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R&D, Export, and Investment Decision

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Abstract

This paper provides an empirical analysis of the mechanism through which R&D and export influence investment decision. The analysis is based on a large representative and cross-country comparative sample of manufacturing firms across seven European countries. To control for reverse causality between export decision and R&D spending and investment, we use an instrumental variable analysis to overcome the problem of endogeneity. Employing a three step procedure, it is assumed that R&D decision is endogenously determined by receiving public subsidies, and, in turn, affect investments through its impact on engagement by the firm in international trade. The results suggest that R&D positively affects export propensity. We find that there is an average increase in propensity to invest for those firms which decide to engage in R&D activities. The results also reveal that the effect of decision to export on investment behaviour is positive and highly significant, when accounting for endogeneity of export activity.

Keywords: export, R&D, IV model

JEL classification: O32, F14, C36, B22

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Introduction

There is a general consensus among economists that R&D and engagement in international markets are two main forces of economic growth. Several authors have studied the relationship between R&D and productivity growth (Jones and Williams, 1998), as well as between export and growth (Grossman and Helpman, 1995). Also the interaction between innovation and international trade further foster economic growth, through technological spillovers, channelled by trade (Coe and Helpman, 1995). However, investment (as a share of GDP) is the most robust explanatory variable of a country's growth in empirical studies using international panel data (Sala-i-Martin, 1997).

Eurostat (2015) reveals that between 2004 and 2014, gross capital formation decreased by 1.8%, due, in large part, to sharp falls between the outbreak of the global financial crisis in 2007 and 2009 (–11.9%), and 2012–2013. In 2007–2009, investment rate of non-financial corporations declined from over 34% to 21.6% in Spain, and by 3.1 and 2.6 percentage points, respectively, in Italy and UK.

This paper investigates the mechanism through which R&D and export influence investment decision in seven European countries during 2007–2009. Using micro-level data, we assess the firms' decision about investing or not, differentiating between R&D-performing firms and those which did not carry out R&D expenditures. Moreover, we differentiate firms between those which reported positive exports before 2008 and those which did not.

Although prior empirical research has addressed the returns to R&D (Chan et al, 2001; Medda and Piga, 2014), it is still not completely clear whether R&D affect the investment decision by a firm (Lin, 2012). Exporting activity, also, positively influences performance by the firm, however, limited research is available on the relationship between international trade and investments. With this study we attempt to shed some light onto these mechanisms, trying to disentangle the strategic decisions by the firm regarding R&D, exports, and investment. Also, this represents a novelty in the empirical literature. Investment behaviour studies have mainly focused on the financial factors and uncertainty as determinants of a firm's investments (Mairesse, Hall, Mulkay, 1999; Carruth, 2000).

We analyse the relationship between R&D and investments, on one side, and exports and investments, on the other. Given their ability to manage risk, firms which spend on R&D expect higher returns on investment than do traditional firms, and are more likely to bear high capital costs, and hence invest more, especially when there is a shortage of available credit. Further, R&D programs may lead to product or process innovations, which may result in new investment programs. (Mairesse and Siu, 1984).

Innovative activities may require additional facilities and equipment to be pursued, thus involving physical investment by the firm (Lach and Rob, 1996). Lin (2012) argues that because physical capital embodies current technological progress, R&D increases the productivity of physical capital and reduces production costs, so that a firm's expected returns on physical investment are increased when it spends in R&D.

Furthermore, there is a sizeable body of theoretical and empirical work that recognizes the importance of R&D for productivity (Medda and Piga, 2014), competitiveness (Cohen and Levinthal, 1989), and export (Fryges et al, 2015; Wagner, 2007). Firms are required to invest in technology in order to push production and quality up to international standards of

competition. In fact, firms' activity in the international markets lies at the core of competitiveness. At the same time profits from good export performance can be used for investment, particularly if firms depend greatly on internal funds (Aw et al, 2011).

Finally, engagement in international trade enhances firms' competitiveness, especially in times of global financial and real economy crisis, hence stimulating productivity and investments (Harris and Li, 2009). Altomonte et al (2012) exploit the same dataset and find a positive correlation between firms' international activity and productivity.

