m_desvivolumen	3.08e-09	9.26e-09	1.39e-09	-1.30e-09
	(8.68e-09)	(6.39e-09)	(1.49e-09)	(1.42e-09)
m_desvilcashflowR	0.490	0.108**	-0.196***	0.0336
	(0.309)	(0.0546)	(0.0683)	(0.0447)
m_expansivdemand	1.194	0.0365	-0.0760	0.183
	(0.954)	(0.184)	(0.195)	(0.139)
m_recesivdemand	-1.114	-0.0486	-0.0984	0.108
	(0.899)	(0.156)	(0.193)	(0.130)
m_ncomp0_10	0.742	-0.0771	0.342	0.165
	(0.984)	(0.171)	(0.228)	(0.144)
m_ncomp10_25	-0.375	0.365*	0.319	0.217
	(1.204)	(0.215)	(0.276)	(0.178)
m_ncompm_25	0.528	0.111	0.00539	0.299
	(1.483)	(0.238)	(0.356)	(0.210)
m_salestopublic	2.161	-0.730*	0.313	-0.139
	(2.587)	(0.437)	(0.477)	(0.410)
m_pil	-0.0227	-0.000294	0.0132	0.00615
	(0.0636)	(0.0115)	(0.0121)	(0.00914)
m_ptim	-0.0384	0.0227***	0.0161**	0.00109
	(0.0378)	(0.00736)	(0.00771)	(0.00596)
m_appropriability	-0.0164	0.0344	0.0346***	-0.000635
	(0.0246)	(0.0382)	(0.00641)	(0.00511)
m_CI1N	-0.00263	9.98e-05	-0.00344	-0.000624
	(0.0200)	(0.00401)	(0.00393)	(0.00290)
m_ltage	-2.214*	-0.436**	-0.211	0.0781

	(1.245)	(0.205)	(0.283)	(0.180)
m_lsize	0.936	-0.0565	-0.264	-0.0727
	(0.898)	(0.149)	(0.206)	(0.126)
mean_size	-1.613**	-0.154	0.00927	-0.278***
	(0.675)	(0.124)	(0.149)	(0.0972)
m_foreign	0.673	-0.0136	-0.346	-0.196
	(1.343)	(0.338)	(0.250)	(0.197)
m_PBTN	0.000447	-0.000342	-0.000385	-0.000118
	(0.00174)	(0.000454)	(0.000413)	(0.000260)
m_persoc	1.048	0.158	-0.0721	0.166
	(0.999)	(0.215)	(0.190)	(0.144)
dsector2	-0.252	0.0907	-0.0672	0.0741
	(0.811)	(0.129)	(0.172)	(0.108)
dsector3	-1.738***	0.283**	-0.107	0.260***
	(0.649)	(0.126)	(0.137)	(0.0958)
dsector4	2.103***	0.120	0.309**	0.268**
	(0.740)	(0.159)	(0.147)	(0.109)
dsector5	-1.471*	0.191	0.185	0.189*
	(0.773)	(0.161)	(0.157)	(0.113)
dsector6	-3.810***	0.0521	-0.270**	0.0791
	(0.614)	(0.104)	(0.136)	(0.0846)
dsector7	-2.136***	0.152	-0.142	-0.00785
	(0.770)	(0.129)	(0.186)	(0.111)
dsector8	-1.980**	0.0926	-0.0948	-0.0184
	(0.800)	(0.127)	(0.184)	(0.115)
dsector9	-3.134***	0.172	-0.510**	-0.182*
	(0.720)	(0.114)	(0.202)	(0.110)
Constant	3.962*	-2.538***	0.848*	-3.021***
	(2.164)	(0.384)	(0.495)	(0.316)
Observations	7,155	7,155	7,162	7,162

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

It has been widely proved that export and R&D are persistent strategies. Through a probability approach, where the analysis is done for the likelihood of exporting (performing R&D), that could be checked looking at the sign and significance of the lagged dependent variable. Indeed, if we look either the biprobit regression in Table 3 or the estimation of the selection equation in Table 4 (column 2 and 4), being an exporter (a firm performing R&D) in t-1 positively affects to the probability of exporting (performing R&D) in t.[23] When the analysis is done within an intensity

[23] Sequential adoption it is also confirmed in the selection equation since being an exporter in t-1 positively affects to the probability on performing R&D in t and vice versa.

framework, persistence would be confirmed if past export intensity (R&D intensity) positively affects to current export (R&D) intensity. As can be seen in column 1 and 3 in Table 4 this is the result obtained, confirming also through intensity the persistence of export and R&D. As occurred in the adoption decision, cash flow it is also positive and significant for the R&D intensity, confirming the importance of internal funds not only for the decision of performing R&D but also for its intensity. As was mentioned before though, the main objective of the second part of this study is examining the synergies between export and R&D intensity. Therefore, the variables of interest are the lagged R&D intensity in the export equation and vice versa. From previous research (also corroborated in this paper) we know that the crisis positively affected to the probability of exporting and, also, that increased the probability of adding export by R&D firms, but reduced the probability that exporting firms embark on R&D strategies (Vicente-Chirivella and Battisti, 2017). That is, there was a positive effect from R&D to export but no vice versa. To check whether this is also the case between the export and R&D intensity, as a first prove, the analysis is only done during the crisis years. Then, in the same way that was done in the biprobit specifications, interaction terms are introduced in the model to test what happened during the different years of the crisis.

As occurred in the probabilistic approach, since 2008 onwards the R&D intensity positively affected to the export intensity (see *R&D volume* $_{t-1}$ in column 1 in Table 4), confirming the reinforcement from R&D to export. However, export intensity had no significant effects on R&D intensity, corroborating the asymmetries between export and R&D synergies also in intensities.

To get a deeper understanding of the crisis effects, interaction terms between the crisis dummy variable and the intensity variables were introduced in the model. In this way, the analysis can be done for different periods of the crisis. The results are presented in Table 5. As can be seen in columns 1, 5 and 9 (see *R&D Vol* $_{t-1}$*C)* during the first three years of the crisis there was a positive effect of R&D intensity on export intensity, being insignificant for the rest of the crisis years. Again, export and R&D persistence is always corroborated both in the selection but also in the interest equation.[24] Finally, cash flow was positive and significant not only for the R&D adoption (as was already proved in the biprobit specifications) but also for the R&D intensity.

Vicente-Chirivella and Battisti (2017) showed that the crisis had increased the probability of exporting for firms already performing R&D but not the opposite. Similarly, in this paper the results

[24] Sequential adoption it is highly significant both in the export and in the R&D decision adoption (see Export $_{t-1}$ in the R&D selection equation and R&D $_{t-1}$ in the export selection equation).

indicate that, at least during the first years of the crisis, the intensity of R&D positively affected to the intensity of export but not the opposite. Both adoption and intensity approaches point out the asymmetries in the synergies between export and R&D during the crisis period.

A possible explanation for the previous results is that, given that R&D investments improve productivity of companies (therefore the competitiveness in international markets) and the likelihood of improving or commercializing a new products, during a period of time where more firms were exporting, a positive effect of R&D intensity on export intensity is expected. The higher the R&D investment the higher the export intensity, either because the firm is more competitive or because has more (or better) products to sell abroad. However, this positive relationship may not hold from export to R&D intensity for various reasons. Once the firm has reached the productivity level to entry in international markets, the firm may have to decrease its mark-up in order to be competitive. This decrease will lead to less internal funds and therefore less available funds to increase R&D intensity. Moreover, once a firm is operating in international markets it may be that some minimal investment in R&D is necessary to maintain the firm's absorptive capacity, but that the effect of export intensity upon R&D intensity is not significant anymore. Finally, this asymmetry between export and R&D intensity it may be also explained by the type of goods that the firm is exporting. If the product exported is homogenous, once the firm is selling abroad the more the firm exports the less needs to increase the R&D intensity because the efficiency improvements are coming from the scale of production rather than from its R&D intensity. Nevertheless, if the firm is exporting differentiated goods, in order to keep its competitiveness, innovation will still be a key aspect. Given the data available, only this last option is plausible to be tested. According to Rauch (1999), most consumption goods are classified as differentiated. Therefore, the sample is split between firms belonging to a final consumption industrial sector and those that do not.[25]Results are presented in Table 6. Interestingly the positive effect of R&D intensity on export intensity it is significant both for sectors selling differentiated goods and for those selling not differentiated goods. However, a positive effect from export intensity to R&D intensity it is only found for sectors selling differentiated goods, confirming the conjecture made above.

[25] Meat, food and tobacco, beverages, textiles, leather, and shoes, motors and cars, furniture and other manufacturing goods, have been considered as final consumption sectors.

Table 5

HECKMAN WOOLDRIDGE INTERACTION FOR VOLUMES

VARIABLES	(2008) Export Volume	(2008) Export Adoption	(2008) R&D Volume	(2008) R&D Adoption	(2009) Export Volume	(2009) Export Adoption	(2009) R&D Volume	(2009) R&D Adoption	(2010) Export Volume	(2010) Export Adoption	(2010) R&D Volume	(2010) R&D Adoption
Crisis	1.230***	0.0550	-0.120	0.0158	1.010**	0.0541	-0.163	-0.0206	0.663	0.150**	-0.263*	0.0333
	(0.463)	(0.0672)	(0.141)	(0.0538)	(0.458)	(0.0679)	(0.141)	(0.0540)	(0.457)	(0.0673)	(0.141)	(0.0528)
Export Vol $_{t-1}$	0.784***		-0.00496*		0.784***		-0.00563**		0.780***		-0.00456*	
	(0.0103)		(0.00292)		(0.00962)		(0.00277)		(0.00919)		(0.00267)	
R&D Vol $_{t-1}$	-0.00945		0.713***		-0.0566		0.692***		-0.00924		0.710***	
	(0.106)		(0.0237)		(0.0987)		(0.0219)		(0.0950)		(0.0211)	
Export Vol $_{t-1}$C	0.00636		-0.00121		0.00588		-0.000463		0.0145		-0.00165	
	(0.00936)		(0.00254)		(0.00898)		(0.00246)		(0.00894)		(0.00247)	
R&D Vol $_{t-1}$C	0.240*		0.0194		0.385***		0.0696**		0.312**		0.0346	
	(0.130)		(0.0295)		(0.130)		(0.0295)		(0.133)		(0.0301)	
Cash-Flow $_{t-1}$	0.0696	-0.0296	0.148***	0.0532**	0.0739	-0.0291	0.149***	0.0526**	0.0687	-0.0281	0.151***	0.0530**
	(0.153)	(0.0276)	(0.0459)	(0.0230)	(0.152)	(0.0275)	(0.0459)	(0.0230)	(0.153)	(0.0276)	(0.0459)	(0.0230)
External funds $_{t-1}$	-1.99e-10	7.01e-10	0	-1.41e-10	-1.75e-10	5.84e-10	-0	-1.39e-10	-1.87e-10	5.84e-10	-0	-1.39e-10
	(1.29e-09)	(2.21e-09)	(2.86e-10)	(2.75e-10)	(1.29e-09)	(2.21e-09)	(2.86e-10)	(2.75e-10)	(1.29e-09)	(2.20e-09)	(2.86e-10)	(2.71e-10)
Expansive demand $_{t-1}$	-0.138	0.116	-0.0919	-0.0560	-0.0874	0.117	-0.0943	-0.0567	-0.109	0.121	-0.0998	-0.0554
	(0.394)	(0.0782)	(0.113)	(0.0596)	(0.394)	(0.0783)	(0.113)	(0.0596)	(0.394)	(0.0784)	(0.113)	(0.0596)
Recessive demand $_{t-1}$	0.177	-0.00772	0.214**	-0.0217	0.121	-0.0118	0.212**	-0.0157	0.287	-0.0200	0.225**	-0.0241
	(0.359)	(0.0662)	(0.107)	(0.0540)	(0.362)	(0.0672)	(0.108)	(0.0545)	(0.357)	(0.0661)	(0.106)	(0.0538)
Export $_{t-1}$		2.720***		0.211***		2.720***		0.212***		2.719***		0.210***
		(0.0545)		(0.0676)		(0.0546)		(0.0676)		(0.0546)		(0.0676)
R&D $_{t-1}$		0.186**		2.181***		0.185**		2.180***		0.184**		2.180***
		(0.0722)		(0.0480)		(0.0722)		(0.0481)		(0.0723)		(0.0480)
Constant	3.815***	-2.059***	-0.00480	-2.563***	4.033***	-2.054***	0.0149	-2.567***	4.186***	-2.027***	-0.0379	-2.554***
	(1.315)	(0.236)	(0.432)	(0.194)	(1.313)	(0.236)	(0.431)	(0.194)	(1.312)	(0.237)	(0.430)	(0.195)
Observations	11,841	11,841	11,853	11,853	11,841	11,841	11,853	11,853	11,841	11,841	11,853	11,853

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 5 cont.

HECKMAN WOOLDRIDGE INTERACTION FOR VOLUMES												
	(2011)	(2011)	(2011)	(2011)	(2012)	(2012)	(2012)	(2012)	(2013)	(2013)	(2013)	(2013)
VARIABLES	Export Volume	Export Adoption	R&D Volume	R&D Adoption	Export Volume	Export Adoption	R&D Volume	R&D Adoption	Export Volume	Export Adoption	R&D Volume	R&D Adoption
Crisis	0.617	0.277***	-0.0713	-0.0570	0.532	0.153**	0.00527	0.0380	0.0365	0.108	-0.0644	0.0119
	(0.465)	(0.0681)	(0.145)	(0.0525)	(0.490)	(0.0703)	(0.156)	(0.0542)	(0.556)	(0.0766)	(0.182)	(0.0592)
Export Vol $_{t-1}$	0.781***		-0.00416		0.786***		-0.00467*		0.789***		-0.00547**	
	(0.00886)		(0.00259)		(0.00859)		(0.00252)		(0.00831)		(0.00246)	
R&D Vol $_{t-1}$	0.0913		0.717***		0.0737		0.703***		0.0865		0.716***	
	(0.0893)		(0.0199)		(0.0848)		(0.0188)		(0.0820)		(0.0182)	
Export Vol $_{t-1}$C	0.0159*		-0.00354		0.00782		-0.00393		0.00318		-0.00155	
	(0.00917)		(0.00258)		(0.00976)		(0.00279)		(0.0112)		(0.00325)	
R&D Vol $_{t-1}$C	0.0908		0.0231		0.253		0.109***		0.252		0.0672	
	(0.142)		(0.0322)		(0.164)		(0.0372)		(0.199)		(0.0454)	
Cash Flow $_{t-1}$	0.0799	-0.0244	0.149***	0.0523**	0.0830	-0.0254	0.149***	0.0536**	0.0754	-0.0273	0.148***	0.0532**
	(0.153)	(0.0276)	(0.0459)	(0.0230)	(0.153)	(0.0276)	(0.0459)	(0.0230)	(0.153)	(0.0276)	(0.0459)	(0.0230)
External funds $_{t-1}$	-1.50e-10	6.44e-10	-0	-1.43e-10	-1.57e-10	5.48e-10	-0	-1.41e-10	-1.54e-10	6.20e-10	0	-1.42e-10
	(1.30e-09)	(2.19e-09)	(2.86e-10)	(2.74e-10)	(1.30e-09)	(2.20e-09)	(2.86e-10)	(2.72e-10)	(1.30e-09)	(2.21e-09)	(2.86e-10)	(2.72e-10)
Expansive demand $_{t-1}$	-0.162	0.121	-0.0894	-0.0559	-0.111	0.119	-0.0931	-0.0548	-0.142	0.118	-0.0943	-0.0552
	(0.395)	(0.0785)	(0.114)	(0.0596)	(0.395)	(0.0782)	(0.113)	(0.0596)	(0.395)	(0.0782)	(0.114)	(0.0596)
Recessive demand $_{t-1}$	0.449	-0.00814	0.185*	-0.0196	0.448	0.00384	0.190*	-0.0194	0.439	0.00579	0.193*	-0.0191
	(0.355)	(0.0656)	(0.105)	(0.0534)	(0.355)	(0.0655)	(0.105)	(0.0533)	(0.356)	(0.0655)	(0.105)	(0.0534)
Export $_{t-1}$		2.721***		0.215***		2.717***		0.209***		2.719***		0.211***
		(0.0547)		(0.0676)		(0.0546)		(0.0676)		(0.0545)		(0.0676)
R&D $_{t-1}$		0.183**		2.182***		0.186***		2.179***		0.186**		2.180***
		(0.0725)		(0.0480)		(0.0723)		(0.0481)		(0.0722)		(0.0480)
Constant	4.096***	-1.992***	-0.0368	-2.584***	3.925***	-2.021***	-0.00563	-2.551***	3.688***	-2.039***	0.0136	-2.560***
	(1.311)	(0.237)	(0.430)	(0.195)	(1.310)	(0.237)	(0.429)	(0.195)	(1.309)	(0.237)	(0.430)	(0.195)
Observations	11,841	11,841	11,853	11,853	11,841	11,841	11,853	11,853	11,841	11,841	11,853	11,853

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

Table 6

	NO DIFFERENTIATED				DIFFERENTIATED			
VARIABLES	(1) Export Wooldridge	(2) Export Wooldridge	(5) R&D Wooldridge	(6) R&D Wooldridge	(9) Export Wooldridge	(10) Export Wooldridge	(13) R&D Wooldridge	(14) R&D Wooldridge
Export intensity $_{t-1}$	0.805***		-0.00388		0.824***		0.00706**	
	(0.0121)		(0.00280)		(0.0142)		(0.00308)	
R&D intensity $_{t-1}$	0.375***		0.798***		0.339**		0.660***	
	(0.119)		(0.0209)		(0.158)		(0.0247)	
Export $_{t-1}$		2.678***		0.216*		2.893***		0.387***
		(0.0865)		(0.113)		(0.115)		(0.135)
R&D $_{t-1}$		0.165		2.301***		0.157		2.299***
		(0.122)		(0.0697)		(0.156)		(0.0861)
Cash-Flow $_{t-1}$	0.335	-0.00752	0.0559	0.0523	0.0583	-0.0939	0.212***	0.0429
	(0.251)	(0.0439)	(0.0587)	(0.0361)	(0.289)	(0.0580)	(0.0607)	(0.0475)
External funds $_{t-1}$	-0.00127	-0.000538	-0.000222	-0.000158	9.93e-06	0.0121	-3.47e-05	0.000277
	(0.00171)	(0.00242)	(0.000300)	(0.000494)	(0.00580)	(0.00809)	(0.000892)	(0.000948)
Expansive demand $_{t-1}$	0.329	0.245*	0.0803	0.0209	-1.111	0.0114	-0.196	-0.260*
	(0.662)	(0.135)	(0.154)	(0.0970)	(0.827)	(0.198)	(0.157)	(0.134)
Recessive demand $_{t-1}$	0.956*	0.00969	0.0930	-0.0877	-0.843	-0.0868	0.217	-0.0604
	(0.567)	(0.101)	(0.133)	(0.0826)	(0.667)	(0.138)	(0.133)	(0.108)
Number of competitors 0–10 $_{t-1}$	-1.155	-0.159	-0.230	-0.00900	-0.366	0.265	-0.147	0.112
	(0.872)	(0.153)	(0.231)	(0.130)	(1.075)	(0.214)	(0.233)	(0.170)
Number of competitors 10–25 $_{t-1}$	0.613	-0.348*	-0.348	-0.122	0.958	0.487*	0.110	0.325*
	(1.058)	(0.183)	(0.269)	(0.157)	(1.239)	(0.254)	(0.280)	(0.196)
Number of competitors >25 $_{t-1}$	-0.973	-0.369*	-0.127	-0.0718	-0.139	0.274	-0.187	-0.143
	(1.387)	(0.217)	(0.365)	(0.193)	(1.525)	(0.289)	(0.348)	(0.237)
Public sales $_{t-1}$	1.042	0.254	-0.139	0.149	-4.915	0.827	-1.702*	0.153