This work follows this stream of literature, studying the effect of exporting decision on investment behaviour. We focus particular attention on the mechanism through which R&D and export influence investment decision. Firstly, we study the relationship between R&D decision (whether a firm has carried out R&D activities or not) and investments behaviour (whether a firm exhibits positive investments or not). The econometric methodology takes into account that firms that invest in R&D do not arise randomly in the sample. This may potentially introduce an endogeneity issue. Successful firms which conduct innovative activities are more likely to invest in physical capital. Hence, an IV specification is employed, where R&D is endogenously determined by public incentives to conduct R&D, along with other exogenous factors.

Successively, we investigate whether the characteristics of the firm which influence export decision may be correlated with investment behaviour. When estimating the impact of export on investment we treat export decision as an endogenous variable. Employing a three-step procedure, it is assumed that R&D decision is endogenously determined by receiving public subsidies, and, in turn, affects investments through its impact on engagement by the firm in international trade.

The analysis is based on a large and representative sample of European manufacturing firms, namely the Efige dataset. This provides information about exporting activity, investment and R&D expenditure by the firms, along with other survey and balance-sheet data. Data are cross-country comparative and are collected for seven countries: Germany, France, Italy, Spain, the UK, Austria and Hungary. The data-set refers to the period 2007-2009, when there was a financial squeeze in all European countries.

Among the factors which influence a firm's decision to carry out R&D, the analysis places particular emphasis on public financial support for R&D. Considerable effort has been devoted to evaluating the efficiency of public support for R&D, on the grounds that there may be underinvestment in R&D. Since innovative firms operate in a field where there is high technical uncertainty, even when they succeed they are not able to gain the full return associated with their innovations (Jones and Williams, 2000). In this analysis, public R&D grants influence a firm's investment behaviour, but solely through their impact of a firm's decision about whether or not to carry out R&D, and hence on export activity.

Hyytinen and Toivanen (2005) provide evidence that government funding helps firms in industries that are dependent on external financing. Czarnitzki and Toole (2007) find that R&D subsidies mitigate the effects of market uncertainty for the products of R&D investment and suggest ways in which public policies can increase R&D investment. Carboni (2011, 2012) found that public programs support marginal R&D projects which are expected to be low in profit and which would not be pursued without a subsidy.

The analysis reveals that R&D spending is positively correlated with the decision of being involved in international markets. Moreover, there emerges an average increase in propensity to invest for those firms which decide to engage in R&D activities, having received a financial incentive, in a range from 3% to 6.2%. The effect of decision to export on investment behaviour is found to be positive and highly significant, solely when we account for endogeneity of exporting activity, with marginal effects in a 9% - 19% range, depending on the model specification.

These results are in line with existing studies documenting the positive association between R&D, export and firm's performance. However, to the best of our knowledge, this study is the first analysing investments as resulting from a sequential decision process regarding carrying out R&D activities, exporting, and investment behaviour.

The remainder of the paper is organized as follows. Section 1 describes the data set and section 2 presents the variables employed in the econometric analysis. Section 3 describes the estimation equation and the econometric technique. Section 4 contains the estimates of the effect of R&D on investment behaviour. The conclusions are reported in section 5.

1 Data and descriptive statistics

Data used in this study are taken from the EFIGE dataset, a representative (at the country level for the manufacturing industry) and cross-country comparable sample of 14,911 manufacturing firms across seven European countries: about 3,000 firms from each of France, Germany, Italy and Spain, 2,000 from the UK, and 500 each from Austria and Hungary. The EFIGE questionnaire provides information on the structure and the behaviour of firms. It is complemented with their balance sheets, taken from Amadeus, a database of comparable financial information for public and private European companies collected by the Bureau van Dijk.

The database, for the first time in Europe, contains qualitative and quantitative data on the characteristics and activities of firms. This results in a total of around 150 different variables, split into six different sections (proprietary structure of the firm; structure of the workforce; investment, technological innovation and R&D; internationalization; finance; market and pricing). The firms included in the dataset were selected using a sampling design that stratifies them by sector and firm size. Three elements were used in the sample stratification: industries (11-NACE classification), regions (NUTS-1 level of aggregation) and size class (10-19; 20-49; 50-250; more than 250 employees). The reference population consists of firms with more than 10 employees.