	(2.277)	(0.414)	(0.476)	(0.364)	(5.311)	(0.915)	(0.987)	(0.907)
High skill labor $_{t-1}$	-0.0222	0.00372	0.0198	-0.000675	0.0351	-0.00955	0.0238	-0.00952
	(0.0508)	(0.0106)	(0.0128)	(0.00781)	(0.0920)	(0.0163)	(0.0174)	(0.0135)
Med skill labor $_{t-1}$	0.0253	-0.0124**	-0.00638	0.00562	0.0107	-0.0115	-0.00249	-0.00587
	(0.0329)	(0.00606)	(0.00680)	(0.00503)	(0.0428)	(0.0125)	(0.00909)	(0.00790)
Appropriability $_{t-1}$	0.00158	0.0462	-0.0115*	0.000241	0.00865	0.00846	-0.00960	0.00371
	(0.0139)	(0.0437)	(0.00617)	(0.00231)	(0.0511)	(0.0224)	(0.00798)	(0.00913)
Market share $_{t-1}$	-0.0179	4.63e-05	-0.000747	-0.00110	0.0151	0.00121	0.000944	-0.000965
	(0.0199)	(0.00399)	(0.00436)	(0.00291)	(0.0225)	(0.00489)	(0.00445)	(0.00358)
Age $_{t-1}$	5.530***	0.636*	0.200	0.0907	-1.157	0.682	-0.128	0.0313
	(1.963)	(0.336)	(0.503)	(0.281)	(2.333)	(0.424)	(0.483)	(0.362)
Size $_{t-1}$	-0.793	0.0669	0.327	0.380**	-1.196	0.300	0.0747	0.305
	(1.078)	(0.170)	(0.275)	(0.148)	(1.211)	(0.247)	(0.271)	(0.198)
Foreign $_{t-1}$	0.233	-0.253	0.126	-0.242	-1.008	0.317	-0.00531	0.130
	(1.440)	(0.413)	(0.286)	(0.216)	(1.878)	(0.467)	(0.361)	(0.284)
Labour productivity $_{t-1}$	0.00207	-0.000258	0.000555	-0.000471	9.30e-05	0.00147**	-0.000519	0.000175
	(0.00238)	(0.000547)	(0.000524)	(0.000352)	(0.00160)	(0.000698)	(0.000698)	(0.000303)
Group $_{t-1}$	0.138	0.0204	0.234	0.138	-0.903	-0.483	-0.117	-0.116
	(1.044)	(0.237)	(0.229)	(0.153)	(1.297)	(0.323)	(0.227)	(0.192)
Export intensity status	0.130***		0.00310		0.132***		-0.00163	
	(0.0126)		(0.00296)		(0.0147)		(0.00323)	
R&D intensity status	-0.218**		0.0941***		0.0639		0.00682	
	(0.109)		(0.0193)		(0.0770)		(0.0106)	
Export status		0.772***		0.179*		0.861***		-0.164
		(0.0904)		(0.106)		(0.121)		(0.130)
R&D status		0.197*		0.464***		0.137		0.601***
		(0.114)		(0.0700)		(0.148)		(0.0866)
m_desvivolumenMILL	0.0110	0.00851	0.00340	0.00192	-0.00226	0.00905	-0.000704	-0.00270
	(0.0129)	(0.00736)	(0.00233)	(0.00403)	(0.0116)	(0.0122)	(0.00191)	(0.00181)
m_desvilcashflowR	0.203	-0.0149	-0.1000	-0.0145	0.587	0.204***	-0.316***	0.00124
	(0.375)	(0.0657)	(0.0888)	(0.0543)	(0.378)	(0.0762)	(0.0775)	(0.0608)
m_expansivdemand	2.016*	0.194	-0.293	-0.0253	1.736	-0.195	0.550**	0.480**

	(1.180)	(0.226)	(0.274)	(0.175)	(1.391)	(0.319)	(0.269)	(0.219)
m_recesivdemand	-1.560	-0.144	-0.111	0.0610	-0.254	0.00914	0.352	-0.0435
	(1.150)	(0.198)	(0.277)	(0.164)	(1.231)	(0.246)	(0.256)	(0.195)
m_ncomp0_10	1.812	-0.0743	0.403	0.271	-0.463	-0.162	-0.185	0.0453
	(1.211)	(0.208)	(0.323)	(0.180)	(1.450)	(0.285)	(0.303)	(0.225)
m_ncomp10_25	-0.599	0.509*	0.467	0.489**	-1.626	0.0186	-0.737*	-0.232
	(1.518)	(0.266)	(0.385)	(0.226)	(1.718)	(0.361)	(0.385)	(0.276)
m_ncompm_25	0.546	0.174	-0.200	0.320	0.302	-0.133	-0.188	0.227
	(1.935)	(0.294)	(0.528)	(0.274)	(2.087)	(0.413)	(0.456)	(0.323)
m_salestopublic	-0.940	-0.435	0.163	0.0171	2.061	-1.098	2.008	0.0874
	(2.710)	(0.475)	(0.560)	(0.425)	(7.514)	(1.234)	(1.275)	(1.183)
m_pil	-0.0762	-0.000230	-0.0152	0.00897	0.0294	-0.00224	0.00521	0.0120
	(0.0640)	(0.0125)	(0.0153)	(0.00937)	(0.108)	(0.0194)	(0.0200)	(0.0162)
m_ptim	0.0157	0.0171**	0.0247***	0.00835	-0.0340	0.0219	-0.00534	-0.00170
	(0.0427)	(0.00760)	(0.00944)	(0.00654)	(0.0536)	(0.0155)	(0.0125)	(0.00996)
m_appropriability	-0.0366	0.0266	0.0263***	-0.00235	-0.00929	0.0774	0.0130	-0.00270
	(0.0259)	(0.0516)	(0.00802)	(0.00575)	(0.0727)	(0.0542)	(0.0123)	(0.0120)
m_CI1N	0.0186	-1.07e-05	-0.00301	0.00152	-0.0176	-0.00183	0.00207	-0.00260
	(0.0245)	(0.00499)	(0.00528)	(0.00358)	(0.0300)	(0.00657)	(0.00580)	(0.00474)
m_ltage	-4.238***	-0.541**	-0.206	-0.0150	0.544	-0.447	-0.0144	0.0703
	(1.561)	(0.266)	(0.408)	(0.223)	(1.884)	(0.328)	(0.392)	(0.290)
m_lsize	0.506	0.165	-0.363	-0.0998	1.139	-0.293	-0.0686	-0.139
	(1.134)	(0.184)	(0.288)	(0.156)	(1.266)	(0.259)	(0.278)	(0.206)
mean_size	-0.436	-0.0814	-0.169	-0.292**	-2.239**	-0.383*	-0.0685	-0.262*
	(0.827)	(0.155)	(0.208)	(0.120)	(0.991)	(0.208)	(0.200)	(0.156)
m_foreign	-0.631	0.531	-0.429	0.0300	2.805	-0.328	0.0341	-0.386
	(1.603)	(0.469)	(0.325)	(0.242)	(2.094)	(0.509)	(0.400)	(0.318)
m_PBTN	0.000657	0.00115	-0.00124*	0.000316	-0.00152	-0.00126**	9.01e-05	-0.000429
	(0.00300)	(0.000745)	(0.000674)	(0.000460)	(0.00198)	(0.000588)	(0.000666)	(0.000322)
m_persoc	0.780	-0.165	0.0156	-0.142	0.330	0.798**	0.101	0.719***
	(1.237)	(0.276)	(0.272)	(0.181)	(1.545)	(0.375)	(0.278)	(0.229)
Constant	-0.777	-2.898***	0.468	-3.535***	6.259**	-2.546***	0.946	-2.981***

	(2.683)	(0.460)	(0.696)	(0.391)	(2.833)	(0.571)	(0.608)	(0.444)
Observations	4,798	4,798	4,802	4,802	2,968	2,968	2,972	2,972

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

4.3 Robustness

In order to corroborate the previous results both in the probability approach and when the analysis is done for the intensity of export and R&D, various robustness checks are run. The external constraint variable now is measured as in Máñez et al. (2014). That is, the cost of firms' new long-term debt, calculated as a weighted average of the unit cost of debts the firm has borrowed in a given year both from banks and from other long-term lenders. As in the former measured of external constraints, to avoid contamination from changing macroeconomic policies the financial cost variable is introduced as the deviation of the current firm's cost of financing with respect to the average cost paid by manufacturing firms in the same year. Negative values for the estimate of cost of firms' new long-term debt should be interpreted as evidence in favour of the existence of external financial constraints. So, a negative and significant coefficient is expected in the R&D equation. Regarding the demand variables (*Recessive* and *Expansive demand*), instead of using these two dummy variables for measuring demand conditions, firms' sales growth in real terms is used as a proxy this time. In the biprobit specification was showed that during certain years of the crisis, firms facing an expansive demand had a lower probability of performing R&D. Therefore, a negative sign in the R&D equation is expected for the new demand variable. The results are presented in Table 7 in Appendix 1. Comparing the variable *External crisis* in Table 3 and Table 7, the positive and significant sign for the export adoption in the former (indicating that firms with higher access to external funds had a higher probability of exporting) it now turns in a negative and significant sign for the R&D adoption (indicating the existence of external financial constraints for R&D). Moreover, comparing the variables *Expansive demand crisis* in Table 3 with *Growth crisis* in Table 8, also the negative effect of a positive demand upon R&D adoption is confirmed.

As a robustness for the intensity analysis, the same model is run but as selection equations instead of having the probability of exporting and the probability of performing R&D, now 3 selection equations are included. One for the probability of only exporting, one for the probability of only performing R&D and one for the probability of performing both activities. In that way, we are not mixing firms that were only exporting (only performing R&D) with those that were performing both activities. Results are presented in Table 8 in Appendix 1. Results are aligned with those presented in Table 4. That is, from 2008 onwards there was a positive and significant effect of R&D intensity on export intensity but not the opposite.

5. CONCLUDING REMARKS

As a continuation of Vicente-Chirivella and Battisti (2017), this paper sheds more light on the factors explaining the export and R&D adoption during the crisis period, and also investigate the synergies between export and R&D intensity. The data used in the paper are drawn from the *Survey of Business Strategies* for the period 2000-2014, being of special interest years beyond 2008. By using both a probabilistic and a Heckman sample selection model, the results obtained are manifold. First, access to external funds is an important factor explaining export adoption during the crisis period, while availability of internal funds seems to be important for R&D adoption. These results corroborate the importance of internal funds for financing innovative activities and the necessity of access to external funds to promote firms' internationalisation. Second, even if demand conditions may be an important factor driven export and R&D adoption, during a period of time of scarce funds in the economy it appears as not significant for the export adoption. In the case of R&D adoption, demand conditions appear as a significant driver presenting a countercyclical pattern. Third, export and R&D emerge as persistent strategies also when the analysis is done within an intensity framework. Finally, from 2008 onwards there was a positive effect from R&D intensity to export intensity but not the opposite, confirming the asymmetries in the complementarity gains between export and R&D during the crisis period found by Vicente-Chirivella and Battisti (2017) using a probabilistic approach. A possible explanation for this result is the nature of the goods that firms are exporting. When firms are exporting to sectors trading homogenous goods, innovation is less important than when the firm is exporting to sectors selling differentiated goods. Therefore, the positive effect of export intensity on R&D intensity may hold for the latter but not for the former. However, this is only a possible explanation and deeper research needs to be done to understand this mechanism.

The findings of the paper contribute to the understanding of the synergies between two of the most important strategies that could improve firms' performance and, therefore, economic growth and also to understand which factors were important during the crisis period explaining the export and R&D adoption decisions of firms. During periods of decreasing domestic demand and financial constraints, lack of access to external funds and drops in internal funds could dangerously damage export and R&D strategies respectively, causing very negative consequences on long term growth. In a period where more firms tend to export, to be able to compete in international markets firms need to increase their innovative intensity, but also fully exploit learning by exporting effects. However, this will only happen when firms have enough absorptive capacity in advance. Hence,

policies aimed to help firms to enter the virtuous circle between export and innovative activities during crisis periods should not only facilitate the international growth of firms but also make sure that firms have enough stock knowledge in advance. This means that, policy should not aim to promote single handed measures facilitating the international growth of firms or their R&D capabilities independently of each other, but should sustain the potential complementarities between export and R&D. With these two aspect on mind, the promotion of international activities not only will allow firms to survive in a hardship period but also, across *learning-by-exporting*, will foster innovation activities and therefore, ensure a sustainable comparative advantage in the long run.

The results of this study confirm the importance of financial factors for export and R&D adoption and the asymmetries on the synergies between export and R&D intensity. However, very little is said about the factors driven these asymmetries. Future research can study the factors and mechanisms through which the crisis has reduced the complementarity gains of export intensity on R&D intensity, but not vice versa.

References

Aghion, P., and Saint-Paul, G. (1998). Virtues of bad times: interaction between productivity growth and economic fluctuations. *Macroeconomic Dynamics*, 2, 322-344.

Aghion, P. and Howitt, P. (1998) Endogenous Growth Theory, MIT Press, Cambridge, MA, and London.

Aghion, P., Angeletos, G.M., Banerjee, A. and Manova, K. (2010). Volatility and growth: Credit constraints and the composition of investment. *Journal of Monetary Economics*, 57(3):246–265.

Aghion, P., Askenazy, P., Berman, N., Cette, G., and Eymard, L. (2012). Credit constraints and the cyclicality of R&D investment: Evidence from France. *Journal of the European Economic Association, 10*(5), 1001-1024.

Ahn, J., and A.F. McQuoid (2013): Capacity Constrained Exporters: Micro Evidence and Macro Implications. Department of Economics Working Papers 1301, Florida International University.

Altomonte, C., Gamba, S., Mancusi, M. L., and Vezzulli, A. (2016). R&D investments, financing constraints, exporting and productivity. *Economics of Innovation and New Technology*, *25*(3), 283-303.

Álvarez, R. and Robertson, R. (2004). Exposure to foreign markets and plant-level innovation: evidence from Chile and Mexico. *The Journal of International Trade & Economic Development*, *13*(1), 57-87.

Arrow, K. (1962). Economic welfare and the allocation of resources for invention, pages 609–626. Princeton University Press.

Atkeson, A. and Burstein, A.T. (2010). Innovation, firm dynamics and international trade. *Journal of Political Economy*, 118(3):433–484.

Aw, B.Y., Roberts, M.J., and Winston, T. (2007) Export market participation, investments in R&D and worker training, and the evolution of firm productivity. *The World Economy*, 30, 83–104.

Aw, B.Y., Roberts, M.J. and Xu, D.Y. (2008). R&D investments, exporting and the evolution of firm productivity. *The American Economic Review*, 98(2):451–456.

Aw, B.Y., Roberts, M.J. and Yi Xu, D. (2011). R&D investment, exporting and productivity dynamics. *The American Economic Review*, 101(4):1312–1344.

Barlevy, G. (2007). On the cyclicality of research and development. *The American Economic Review*, 1131-1164.

Barrios, S., H. Görg, and E. Strobl (2003). Explaining Firms' Export Behaviour: R&D, Spillovers and the Destination Market. *Oxford Bulletin of Economics and Statistics,* 65 (4): 475–496.

Becchetti, L., and S. Rossi (2000). The Positive Effect of Industrial District on the Export Performance of Italian Firms. *Review of Industrial Organization* 16 (1): 53-68.

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

Becker, S.O. and Egger, P.H. (2013). Endogenous product versus process innovation and a firm's propensity to export. *Empirical Economics*, 44(1):329–354.

Belke, A. H., Oeking, A., and Setzer, R. (2014). Exports and Capacity Constraints--A Smooth Transition Regression Model for Six Euro Area Countries.

Bellone, F., P. Musso, L. Nesta and S. Schiavo (2010), Financial Constraints and Firm Export Behaviour. *The World Economy* 30 (3), 347-373.

Beneito, P., Rochina-Barrachina, M.E. and Sanchis-Llopis, A. (2015). Ownership and the cyclicality of firms' R&D investment. *International entrepreneurship and management Journal*, *11*(2), 343-359.

Berger, A.N. and Udell, G.F. (1990). Collateral, loan quality and bank risk. *Journal of Monetary Economics, 25*(1), 21-42.

Berman, N. and J. Héricourt (2010). Financial factors and the margins of trade: evidence from cross-country firm-level data. *Journal of Development Economics*, 93(2), 206–217.

Berman, N., Berthou, A., and Héricourt, J. (2015). Export dynamics and sales at home. *Journal of International Economics*, *96*(2), 298-310.

Bernard, A.B. and Jensen, J.B. (1997). Exporters, skill upgrading, and the wage gap. *Journal of International Economics*, 42(1):3–31.

Bernard, A. B. and Jensen, J. B. (1999). Exceptional exporter performance: cause, effect, or both. *Journal of International Economics* 47, 1–25.

Bernard, A. B. and J.B. Jensen (2004): Why Some Firms Export. *Review of Economics and Statistics* 86, pp. 561-569.

Bhattacharya, S., and Ritter, J.R. (1983). Innovation and communication: Signalling with partial disclosure. *The Review of Economic Studies, 50*(2), 331-346.

Blum, B., Claro, S. and I. Horstmann (2011): Occasional vs Perennial Exporters: The Impact of Capacity on Export Mode, mimeo.

Bond, S., Harhoff, D., and Van Reenen, J. (2005). Investment, R&D and financial constraints in Britain and Germany. *Annales d'Economie et de Statistique*, 433-460.

Brealey, R., Leland, H.E. and Pyle, D.H. (1977). Informational asymmetries, financial structure, and financial intermediation. *The journal of Finance, 32*(2), 371-387.

Brown, J. R., Fazzari, S. M., and Petersen, B. C. (2009). Financing innovation and growth: Cash flow, external equity, and the 1990s R&D boom. *The Journal of Finance, 64*(1), 151-185.

Buch, C. M., I. Kesternich, A. Lipponer and M. Schnitzer (2010). Exports versus FDI revisited: does finance matter?. Deutsche Bundesbank Discussion Paper Series 1: Economic Studies, No. 03/2010. Deutsche Bundesbank: Frankfurt.

Bustos, P. (2011). Trade liberalization, exports, and technology upgrading: Evidence on the impact of Mercosur on Argentinian firms. *The American Economic Review*, 101(1):304–340.

Campa, J.M. (2004): Exchange rates and trade: How important is hysteresis in trade? *European Economic Review* 48, pp. 527-548.

Carpenter R.E. and B. C. Petersen (2002). Capital Market Imperfections, High-Tech Investment, and New Equity Financing. *Economic Journal, Royal Economic Society*, vol. 112(477), pages F54-F72, February.

Chaney, T. (2016). Liquidity constrained exporters. *Journal of Economic Dynamics and Control*, 72, 141-154.

Cohen, W. M., & Levinthal, D. A. (1989). Innovation and learning: the two faces of R&D. *The economic journal*, *99*(397), 569-596.

Cohen, W. M., and Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 35(2): 128-152.

Comin, D., and Gertler, M. (2006). Medium-Term Business Cycles. *The American Economic Review, 523-551.*

Cornell, B., and Shapiro, A. C. (1988). Financing corporate growth. *Journal of Applied Corporate Finance, 1*(2), 6-22.

Costantini, J. and Melitz, M. (2008). The dynamics of firm-level adjustment to trade liberalization. *The Organization of Firms in a Global Economy*, 107:141.

Damijan, J. and C. Kostevc (2011), 'Firms' pattern of trade and access to finance,' LICOS Discussion Papers 27811. LICOS–Centre for Institutions and Economic Performance: KU Leuven.

De Jong, J.P.J. and Vermeulen, P.A.M. (2007). Determinants of product innovation in small firms. *International Small Business Journal*, 24 (6), 587–609.

Dieppe A, Dees S, Jacquinot P, Karlsson T, Osbat C, Ö zyurt S, Vetlov I, Jochem A, Bragoudakis Z, Sideris D, Bricongne JC, Gaulier G, Pisani M, Papadopoulou N, Micallef B, Ajevskis V, Brzoza-Brzezina M, Gomes S, Krekó J, Vyskrabka M (2012). Competitiveness and external imbalances within the euro area, *ECB occasional paper series*, no. 139.

Di Mauro, F., and Forster, K. (2008). Globalisation and the competitiveness of the euro area. *ECB occasional paper*, (97).

Dunning, J.H. (1993). Multiinational enterprises and the global economy. Harlow: Addison-Wesley.

Efthyvoulou, G., and Vahter, P. (2016). Financial constraints, innovation performance and sectoral disaggregation. *The Manchester School*, *84*(2), 125-158.

Egger, P., and Kesina, M. (2013). Financial constraints and exports: evidence from Chinese firms. *CESifo Economic Studies, 59*(4), 676-706.

Elliott, J. W. (1971). Funds flow vs. expectational theories of research and development expenditures in the firm. *Southern Economic Journal*, 409-422.

Eriksson, K., Johanson, J., Majkgard, A., and Sharma, D. D. (1997). Experiential knowledge and cost in the internationalization process*. Journal of International Business Studies*, 28(2): 337-360.

Esteves, P. S., and Rua, A. (2015). Is there a role for domestic demand pressure on export performance?. *Empirical Economics*, *49*(4), 1173-1189.

Fagan, G., Henry, J., and Mestre, R. (2005). An area-wide model for the euro area. *Economic Modelling*, *22*(1), 39-59.

Fatas, A. (2000). Do business cycles cast long shadows? Short-run persistence and economic growth. *Journal of Economic Growth*, *5*(2), 147-162.

Filatotchev, I., and Piesse, J. (2009). R&D, internationalization and growth of newly listed firms: European evidence. *Journal of International Business Studies*, 40(8), 1260-1276.

Forlani, E. (2010). Liquidity constraints and firm's export activity. *Centro Studi Luca d'Agliano Development Studies Working Paper*, (291).

Girma, S., Görg, H., and Hanley, A. (2008). R&D and exporting: A comparison of British and Irish firms. *Review of World Economics*, 144(4), 750-773.

Golovko, E. and Valentini, G. (2011). Exploring the complementarity between innovation and export for smes' growth. *Journal of international business Studies*, 42(3):362–380.

Greenaway, D., Guariglia, A., and Kneller, R. (2007). Financial factors and exporting decisions. *Journal of international economics, 73*(2), 377-395.

Griffith, R., S. Redding and J. V. Reenan (2004). Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries. *Review of Economics and Statistics*, 86, 4, 883–95.

Grossman, G. M., and Helpman, E. (1991). Trade, knowledge spillovers, and growth. *European economic review*, 35(2-3), 517-526.

Grossman, G., and E. Helpman (1993). Innovation and Growth in the Global Economy. Cambridge, Mass.: MIT Press.

Hajivassiliou, V., and Savignac, F. (2011). Novel Approaches to Coherency Conditions in LDV Models with an Application to Interactions between Financing Constraints and a Firm's Decision and Ability to Innovate. *LSE discussion papers, 36*.