All the questions were for the year 2008, with some questions asking information about 2009 and the balance sheet data from previous years. After some necessary cleaning, the final dataset includes 14,010 European firms (see Table 1). About 21.4% are from Italy, 3.2% from Austria, 20.7% each from France and from Germany, 3.3% from Hungary, about 16% from Spain, and 15% from the UK (see Altomonte and Aquilante, 2012 for more information). Most firms are small: 73% of the firms have less than 50 employees; only 6.9% of firms are large, with 250 employees or more.

Indeed, one limit of the dataset is that it is only a cross-section. This clearly prevents the analysis from addressing long-term considerations.

About half of the firms in the sample carried out R&D. Statistics reveal small differences among size classes. Conversely, differences show to be marked across industries. Across countries, Italy, Germany and UK have larger shares of R&D performing firms, while firms from Austria, France and Spain are more likely to receive fiscal grant to conduct R&D activities. 64,7% of the firms declare to have exported with a relatively larger propensity in Austria and Italy. Again, small differences across firms' size is observed. Cross-country comparisons show that Germany is the country with the largest percentage of firms which exhibit positive investments (97.3%). In Italy, by contrast, only 81.4% of companies did invest. This is significantly below the mean value for the whole sample (87.6%).

Table 2 provides cross-tabulations of our four key variables: R&D-fiscal grant, R&D, export, and investments. It emerges that R&D is not necessarily considered as an investment, as 567 firms out of 1,744 which declare no investments have carried out R&D activities. Furthermore, over half of the firms with positive investments also carried out R&D. Note that 41.1% of the sample firms declare positive investments but no R&D activity. The relationship between export and investments appears to be strong: for nearly two-thirds of companies which recorded positive investments an export activity is observed; conversely, of the firms which did export, over 88% exhibit positive investments. Table 2 also shows that R&D-performing firms are more likely to export: 79.1% of firms which declare to have carried out R&D expenditures also have positive exporting, against 50% of exporting firms observed among non-R&D performing companies.

All firms which received R&D fiscal grants realized R&D activities, and 33.8% of firms in the sample carried out R&D expenditures regardless of fiscal incentives. Ruling out the possibility of so-called "defiers" (i.e. agents whose behaviour is the opposite of the group they are assigned to) and using the taxonomy reported in Angrist and Pischke (2009), such firms are "always takers": firms which do R&D regardless of receiving public funding. By contrast, those firms which undertake R&D after having received R&D grants are mainly so called "compliers", i.e. firms which would not have carried out R&D in the absence of R&D grants.

2 Dependent variables and controls

This section describes the variables used in the empirical analysis. The dependent variable, which characterizes a firm's investment behaviour, is a dummy indicating if a firm has undertaken investments or not (*D_INV*). R&D and export behaviour are also captured by two dummies indicating if firms have carried out R&D expenditures (*D_R&D*) and if firms exhibited positive exporting before 2008 (*D_EXP*). An additional variable (*D_GRANT*) indicates if firms have received fiscal incentives to conduct R&D activities.

The use of binary dependent variables allows us to better disentangle the mechanisms beyond firms' strategic decisions to innovate, export and invest which is actually the main objective of this work. In fact, it may be important to increase the numbers of firms which carry out those activities, rather than increase the amount spent on R&D and investment, and sales from exports, by "happy few" competitive firms (Mayer and Ottaviano, 2007).

Table 3 outlines the aim of this work, by presenting a decomposition of the sample which stresses the influence that fiscal incentives have on R&D activities which in turn influence export behaviour. It is argued that fiscal incentives affect export decision only by

their impact on R&D decision. Moreover, it is argued that exporting firms may have different propensity to invest from non-exporting companies. Among firms which carried out R&D activities, 85.5% declare to have exported, having received fiscal incentives to conduct R&D, while 76% have exported having not received any R&D grant.