Hall, B., (1991). Recessions and reorganizations. NBER Macroeconomic Annual.

Hall, B. H. (1992). Investment and research and development at the firm level: does the source of financing matter?. National Bureau of Economic Research 4096.

Hall, B.H. (2002). The financing of research and development. *Oxford review of economic policy, 18*(1), 35-51.

Hao, K. Y., and Jaffe, A. B. (1993). Effect of liquidity on firms' R&D spending. *Economics of Innovation and New technology, 2*(4), 275-282.

Harhoff, D. (1998). Are there financing constraints for R&D and investment in German manufacturing firms? *Annales d'Economie et de Statistique*, 421-456.

Heckman, J.J. (1979). Sample selection bias as a specification error. *Econometrica*, 47, 153-161.

Himmelberg, C. P., and Petersen, B. C. (1994). R&D and internal finance: A panel study of small firms in high-tech industries. *The Review of Economics and Statistics*, 38-51.

Hobday, M. (1995). East Asia Latecomer Firms: Learning the Technology of Electronics. *World Development*, 23 (7): 1171–1193.

Hutchinson, J. and A. Xavier (2006), Comparing the Impact of Credit Constraints on the Growth of SMEs in a Transition Country with an Established Market Economy. *Small Business Economics*, 27, 169-179.

Ito, H. and A. Terada-Hagiwara (2011), An Analysis of the Effects of Financial Market Imperfections on Indian Firm's Exporting Behaviour. Department of Economics, Portland State University: Mimeo.

Jensen, M.C. and Meckling, W.H. (1976). Theory of the firm: managerial behaviour, agency costs and ownership structure. *Journal of Financial Economics*, 3, 305–360.

Kotha, S., Rindova, V. P., and Rothaermel, F. T. (2001). Assets and actions: Firm-specific factors in the internationalization of US Internet firms. *Journal of International Business Studies*, 32(4): 769-791.

Lachenmaier, S., and L. Wößmann (2006). Does Innovation Cause Exports? Evidence from Exogenous Innovation Impulses and Obstacles Using German Micro Data. *Oxford Economic Papers* 58 (2): 317–350.

Lev, B. (2000). Intangibles: Management, measurement, and reporting. Washington, DC. : Brookings Institution Press.

Long, N. V., H. Raff and F. Stähler (2011). Innovation and trade with heterogeneous firms. *Journal of International Economics*, 84, 149–159.

López-García, P., Montero, J. M., and Moral-Benito, E. (2013). Business cycles and investment in productivity-enhancing activities: Evidence from Spanish Firms. *Industry and Innovation*, *20*(7), 611-636.

Love, J.H., Roper, S. and Vahter, P. (2014). Learning from openness: The dynamics of breadth in external innovation linkages. *Strategic management journal*, 35(11), 1703-1716.

Lu, J. W., and Beamish, P. W. (2001). The internationalization and performance of SMEs. *Strategic Management Journal*, 22(6-7): 565-586.

Mancusi, M. L., and Vezzulli, A. (2010). R&D, innovation and liquidity constraints. Paper presented at the CONCORD 2010 Conference, Sevilla.

Mancusi, M. L., and Vezzulli, A. (2014). R&D and Credit Rationing in SMEs. *Economic Inquiry, 52*(3), 1153-1172.

Manole, V. and M. Spatareanu (2010). Exporting, capital investment and financial con- straints. *World Economic Review*, 146(1), 23–37.

Manova, K. (2013). Credit constraints, heterogeneous firms, and international trade. *The Review of Economic Studies, 80*(2), 711-744.

Máñez, J.A., Rochina, M.E., and J.A. Sanchis Llopis (2008): Sunk Cost Hysteresis in Spanish Manufacturing Exports. *Review of World Economics* 144, pp. 272-294.

Máñez, J.A., Rochina-Barrachina, M.E., Sanchis, A. and Sanchis, J.A. (2009). The role of sunk costs in the decision to invest in R&D. *The Journal of Industrial Economics*, 57(4):712–735.

Máñez, J. A., Rochina-Barrachina, M. E., Sanchis-Llopis, J. A., and Vicente-Chirivella, Ó. (2014). Financial constraints and R&D and exporting strategies for Spanish manufacturing firms. *Industrial and Corporate Change*, *23*(6), 1563-1594.

Máñez, J.A., Rochina-Barrachina, M.E. and Sanchis-Llopis, J.A. (2015). The dynamic linkages among exports, R&D and productivity. *The World Economy*, 38(4), 583-612.

Melitz, M. (2003), The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71, 1695-1725.

Minetti, R., and Zhu, S. C. (2011). Credit constraints and firm export: Microeconomic evidence from Italy. *Journal of International Economics, 83*(2), 109-125.

Mueller, D. C. (1967). The firm decision process: An econometric investigation. *The Quarterly Journal of Economics*, 58-87.

Muûls M. (2008), Exporters and credit constraints. A firm-level approach. Working Paper Research 139, National Bank of Belgium.

Ouyang, M. (2011). On the cyclicality of R&D. *The Review of Economics and Statistics*, 93, 542 –553.

Peters, B., Roberts, M.J. and Vuong, V.A. (2015). Firm R&D investment and export market exposure. In Paper presented at the Conference on the Economics of Innovation and Patenting 2015, Mannheim.

Roberts, M.J. and Tybout, J.R. (1997). The decision to export in Colombia: an empirical model of entry with sunk costs. *The American Economic Review*, 545-564.

Roberts, M.J. and Tybout, J.R. (1999). An empirical model of sunk costs and the decision to export. *World Bank Policy Research Working Paper*, (1436).

Romer, P. (1990). Endogenous Technical Change. *Journal of Political Economy* 98 (1): 71–102.

Roper, S. and Love, J.H. (2002). Innovation and export performance: evidence from the UK and German manufacturing plants. *Research policy*, 31(7):1087–1102.

Salomon, R.M. and Shaver, J.M. (2005). Learning by exporting: new insights from examining firm innovation. *Journal of Economics & Management Strategy*, *14*(2), 431-460.

Salomon, R. and Jin, B. (2008). Does knowledge spill to leaders or laggards? Exploring industry heterogeneity in learning by exporting. *Journal of International Business Studies*, 132-150.

Savignac, F. (2008). Impact of financial constraints on innovation: what can be learned from a direct measure? *Econ. Innov. New Techn., 17*(6), 553-569.

Scherer, F. M. (1965). Firm size, market structure, opportunity, and the output of patented inventions. *The American Economic Review*, 1097-1125.

Schiantarelli, F. and A. Sembenelli (2000). Form of ownership and financial constraints: panel data evidence from flow or funds and investment equations. *Empirica*, 27, 175–192.

Schumpeter, J. (1939). Business cycles. New York: McGraw-Hill.

Soderbery, A. (2014). Market size, structure, and access: Trade with capacity constraints. *European Economic Review*, *70*, 276-298.

Sterlacchini, A. (2001). The Determinants of Export Performance: A Firm Level Study in Italian Manufacturing. *Review of World Economics*, 137 (3): 450–472.

Stiebale, J. (2011). Do financial constraints matter for foreign market entry? A firm-level examination. *The World Economy*, 34(1), 123–153.

Stiglitz, J.E. and Weiss, A. (1981). Credit rationing in markets with imperfect information. *The American economic review*, *71*(3), 393-410.

Suárez-Porto, V., and Guisado-González, M. (2014). Analysis of the determinants of exporting intensity in the field of innovation. *Investigaciones Europeas de Dirección y Economía de la Empresa*, 20(2), 79-86.

Tiwari, A. K., Mohnen, P., Palm, F. C., and van der Loeff, S. S. (2007). Financial constraint and R&D investment: Evidence from CIS. United Nations University, Maastricht Economic and social Research and training centre on Innovation and Technology.

Ughetto, E. (2008). Does finance matters for R&D investment? New evidence from a panel of Italian firms. *Cambridge Journal of Economics*, 32(6), 907–925.

Vicente-Chirivella, Ó., and Battisti, G. (2017). The decision to invest in export and R&D: adoption sequence and the impact of the financial and the economic crisis.

Wagner, J. (2007). Exports and Productivity: A Survey of the Evidence from Firm-Level Data. *The World Economy*, 30 (1): 60–82.

Wagner, J. (2012). International Trade and firm performance: A Survey of empirical studies since 2006. *Review of World Economics*, 148, 235-267

Wagner, J. (2014). Credit constraints and exports: a survey of empirical studies using firm-level data. *Industrial and Corporate Change*, dtu037.

Wagner, J. (2014b). Credit constraints and exports: evidence for German manufacturing enterprises. *Applied Economics*, *46*(3), 294-302.

Wooldridge, J. M. (2005). Simple solutions to the initial conditions problem in dynamic, nonlinear panel data models with unobserved heterogeneity. *Journal of applied econometrics*, *20*(1), 39-54.

Young, A. (1991). Learning by Doing and Dynamic Effects of International Trade. *Quarterly Journal of Economics* 106 (2): 369–405.

Zahra, S. A., Ireland, D. R., and Hitt, M. (2000). International expansion by new venture firms: International diversity, mode of market entry, technological learning, and performance. *Academy of Management journal*, 43(5): 925-950.