Among firms which declare to have exported, 83.3% (2,896 firms over 3,478) record positive investments, having not carried out R&D activities, while 91.9% (3,285+1,855 firms over 3,600+1,993) show positive investments having undertaken R&D expenditures. This supports our hypothesis that a channel exists from fiscal incentives aimed to spur firms' R&D activities to traditional investment decision, through R&D spending and export behaviour. Table 4 reports statistics for the variables included in the analysis, as factors affecting R&D, export and/or investment decision.

Given its potential importance in investment decisions, a size variable, expressed as the logarithm of the number of employees (*EMPL*), is considered in the model. Given the considerable amount of heterogeneity in the production system, size may be important for understanding the differences in the average behaviour of firms (Hubbard, 1998), and as a factor impacting financial constraints. Furthermore, firm size is supposed to reflect a firm's ability to absorb new technology, its organizational capacity, economies of scale and scope, access to markets and acquirement of resource. A firm's size is also a crucial factor in determining whether or not to conduct R&D activities, and how much to invest in it (Cohen and Klepper, 1996).

The sources of investments may vary considerably across firms. Hall (2002) argues that external financing of innovation may be more costly than other investments. As a result a variable indicating the amount of internal financing (*INV_internal-finan*) is included in the model. This is measured as a percentage of self-financing of investments in plants, machines, equipment and ICT in the last three years.

A measure of the financial constraints, captured by some variables indicating a firm's willingness to apply for more credit, is also considered (*RATION*). Such constraints are, in general, good at explaining under-investment in technology and in R&D expenditure.

A great deal of the theoretical and empirical literature on firm-level investment has focused on the role that financial factors and liquidity play in investment decision (Schiantarelli, 1996; Hubbard, 1998; Mairesse, Hall, Mulkay, 1999). The argument is that having access to internal resources facilitates investment, by limiting the risks that arise when firms use external sources of finance. Internal funds are typically characterized by low information costs (Devereux and Schiantarelli, 1990), which in turn influence a firm's investment activity.

The age of the firms, measured in years since their foundation, is also included in the model (*AGE*). If a learning-by-doing process occurs (Arrow, 1962), the stock of intangible assets, which is cumulative in nature, is likely to grow with the age of the firm. Wagner (2015) finds that older firms are more likely to export.

We also distinguish between firms which received public R&D grants and those which did not (Carboni 2013a,b). A binary variable indicates if firms belong to the former group or the latter (*DU_fiscal_grant*). Two variables which are equal to one if the firm is part of a foreign group (*GROUP_foreign*) and if the firm is part of a domestic group (*GROUP_national*) are also considered in the model. Schiantarelli and Sembenelli (2000) found that firms belonging to large and medium-sized business groups are less sensitive to cash flow

constraints.

A variable controlling for large firms (250 or more employees, *SIZE_large*) and an interaction term controlling for mainly self-financed firms (>50% of sales) and able to access more credit (*INT_FIN_high_RATION*) are also included among the regressors.

Industry dummies are used to pick-up sector heterogeneity. For similar reasons, country dummies are also included in the analysis.

Admittedly, more explanatory variables should have been included, as proxies for the relative costs of labour and capital and the financial structure of the firms. However, the dataset severely limits this possibility, and the use of this and other desirable information would have meant the loss of up to five thousand observations, depending on the variable considered. Thus we preferred to improve the robustness of the estimates by including the largest possible number of firms with reliable information in the sample.

3 The analytical setting

The purpose of the following is to investigate what determines a firm's investment decisions, with particular emphasis on the role of research and exporting activities. It is assumed that firms determine whether or not to invest in R&D rationally, and thus the sub-sample of firms performing R&D is not random, which may potentially introduce an endogeneity issue. Secondly, innovative activities affect firms' propensity to compete in international markets. R&D and exports are then two strategic factors which induce firms to invest more.

The questions of both endogeneity and simultaneity are dealt with by employing a system estimation method to analyse how the characteristics that influence a firm's strategy affect the likelihood that they will opt for a particular decision. The analysis also combines the decision to carry out R&D with the propensity to export, in order to assess its relationship with the general investment behaviour of the firms.

In order to compare the investment behaviour of R&D-performing firms and non-R&D firms, on one side, and exporting firms and non-exporting firms, on the other, we can employ an investment equation which controls for firm-specific characteristics (vector X^1) and macroeconomic factors (vector Z). The latter is to account for country-specific and industry effects; the former includes firms' size, age, source of financing and measures of cash flow and credit constraints, among the firm-specific characteristics. Our dependent variable is a dummy indicating if firms declare to have carried out traditional investments or not:

$$D\_INV_i = f(X_i^1, Z_i, D\_R\&D_i) \quad (1a)$$

$$D\_INV_i = f(X_i^1, Z_i, D\_EXP_i) \quad (1b)$$

In eq. (1a) investment decision depends on a variable which takes value equal to zero if no R&D spending is observed for firm *i*, otherwise it is equal to one if positive R&D expenditures are reported by firm *i*. Eq. (1b) includes among independent variables a dummy indicating if firm *i* has exported or not. Simultaneously with the decision whether to invest in physical capital, or prior to this decision, firms decide on their innovative and exporting strategies. Hence the R&D equation and an export equation is as follows:

$$D\_R\&D_i = f(X_i^2, Z_i, DU\_fiscal\_grant_i) \quad (2a)$$

$$D\_EXP_i = f(X_i^2, Z_i, D\_R\&D_i) \quad (2b)$$

where X^2 represents a vector of the firm specific characteristics which affect the decision about conducting innovative activities and whether to export or not. As above, a vector Z of country-specific and industry variables is included. *DU_fiscal_grant* is a variable indicating whether a firm has received a public R&D grant which influences the R&D behaviour of the firm (namely the decision of whether or not to engage in innovative activities), but it does not impact investment behaviour directly. Since public subsidies or other public incentives aimed at stimulating R&D activities by the firm cannot be used for purposes other than R&D, it is assumed that public incentives affect investment behaviour solely through their impact on R&D decisions.

Studying the impact of R&D decision on the propensity to invest, unobservable characteristics differentiate the behaviour of R&D performing firms from non-R&D performing firms and, as a consequence, the OLS estimation of investment equation produces biased and inconsistent estimators for the parameters in the model. Following Wooldridge (2002), we use a two-stage approach, where as a first step we estimate an R&D equation (eq. 2a), compute predicted values and use them as an instrument for R&D in equation (1a).

Successively, a three-step procedure is applied to take into account that R&D behaviour may influence investment decision through its impact on the propensity to export. Hence the predicted values from eq. 2a are used as an instrument for R&D in order to estimate the propensity to export (eq. 2b). We control for endogeneity of export decision in eq. 1b by using predicted values from eq. 2b as an instrument for export in the investment decision equation. Note that equations 2a and 2b do not assume the form of a probit/logit model even if R&D and exports are represented by binary variables decision. A simple OLS model is, instead, employed for this purpose. As Angrist and Krueger (2001) argue, using a non-linear first stage to generate fitted values for the second stage is not necessary and may even result in inconsistent estimates, unless the first stage model is exactly correct.

Angrist and Krueger (2001) provide similar arguments for second-stage equation too. They argue that if the second-stage relationship is non-linear, then a correctly specified functional form is required for an easy interpretation of the results, while linear 2SLS captures the average causal effect of R&D and export on investments for those firms whose behaviour would be changed by the instrument if it were assigned in a randomized trial. In some cases both results (instrumental variable and bivariate probit) are provided.

4 Econometric results

Given the main objective of this work, which is to investigate whether R&D and exporting decision affect firms' investment behaviour, the analysis tries firstly to assess whether R&D-performing firms are more likely to exhibit positive investment expenditures. It is assumed that firms that carry out R&D may arise randomly, giving rise to a potential endogeneity issue which we deal with by employing a two-step procedure where public incentives to conduct R&D is the main driver influencing the R&D decision.