Appendix 1

Table 7

ROBUSTNESS MEASURING DEMAND BY GROWTH AND EXTERNAL AS DEVIATION OF COST OF DEBT FOR MANUFACTURING														
VARIABLES	(1) Whole period	(2) Whole period	(4) 2008	(5) 2008	(7) 2009	(8) 2009	(10) 2010	(11) 2010	(13) 2011	(14) 2011	(16) 2012	(17) 2012	(19) 2013	(20) 2013
Export $_{t-1}$	2.677***	0.228***	2.671***	0.226***	2.669***	0.228***	2.668***	0.225***	2.667***	0.229***	2.666***	0.223***	2.670***	0.221***
	(0.0662)	(0.0749)	(0.0660)	(0.0748)	(0.0659)	(0.0750)	(0.0659)	(0.0749)	(0.0658)	(0.0749)	(0.0659)	(0.0749)	(0.0661)	(0.0744)
R&D $_{t-1}$	0.177**	2.272***	0.176**	2.250***	0.176**	2.250***	0.177**	2.248***	0.175**	2.249***	0.177**	2.249***	0.178**	2.251***
	(0.0707)	(0.0496)	(0.0700)	(0.0494)	(0.0700)	(0.0493)	(0.0703)	(0.0493)	(0.0705)	(0.0491)	(0.0702)	(0.0493)	(0.0702)	(0.0493)
Cash-Flow $_{t-1}$	-0.0275	0.0558***	-0.0448	0.0473**	-0.0326	0.0502**	-0.0250	0.0533**	-0.0191	0.0508**	-0.0290	0.0556***	-0.0329	0.0603***
	(0.0261)	(0.0206)	(0.0281)	(0.0237)	(0.0270)	(0.0227)	(0.0270)	(0.0223)	(0.0265)	(0.0222)	(0.0259)	(0.0215)	(0.0258)	(0.0212)
External funds $_{t-1}$	-0.00209	-0.0104	0.0180	0.0403	-0.0119	0.0284	0.00303	0.0204	0.000702	-0.000199	-0.00364	0.0115	-0.00427	0.00354
	(0.0332)	(0.0222)	(0.0484)	(0.0395)	(0.0399)	(0.0339)	(0.0441)	(0.0315)	(0.0415)	(0.0270)	(0.0377)	(0.0267)	(0.0339)	(0.0248)
Growth $_{t-1}$	0.195*	0.0440	0.254	0.262	0.251*	0.265*	0.146	0.199	0.172	0.113	0.245**	0.0513	0.243**	0.00804
	(0.111)	(0.103)	(0.165)	(0.162)	(0.138)	(0.148)	(0.138)	(0.134)	(0.118)	(0.116)	(0.114)	(0.109)	(0.109)	(0.103)
Crisis			0.0942	-0.00767	0.0902	-0.0371	0.173***	0.00425	0.237***	-0.0725	0.145**	0.0281	0.101	0.0172
			(0.0586)	(0.0487)	(0.0611)	(0.0485)	(0.0573)	(0.0499)	(0.0630)	(0.0506)	(0.0607)	(0.0515)	(0.0696)	(0.0586)
Internal crisis			0.0195	0.0150	-0.000884	0.0110	-0.0187	0.00691	-0.0273	0.0125	-0.00103	0.00338	0.00858	-0.0372
			(0.0219)	(0.0203)	(0.0225)	(0.0203)	(0.0219)	(0.0214)	(0.0240)	(0.0209)	(0.0257)	(0.0234)	(0.0274)	(0.0282)
External crisis			-0.0320	-0.101**	0.0302	-0.0876**	-0.0122	-0.0787*	-0.0117	-0.0300	0.0149	-0.125**	0.0465	-0.135*
			(0.0557)	(0.0464)	(0.0483)	(0.0440)	(0.0529)	(0.0433)	(0.0545)	(0.0447)	(0.0591)	(0.0572)	(0.0753)	(0.0765)
Growth crisis			0.0378	-0.383**	0.0611	-0.490***	0.325	-0.425**	0.168	-0.321	0.00673	-0.228	0.133	0.0132
			(0.209)	(0.191)	(0.201)	(0.188)	(0.203)	(0.186)	(0.242)	(0.198)	(0.275)	(0.233)	(0.327)	(0.289)
Number of competitors 0–10 $_{t-1}$	-0.0199	-0.0770	-0.0320	-0.0730	-0.0297	-0.0740	-0.0224	-0.0710	-0.0202	-0.0775	-0.0203	-0.0704	-0.0218	-0.0708
	(0.0926)	(0.0871)	(0.0930)	(0.0861)	(0.0933)	(0.0858)	(0.0932)	(0.0860)	(0.0929)	(0.0860)	(0.0929)	(0.0863)	(0.0935)	(0.0862)
Number of competitors 10–25 $_{t-1}$	-0.00704	0.0178	-0.0134	0.0102	-0.0138	0.00920	-0.0171	0.0142	-0.0117	0.0111	-0.00704	0.0152	-0.00727	0.0154
	(0.115)	(0.103)	(0.115)	(0.103)	(0.115)	(0.103)	(0.116)	(0.103)	(0.115)	(0.103)	(0.115)	(0.103)	(0.115)	(0.104)
Number of competitors >25 $_{t-1}$	-0.192	-0.127	-0.198	-0.136	-0.201	-0.138	-0.196	-0.137	-0.196	-0.139	-0.196	-0.133	-0.194	-0.131
	(0.120)	(0.126)	(0.123)	(0.126)	(0.123)	(0.126)	(0.122)	(0.126)	(0.122)	(0.126)	(0.122)	(0.126)	(0.122)	(0.126)
Public sales $_{t-1}$	0.0108	0.168	0.00561	0.152	-0.0108	0.145	-0.0166	0.144	-0.0154	0.138	-0.00692	0.148	0.00686	0.129
	(0.140)	(0.285)	(0.135)	(0.285)	(0.139)	(0.287)	(0.143)	(0.284)	(0.139)	(0.287)	(0.137)	(0.282)	(0.136)	(0.279)
High skill labor $_{t-1}$	-0.000523	0.00579	0.00103	0.00684	0.000995	0.00716	0.000612	0.00676	0.000620	0.00740	0.000847	0.00652	0.00100	0.00669
	(0.00505)	(0.00481)	(0.00505)	(0.00473)	(0.00503)	(0.00472)	(0.00503)	(0.00476)	(0.00505)	(0.00471)	(0.00504)	(0.00470)	(0.00504)	(0.00472)

Med skill labor $_{t-1}$	-0.00565	0.00356	-0.00559	0.00375	-0.00562	0.00383	-0.00564	0.00383	-0.00558	0.00372	-0.00555	0.00375	-0.00556	0.00374
	(0.00353)	(0.00296)	(0.00352)	(0.00293)	(0.00349)	(0.00294)	(0.00348)	(0.00294)	(0.00347)	(0.00296)	(0.00349)	(0.00295)	(0.00350)	(0.00296)
Appropriability $_{t-1}$	0.00217	0.000143	0.00130	-3.25e-05	0.00128	-1.18e-05	0.00158	-2.22e-05	0.00220	1.29e-05	0.00226	7.33e-05	0.00224	-8.81e-06
	(0.00845)	(0.000637)	(0.00804)	(0.000620)	(0.00832)	(0.000618)	(0.00871)	(0.000618)	(0.00891)	(0.000617)	(0.00890)	(0.000620)	(0.00892)	(0.000613)
Market share $_{t-1}$	-9.76e-05	0.00202	-6.13e-05	0.00200	-6.60e-05	0.00202	2.61e-05	0.00197	-3.17e-07	0.00192	-6.13e-05	0.00195	-7.16e-05	0.00188
	(0.00210)	(0.00172)	(0.00206)	(0.00171)	(0.00205)	(0.00171)	(0.00207)	(0.00171)	(0.00207)	(0.00171)	(0.00205)	(0.00170)	(0.00205)	(0.00170)
Age $_{t-1}$	-0.167	-0.116	0.200	-0.133	0.178	-0.0920	0.0556	-0.157	-0.00778	-0.0587	0.168	-0.184*	0.243**	-0.171*
	(0.168)	(0.142)	(0.129)	(0.114)	(0.128)	(0.114)	(0.126)	(0.111)	(0.122)	(0.108)	(0.115)	(0.101)	(0.108)	(0.0960)
Size $_{t-1}$	0.177*	0.115	0.124	0.135	0.141	0.126	0.172*	0.137	0.194*	0.109	0.148	0.131	0.129	0.125
	(0.100)	(0.0896)	(0.100)	(0.0880)	(0.100)	(0.0886)	(0.0997)	(0.0890)	(0.101)	(0.0889)	(0.101)	(0.0882)	(0.0998)	(0.0875)
Foreign $_{t-1}$	-0.193	-0.0221	-0.200	-0.0216	-0.211	-0.0194	-0.205	-0.0206	-0.214	-0.0249	-0.217	-0.0254	-0.214	-0.0318
	(0.148)	(0.112)	(0.149)	(0.110)	(0.149)	(0.110)	(0.148)	(0.111)	(0.149)	(0.112)	(0.149)	(0.112)	(0.149)	(0.112)
Labour productivity $_{t-1}$	0.000237	-0.000174	0.000167	-0.000192	0.000228	-0.000170	0.000265	-0.000170	0.000288	-0.000184	0.000237	-0.000202	0.000231	-0.000178
	(0.000234)	(0.000211)	(0.000232)	(0.000213)	(0.000237)	(0.000212)	(0.000233)	(0.000211)	(0.000234)	(0.000209)	(0.000234)	(0.000203)	(0.000232)	(0.000197)
Export status	0.786***	0.0198	0.786***	0.0237	0.784***	0.0274	0.783***	0.0269	0.786***	0.0257	0.785***	0.0232	0.783***	0.0249
	(0.0607)	(0.0734)	(0.0602)	(0.0734)	(0.0601)	(0.0734)	(0.0603)	(0.0735)	(0.0605)	(0.0734)	(0.0603)	(0.0732)	(0.0603)	(0.0729)
R&D status	0.137*	0.505***	0.134*	0.510***	0.135*	0.512***	0.134*	0.511***	0.137*	0.509***	0.136*	0.506***	0.137*	0.506***
	(0.0722)	(0.0456)	(0.0717)	(0.0453)	(0.0715)	(0.0454)	(0.0719)	(0.0454)	(0.0720)	(0.0454)	(0.0716)	(0.0454)	(0.0716)	(0.0454)
m_desvi7fincecost	-0.241**	-0.262***	-0.236**	-0.261***	-0.239**	-0.267***	-0.233**	-0.264***	-0.233**	-0.263***	-0.234**	-0.254***	-0.233**	-0.254***
	(0.114)	(0.0951)	(0.114)	(0.0976)	(0.113)	(0.0971)	(0.114)	(0.0968)	(0.114)	(0.0956)	(0.114)	(0.0967)	(0.114)	(0.0959)
m_desvilcashflowR	0.0958**	0.0343	0.104***	0.0341	0.103***	0.0339	0.102**	0.0339	0.0971**	0.0363	0.100**	0.0334	0.103**	0.0357
	(0.0401)	(0.0327)	(0.0399)	(0.0325)	(0.0400)	(0.0325)	(0.0402)	(0.0325)	(0.0402)	(0.0325)	(0.0401)	(0.0325)	(0.0402)	(0.0325)
m_salesgrowth	0.827***	0.660***	0.786**	0.708***	0.784**	0.734***	0.774**	0.718***	0.796**	0.730***	0.772**	0.704***	0.768**	0.709***
	(0.320)	(0.230)	(0.311)	(0.229)	(0.310)	(0.228)	(0.311)	(0.228)	(0.315)	(0.228)	(0.313)	(0.230)	(0.312)	(0.230)
m_ncomp0_10	-0.161	0.205*	-0.151	0.202*	-0.153	0.202*	-0.160	0.198*	-0.163	0.205*	-0.162	0.198*	-0.161	0.196*
	(0.122)	(0.116)	(0.122)	(0.115)	(0.123)	(0.115)	(0.123)	(0.115)	(0.123)	(0.115)	(0.122)	(0.115)	(0.122)	(0.115)
m_ncomp10_25	0.119	0.210	0.122	0.216	0.122	0.214	0.128	0.208	0.122	0.213	0.116	0.210	0.115	0.208
	(0.161)	(0.143)	(0.161)	(0.143)	(0.161)	(0.143)	(0.162)	(0.143)	(0.161)	(0.142)	(0.161)	(0.143)	(0.161)	(0.143)
m_ncompm_25	0.159	0.194	0.165	0.210	0.167	0.211	0.158	0.209	0.161	0.208	0.163	0.202	0.161	0.198
	(0.160)	(0.168)	(0.161)	(0.168)	(0.160)	(0.168)	(0.160)	(0.168)	(0.160)	(0.168)	(0.160)	(0.168)	(0.160)	(0.168)
m_salestopublic	-0.0360	0.0907	-0.0382	0.0960	-0.0198	0.101	0.00453	0.101	0.00939	0.104	-0.0146	0.0993	-0.0283	0.122
	(0.229)	(0.357)	(0.224)	(0.358)	(0.226)	(0.360)	(0.230)	(0.359)	(0.225)	(0.359)	(0.225)	(0.356)	(0.223)	(0.353)
m_pil	0.00202	-0.00173	0.000279	-0.00265	0.000235	-0.00297	0.000509	-0.00247	0.000590	-0.00324	0.000254	-0.00227	7.99e-06	-0.00251
	(0.00643)	(0.00566)	(0.00641)	(0.00558)	(0.00640)	(0.00558)	(0.00640)	(0.00562)	(0.00644)	(0.00557)	(0.00642)	(0.00558)	(0.00642)	(0.00557)
m_ptim	0.00947*	0.00426	0.00939*	0.00394	0.00937*	0.00394	0.00956*	0.00385	0.00940*	0.00405	0.00930*	0.00405	0.00939*	0.00399
	(0.00501)	(0.00424)	(0.00497)	(0.00419)	(0.00493)	(0.00421)	(0.00493)	(0.00422)	(0.00493)	(0.00424)	(0.00493)	(0.00422)	(0.00492)	(0.00423)
m_appropriability	0.0434*	0.00391	0.0425*	0.00397	0.0431*	0.00393	0.0442**	0.00398	0.0437*	0.00399	0.0419*	0.00388	0.0416*	0.00413
	(0.0224)	(0.00434)	(0.0218)	(0.00437)	(0.0220)	(0.00435)	(0.0225)	(0.00437)	(0.0226)	(0.00436)	(0.0220)	(0.00436)	(0.0219)	(0.00435)
m_CI1N	0.000685	-0.00237	0.000643	-0.00247	0.000647	-0.00255	0.000555	-0.00242	0.000520	-0.00237	0.000642	-0.00240	0.000667	-0.00233
	(0.00270)	(0.00222)	(0.00269)	(0.00220)	(0.00269)	(0.00220)	(0.00269)	(0.00220)	(0.00269)	(0.00220)	(0.00269)	(0.00220)	(0.00270)	(0.00220)