Secondly, it is investigated how firms' investment behaviour is affected by the decision whether to export or not, which in turn is supposed to be different between R&D and non-R&D performing firms. As explained in the preceding section, a three-step procedure is

employed in order to take into account the potential endogeneity problem. The schemes in Figure (1) outline the econometric strategy employed. Estimations of eq. 2a and 2b are run in order to build instruments for the R&D and export variables, the former included eq. 2b, and both the former and the latter in (second-stage) eq. 1a and 1b. The results from the first-stage equations are reported in Table 5.

As expected, incentives to R&D have a positive and significant impact on the decision whether to carry out research activities. The same applies for firm's size and the variables capturing internal financing and credit rationing (at 1‰ level of significance). Also the coefficient of the age of the firm is positive and significant, though at a lower level (5%).

Export equation estimates (eq. 2b) take into account the possible endogeneity of R&D, by a IV model. R&D is instrumented by predicted values from eq. 2A, and the test of endogeneity is found significant at 1‰ level of significance, thus supporting our hypothesis. There is a strong and positive effect of R&D decision on the propensity to export. Size and age of firm have a positive and significant impact on export (at 1‰ level of significance) and so has the variable capturing credit rationing (at 5% level), while the variable capturing internal financing is scarcely significant. Finally, in both R&D and export equations there are significant differences between sectors and countries.

Table 6 reports the regression estimates of the impact of carrying out R&D on the investment behavior, along with exogenous covariates and controls. In column (1) and (2) there are reported, respectively, OLS and Probit estimates, which are taken as benchmarks for the IV estimates. In both models the R&D variable shows a significant and positive impact on the propensity to invest. The marginal effects are about 4.3% in the simple OLS estimator, and 3.4% in the Probit model. This result can be interpreted as a 3.4%-4.3% higher investment propensity on average for those firms which engage in R&D activities.

Models in columns (3) and (4) consider the potential endogeneity of R&D instrumenting this latter by the predicted values from OLS regression (2a) in Table 5. Both models show positive and highly significant coefficients for R&D: 6.2% when the standard IV estimator is applied and 0.270 (which implies a marginal effect of 3%) when the bivariate probit estimator is employed. These coefficients can be interpreted as an average increase in the propensity to invest (ranging from 3% to 6.2%) for those firms which, having received a financial incentive, decide to engage in R&D activities. These results can be generalized for all R&D-performing firms, assuming that the beneficial effect of R&D is common for all innovative firms.

The test for endogeneity for both the IV estimator and the bivariate probit model does not allow us to reject the hypothesis of exogeneity of R&D. A similar result is found in Carboni and Medda (2015), where the impact of carrying out R&D activities on investment intensity is tested. However, they found that R&D expenditures over sales is endogenous with respect to investments.

Size, internal financing and credit rationing variables have positive and significant coefficients. Age of the firms, as well as the variable which differentiates firms with more than 250 employees, seem to have no significant effect on investment decision. Belonging to a group, both national and international, has a negative impact on investment behaviour. This result, possibly influenced by the international financial crisis which occurred in the period covered by the dataset, contrasts somewhat with theoretical predictions, which state that firms which are supported by a group have more financial resources to invest, while

smaller firms are more vulnerable to financial crisis.[1]

We then estimated the relationship between a firm's exporting decision and investments. Table 7 (column 1 and 2, respectively) shows the results from a simple OLS regression and a Probit model of investment on the R&D variable, with covariates and controls. The same table in columns (3) – (4) shows the results for model 2 in Figure 1, where export decision is allowed to be endogenous, through the use of instrumental variable methods. The model in column (3) refers to a standard IV variable technique, while in column (4) refers to a bivariate probit model.

The coefficient of export from the OLS and Probit estimates is not significant. We argue that this result may be biased due to endogeneity of export decision. Indeed, when accounting for endogeneity, the marginal effect of decision to export on investment behaviour is found to be positive and highly significant, with a value of 19.1%. The test of endogeneity reported in Table 7 reveals that exports cannot be treated as exogenous, corroborating our econometric strategy.