m_ltage	0.150	0.144	-0.183	0.163	-0.163	0.125	-0.0533	0.184*	0.00631	0.0916	-0.153	0.206**	-0.223**	0.193**
	(0.155)	(0.129)	(0.120)	(0.105)	(0.119)	(0.104)	(0.116)	(0.102)	(0.112)	(0.0994)	(0.107)	(0.0924)	(0.101)	(0.0881)
m_lsize	-0.0982	0.0368	-0.0493	0.0171	-0.0684	0.0245	-0.0984	0.0139	-0.119	0.0392	-0.0746	0.0226	-0.0569	0.0263
	(0.107)	(0.0954)	(0.107)	(0.0944)	(0.107)	(0.0951)	(0.107)	(0.0956)	(0.108)	(0.0953)	(0.107)	(0.0946)	(0.107)	(0.0940)
mean_size	-0.115	-0.169**	-0.102	-0.162**	-0.100	-0.159**	-0.106	-0.163**	-0.115	-0.156**	-0.107	-0.168**	-0.102	-0.166**
	(0.0892)	(0.0771)	(0.0871)	(0.0767)	(0.0873)	(0.0767)	(0.0876)	(0.0765)	(0.0880)	(0.0767)	(0.0878)	(0.0767)	(0.0876)	(0.0766)
m_foreign	0.268	-0.0790	0.276	-0.0753	0.282	-0.0780	0.270	-0.0748	0.280	-0.0738	0.287	-0.0730	0.281	-0.0668
	(0.184)	(0.129)	(0.187)	(0.128)	(0.186)	(0.128)	(0.186)	(0.128)	(0.186)	(0.129)	(0.186)	(0.130)	(0.187)	(0.130)
m_PBTN	-0.000188	-0.000123	-0.000129	-0.000113	-0.000178	-0.000132	-0.000207	-0.000135	-0.000228	-0.000119	-0.000182	-9.59e-05	-0.000177	-0.000121
	(0.000206)	(0.000191)	(0.000213)	(0.000189)	(0.000207)	(0.000189)	(0.000201)	(0.000188)	(0.000197)	(0.000187)	(0.000204)	(0.000180)	(0.000205)	(0.000177)
m_persoc	-0.00398	0.0952	-0.0118	0.0977*	-0.0106	0.0958*	-0.00563	0.0949	-0.00337	0.0931	-0.00941	0.0943	-0.00978	0.0944
	(0.0841)	(0.0581)	(0.0830)	(0.0580)	(0.0830)	(0.0579)	(0.0835)	(0.0579)	(0.0838)	(0.0578)	(0.0834)	(0.0578)	(0.0831)	(0.0579)
dsector2	-0.0634	0.0869	-0.0674	0.0818	-0.0659	0.0819	-0.0615	0.0860	-0.0604	0.0879	-0.0651	0.0876	-0.0642	0.0865
	(0.0977)	(0.0817)	(0.0970)	(0.0812)	(0.0969)	(0.0813)	(0.0976)	(0.0812)	(0.0975)	(0.0816)	(0.0968)	(0.0814)	(0.0968)	(0.0815)
dsector3	0.212**	0.225***	0.212**	0.225***	0.214**	0.224***	0.214**	0.223***	0.219**	0.223***	0.217**	0.220***	0.216**	0.221***
	(0.0914)	(0.0737)	(0.0914)	(0.0730)	(0.0914)	(0.0733)	(0.0916)	(0.0733)	(0.0920)	(0.0731)	(0.0914)	(0.0730)	(0.0912)	(0.0731)
dsector4	0.0110	0.128	0.00770	0.132	0.00888	0.127	0.0113	0.127	0.0128	0.133	0.0123	0.130	0.0126	0.130
	(0.112)	(0.0834)	(0.112)	(0.0833)	(0.112)	(0.0836)	(0.112)	(0.0833)	(0.112)	(0.0831)	(0.112)	(0.0830)	(0.112)	(0.0831)
dsector5	0.150	0.220**	0.152	0.223**	0.150	0.222**	0.152	0.224**	0.149	0.228**	0.152	0.223**	0.155	0.223**
	(0.105)	(0.0901)	(0.105)	(0.0901)	(0.106)	(0.0898)	(0.106)	(0.0898)	(0.106)	(0.0900)	(0.106)	(0.0903)	(0.105)	(0.0902)
dsector6	-0.0407	0.0207	-0.0334	0.0177	-0.0338	0.0196	-0.0395	0.0172	-0.0365	0.0168	-0.0329	0.0152	-0.0300	0.0184
	(0.0829)	(0.0655)	(0.0822)	(0.0655)	(0.0822)	(0.0657)	(0.0825)	(0.0655)	(0.0830)	(0.0656)	(0.0826)	(0.0653)	(0.0824)	(0.0653)
dsector7	0.00555	-0.0478	0.0134	-0.0344	0.0116	-0.0304	0.00107	-0.0326	0.00402	-0.0371	0.00969	-0.0409	0.0105	-0.0471
	(0.0929)	(0.0827)	(0.0929)	(0.0827)	(0.0933)	(0.0827)	(0.0938)	(0.0825)	(0.0936)	(0.0825)	(0.0932)	(0.0824)	(0.0935)	(0.0823)
dsector8	-0.0944	-0.0293	-0.0936	-0.0308	-0.0952	-0.0305	-0.0998	-0.0296	-0.0970	-0.0291	-0.0941	-0.0310	-0.0948	-0.0364
	(0.0867)	(0.0849)	(0.0865)	(0.0848)	(0.0866)	(0.0847)	(0.0866)	(0.0845)	(0.0868)	(0.0843)	(0.0869)	(0.0843)	(0.0868)	(0.0846)
dsector9	-0.0416	-0.297***	-0.0349	-0.299***	-0.0336	-0.296***	-0.0380	-0.297***	-0.0389	-0.300***	-0.0348	-0.302***	-0.0324	-0.302***
	(0.0930)	(0.0873)	(0.0938)	(0.0866)	(0.0937)	(0.0870)	(0.0935)	(0.0866)	(0.0934)	(0.0870)	(0.0937)	(0.0866)	(0.0937)	(0.0867)
dyear3	-0.474***	-0.0425												
	(0.170)	(0.128)												
dyear4	-0.548***	-0.260**												
	(0.152)	(0.123)												
dyear5	-0.436***	0.0702												
	(0.139)	(0.111)												
dyear6	-0.292**	0.00283												
	(0.137)	(0.116)												
dyear7	-0.419***	-0.120												
	(0.148)	(0.113)												
dyear8	-0.324**	-0.208**												
	(0.133)	(0.104)												

dyear9	-0.303**	-0.0687												
	(0.119)	(0.0970)												
dyear10	-0.382***	-0.171*												
	(0.125)	(0.100)												
dyear11	-0.366***	0.0275												
	(0.120)	(0.0974)												
dyear12	-0.0597	-0.252***												
	(0.111)	(0.0970)												
dyear13	-0.0942	-0.0675												
	(0.116)	(0.0871)												
dyear14	-0.202	-0.224**												
	(0.124)	(0.0962)												
Constant	-1.416***	-2.529***	-1.887***	-2.631***	-1.857***	-2.634***	-1.831***	-2.622***	-1.830***	-2.611***	-1.850***	-2.609***	-1.856***	-2.590***
	(0.259)	(0.212)	(0.226)	(0.183)	(0.226)	(0.183)	(0.228)	(0.182)	(0.228)	(0.183)	(0.227)	(0.183)	(0.228)	(0.183)
Observations	13,045	13,045	13,045	13,045	13,045	13,045	13,045	13,045	13,045	13,045	13,045	13,045	13,045	13,045

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8

Robustness with only export, only R&D and both in the selection equations							
	Post Crisis						
VARIABLES	(1) Export Volume	(2) Only Export Adoption	(5) R&D Volume	(6) Only R&D Adoption	(9) Export Volume	(13) R&D Volume	(14) Both Adoption
Export volume $_{t-1}$	0.794***		0.0539		0.791***	-0.00130	
	(0.0135)		(0.142)		(0.0146)	(0.00203)	
R&D volume $_{t-1}$	0.312		0.615***		0.276**	0.716***	
	(0.455)		(0.0745)		(0.127)	(0.0174)	
Export $_{t-1}$		2.492***		-2.509***			1.765***
		(0.0700)		(0.174)			(0.125)
R&D $_{t-1}$		-2.232***		2.021***			2.164***
		(0.0588)		(0.139)			(0.0592)
Cash-Flow $_{t-1}$	0.408	-0.0441*	0.110	0.0601	0.188	0.151***	0.0448
	(0.266)	(0.0254)	(0.211)	(0.0595)	(0.306)	(0.0427)	(0.0315)
External funds $_{t-1}$	0.0114	-0.000164	0.00250	-0.00232	-0.000881	-8.19e-05	9.99e-05
	(0.0125)	(0.000724)	(0.00779)	(0.00224)	(0.00157)	(0.000221)	(0.000488)
Expansive demand $_{t-1}$	-0.0211	0.136*	-0.139	-0.0678	-0.219	-0.0109	-0.130
	(0.758)	(0.0734)	(0.625)	(0.164)	(0.788)	(0.110)	(0.0838)
Recessive demand $_{t-1}$	0.000774	0.0182	0.177	-0.0798	0.265	0.180*	-0.0995
	(0.621)	(0.0592)	(0.539)	(0.130)	(0.677)	(0.0946)	(0.0717)
Number of competitors 0–10 $_{t-1}$	-1.985**	0.0199	-0.356	-0.0745	0.911	-0.304*	0.0239
	(0.897)	(0.0915)	(0.806)	(0.205)	(1.205)	(0.168)	(0.113)
Number of competitors 10–25 $_{t-1}$	0.747	-0.0450	1.074	-0.0132	1.116	-0.340*	0.0642
	(1.062)	(0.107)	(0.936)	(0.235)	(1.395)	(0.194)	(0.133)
Number of competitors >25 $_{t-1}$	-0.658	0.0452	-0.339	-0.121	-0.201	-0.175	-0.165
	(1.291)	(0.129)	(1.072)	(0.275)	(1.853)	(0.258)	(0.164)
Public sales $_{t-1}$	-0.553	0.164	-1.635	-0.0157	-2.711	0.636	0.283
	(3.185)	(0.289)	(1.609)	(0.471)	(2.935)	(0.411)	(0.375)
High skill labor $_{t-1}$	-0.0421	-0.00404	0.0390	-0.00923	-0.00406	0.00300	-0.000286
	(0.0817)	(0.00718)	(0.0676)	(0.0141)	(0.0700)	(0.00980)	(0.00852)
Med skill labor $_{t-1}$	0.000633	-0.00926**	0.00315	0.00463	0.0613	-0.0102*	0.00285
	(0.0460)	(0.00409)	(0.0457)	(0.00862)	(0.0386)	(0.00540)	(0.00492)
Appropriability $_{t-1}$	0.00135	0.000113	0.0353	-0.0162	0.00452	-0.0145***	0.000172
	(0.0144)	(0.00209)	(0.0722)	(0.0171)	(0.0338)	(0.00473)	(0.00212)
Market share $_{t-1}$	0.0385*	-0.00175	-0.0188	-0.0130***	-0.0366	0.00365	0.00230
	(0.0228)	(0.00211)	(0.0183)	(0.00502)	(0.0224)	(0.00313)	(0.00240)
Age $_{t-1}$	2.705	0.195	4.414***	-0.554	3.679	-0.378	0.176
	(2.020)	(0.194)	(1.712)	(0.416)	(2.529)	(0.353)	(0.244)
Size $_{t-1}$	-1.559	-0.146	3.222***	-0.108	-0.704	-0.0147	0.329**

	(1.069)	(0.103)	(0.999)	(0.216)	(1.404)	(0.196)	(0.128)
Foreign $_{t-1}$	2.934	-0.112	-2.836	-0.517	-2.277	0.128	0.0667
	(1.988)	(0.177)	(2.007)	(0.411)	(1.544)	(0.216)	(0.179)
Labour productivity $_{t-1}$	0.000427	0.000172	-0.000613	-0.000326	0.00162	-1.28e-05	-0.000168
	(0.00166)	(0.000224)	(0.00191)	(0.000554)	(0.00274)	(0.000381)	(0.000247)
Group $_{t-1}$	0.773	-0.0847	-1.103	0.130	-1.157	0.114	0.0513
	(1.302)	(0.118)	(1.143)	(0.260)	(1.111)	(0.155)	(0.125)
Export volume status	0.152***		-0.0379		0.118***	0.00314	
	(0.0140)		(0.0328)		(0.0148)	(0.00206)	
R&D volume status	-0.133		-0.0353		-0.0462	0.0376***	
	(0.255)		(0.0430)		(0.0725)	(0.0101)	
Export status		0.570***		-0.351**			0.134
		(0.0675)		(0.159)			(0.0941)
R&D status		-0.333***		0.280**			0.442***
		(0.0563)		(0.138)			(0.0582)
m_desvivolumen	-0.00904	-0.000276	-0.0583**	-0.00200	0.00447	0.00124	-0.00101
	(0.0229)	(0.00152)	(0.0288)	(0.00433)	(0.0102)	(0.00143)	(0.00144)
m_desvilcashflowR	0.496	0.0725*	-0.386	0.0866	0.170	-0.212***	0.0112
	(0.405)	(0.0385)	(0.370)	(0.0904)	(0.485)	(0.0677)	(0.0480)
m_expansivdemand	1.788	0.0180	0.832	0.518*	0.627	-0.176	0.111
	(1.339)	(0.128)	(1.182)	(0.267)	(1.379)	(0.193)	(0.146)
m_recesivdemand	-0.234	-0.0200	-0.897	0.392	-2.247	-0.0381	0.0448
	(1.195)	(0.114)	(1.003)	(0.247)	(1.381)	(0.193)	(0.138)
m_ncomp0_10	2.113*	-0.108	0.544	0.365	-1.144	0.295	0.131
	(1.239)	(0.124)	(1.104)	(0.283)	(1.635)	(0.228)	(0.153)
m_ncomp10_25	0.404	0.0700	0.527	0.122	-1.399	0.325	0.160
	(1.533)	(0.152)	(1.537)	(0.352)	(1.971)	(0.275)	(0.190)
m_ncompm_25	1.437	-0.0200	0.408	0.510	-1.273	0.0516	0.257
	(1.814)	(0.181)	(1.612)	(0.383)	(2.584)	(0.360)	(0.229)
m_salestopublic	0.589	-0.490	4.055**	0.551	3.388	-0.557	-0.274
	(3.876)	(0.345)	(1.918)	(0.545)	(3.546)	(0.496)	(0.439)
m_pil	0.0258	0.00216	-0.00671	0.0159	-0.0775	0.0172	0.00658
	(0.0964)	(0.00839)	(0.0771)	(0.0159)	(0.0864)	(0.0121)	(0.0100)
m_ptim	0.000837	0.00799	0.0403	-0.00865	-0.0577	0.0146**	0.00355
	(0.0551)	(0.00513)	(0.0679)	(0.0123)	(0.0534)	(0.00747)	(0.00636)
m_appropriability	-0.0204	-0.000240	0.240	-0.00665	-0.0175	0.0341***	-0.000543
	(0.0412)	(0.00432)	(0.149)	(0.0260)	(0.0437)	(0.00611)	(0.00519)
m_CI1N	-0.0528*	0.00237	0.0395*	0.00721	0.0423	-0.00551	-0.00200
	(0.0293)	(0.00271)	(0.0215)	(0.00564)	(0.0279)	(0.00389)	(0.00306)
m_ltage	-1.910	-0.210	-4.293***	0.378	-2.808	0.252	-0.0590
	(1.585)	(0.153)	(1.352)	(0.331)	(2.046)	(0.285)	(0.194)
m_lsize	1.000	0.0177	-3.191***	0.0861	0.832	-0.0190	-0.102
	(1.143)	(0.110)	(1.032)	(0.231)	(1.479)	(0.206)	(0.136)
mean_size	-1.000	-0.0431	-1.705*	-0.192	-2.072*	0.0426	-0.293***
	(0.897)	(0.0854)	(0.890)	(0.194)	(1.063)	(0.148)	(0.105)
m_foreign	-2.240	0.251	3.572	0.389	2.541	-0.326	-0.340*
	(2.193)	(0.197)	(2.313)	(0.459)	(1.730)	(0.242)	(0.201)
m_PBTN	-0.00158	9.50e-05	-0.00202	8.73e-06	0.000796	-0.000346	-7.42e-05

	(0.00222)	(0.000239)	(0.00250)	(0.000657)	(0.00293)	(0.000408)	(0.000263)
m_persoc	-0.0838	-0.140	1.449	-0.292	1.692	-0.0609	0.202
	(1.542)	(0.140)	(1.333)	(0.306)	(1.340)	(0.187)	(0.149)
dsector2	0.230	0.0355	-1.056	0.271	-0.901	-0.0293	0.0555
	(1.074)	(0.0966)	(0.875)	(0.191)	(1.256)	(0.175)	(0.118)
dsector3	-1.675*	-0.0108	-0.726	0.332	-2.310**	-0.0924	0.216**
	(0.901)	(0.0859)	(0.835)	(0.202)	(0.971)	(0.136)	(0.0997)
dsector4	2.173*	-0.0472	-0.641	0.203	1.529	0.342**	0.262**
	(1.133)	(0.101)	(1.190)	(0.276)	(1.031)	(0.144)	(0.113)
dsector5	-1.975	0.0380	0.195	0.308	-2.038*	0.118	0.168
	(1.213)	(0.105)	(1.021)	(0.249)	(1.102)	(0.154)	(0.117)
dsector6	-3.454***	0.0962	-0.959	0.521***	-4.714***	-0.232*	-0.0539
	(0.804)	(0.0753)	(0.796)	(0.165)	(0.977)	(0.136)	(0.0909)
dsector7	-2.241**	0.0657	1.054	0.115	-1.981	-0.266	-0.0341
	(0.954)	(0.0939)	(0.942)	(0.226)	(1.339)	(0.186)	(0.119)
dsector8	-1.900*	-0.0544	0.826	-0.538*	-2.289*	-0.152	0.0908
	(1.024)	(0.0950)	(1.082)	(0.295)	(1.297)	(0.181)	(0.123)
dsector9	-2.801***	0.258***	-0.247	0.156	-3.730***	-0.518***	-0.236*
	(0.859)	(0.0869)	(0.995)	(0.205)	(1.438)	(0.200)	(0.122)
Constant	3.957	-1.188***	-0.899	-1.602***	3.954	1.017**	-4.878***
	(2.860)	(0.271)	(2.445)	(0.595)	(3.545)	(0.501)	(0.356)
Observations	7,175	7,175	7,182	7,182	7,165	7,165	7,165

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1