The bivariate model confirms the existence of an endogeneity problem, while the marginal effect of export to investment decision is highly significant and equal to 7.8%. The hypothesis that the estimated slope coefficients of the industry dummies are jointly zero can be safely rejected at one percent significance in all of our models, confirming that there are differences in the investment intensity across industries.

These results are consistent with existing literature documenting the positive association between R&D, export and firm's performance, although to the best of our knowledge, our study is the first analysing investments as resulting from a sequential decision process regarding carrying out R&D activities, exporting, and investment behaviour.

Given the cross sectional nature of the data set, the analysis does not allow us to test the long-term innovative activities behaviour of firms. However, the results show that, even in a period of international crisis, innovative activities sustain firms' investments, both directly and through its effect on exporting activity. Indeed, exporting behaviour induces firms to invest more. However, this result holds when we take account of the hypothesis that decisions on R&D spending, exports and traditional investments are taken simultaneously by the firms.

Interestingly, the estimates reveal that there are substantial cross-country differences in the sample. To be more precise, the analysis shows that in Germany the estimated coefficients are generally larger are than those in the other countries. This implies that, after checking for firm's characteristics, in all the other remaining countries in the sample, firms are less likely to invest than those in Germany. This is confirmed by all the models run for the empirical analysis.

Conclusion

This paper investigates firms' investment behaviour in seven European Countries during the 2007–2009 crisis. Data are taken from the EFIGE dataset, a representative and cross-country comparable sample of manufacturing firms across Germany, France, Italy, Spain, the UK, Austria and Hungary. The data-set refers to the period 2007-2009, when

1 Using the same dataset, Barba Navaretti et al (2011) found that belonging to a national group does not affect propensity to export, while foreign ownership is positively correlated with exports.

there was a financial squeeze in all European countries.

We try to assess firms' decision about investing or not more in detail, differentiating between firms which carried out R&D expenditures and those which did not. The analysis also differentiates firms between those which reported positive exports before 2008 and those which did not. In doing so we attempt to shed some light onto the mechanisms driving the strategic decisions by the firm concerning R&D, exports, and investment. This is novel in the empirical literature which has mainly focused on the financial factors and uncertainty as determinants of a firm's investments.

We analyse the relationship between R&D and exports, on one side, and investments, on the other, in the business sector. The rationale is that R&D-spending firms expect higher returns on investment than do traditional firms, and are more likely to bear high capital costs, and hence to invest more. The analysis pays particular attention to the mechanism through which R&D and export influence investment decision. The driving idea is that R&D-performing firms are more competitive in international markets: those which invest in technology are able to push production and quality up to international standards of competition and, hence, have a larger propensity to export. In turn, companies which are engaged in international trade face opportunities to gain profits from good export performance, which can be used for investment, particularly if firms depend greatly on internal funds.

As a first step, the relationship between R&D decision and investments behaviour is investigated. The econometric methodology takes into account that in a group of firms, those that invest in R&D do not arise randomly. In fact, firms which conduct innovative activities are more likely to invest in physical capital. This may potentially introduce an endogeneity issue. Hence, an IV specification is employed, where R&D is endogenously determined by public incentives to conduct R&D, along with other exogenous factors.

In the same way, characteristics of the firm which influence export decision may be correlated with investment behaviour. When estimating the impact of export on investment we treat export decision as an endogenous variable. Employing a three-step procedure, we assume that R&D decision is endogenously determined by the receiving public subsidies, and, in turn, affect investments through its impact on engagement by the firm in international trade.

The analysis reveals that R&D spending is positively correlated with the decision of being involved in international markets. We find that there is an average increase in propensity to invest for those firms which decide to engage in R&D activities, having received a financial incentive, in a range from 3% to 6.2% depending on the model specification. The results also reveal that the effect of decision to export on investment behaviour is positive and highly significant, solely when accounting for endogeneity of export activity. In this case the marginal effects are in a range from 9% to 19.1%, depending on the model.

The results are consistent with existing literature documenting the positive association between R&D, export and firm's performance. However, to the best of our knowledge, this work is the first analysing investments as resulting from a sequential decision process involving carrying out R&D activities, exporting, and investment behaviour.

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Figure 1

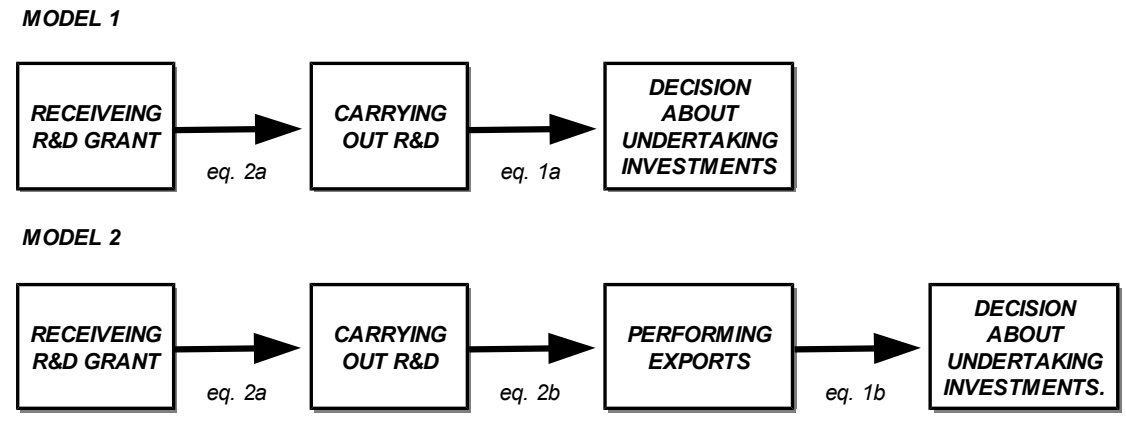
MODEL 1
RECEIVEING R&D GRANT
eq. 2a
CARRYING OUT R&D
eq. 1a
DECISION ABOUT UNDERTAKING INVESTMENTS
MODEL 2
RECEIVEING R&D GRANT
eq. 2a
CARRYING OUT R&D
eq. 2b
PERFORMING EXPORTS
eq. 1b
DECISION ABOUT UNDERTAKING INVESTMENTS.

Table 1 - Dataset: country and industry composition

	Did receive R&D grant		Did undertake R&D		Did export before 2008		Did undertake investments		Total
COUNTRY									
Austria	106	(23.4%)	231	(51.0%)	340	(75.1%)	430	(94.9%)	453
France	587	(20.2%)	1,464	(50.4%)	1,762	(60.6%)	2,426	(83.5%)	2,907
Germany	279	(9.6%)	1,538	(53.0%)	1,825	(62.9%)	2,824	(97.3%)	2,902
Hungary	33	(7.1%)	109	(23.3%)	308	(65.8%)	399	(85.3%)	468
Italy	578	(19.3%)	1,651	(55.2%)	2,155	(72.0%)	2,436	(81.4%)	2,993
Spain	433	(19.8%)	964	(44.0%)	1,347	(61.5%)	1,969	(89.9%)	2,189
U.K.	314	(15.0%)	1,112	(53.0%)	1,334	(63.6%)	1,782	(84.9%)	2,098
MANUFACTURING									
food product, beverage and tobacco	172	(12.0%)	580	(40.5%)	693	(48.4%)	1,295	(90.4%)	1,433
textiles and textile products	210	(11.0%)	821	(43.0%)	1,120	(58.7%)	1,614	(84.5%)	1,909
leather and leather products + manufacture of other non metallic	532	(23.7%)	1,334	(59.4%)	1,536	(68.4%)	1,947	(86.6%)	2,247
wood and wood products	57	(8.6%)	220	(33.2%)	350	(52.9%)	571	(86.3%)	662
coke; refined petroleum products and nuclear fue	0	(0.0%)	6	(30.0%)	13	(65.0%)	20	(100%)	20
chemicals, chemical products and man-made fibres	153	(29.7%)	398	(77.3%)	428	(83.1%)	469	(91.1%)	515
rubber and plastic products	158	(17.6%)	511	(56.8%)	688	(76.4%)	800	(88.9%)	900
basic metals and fabricated metal products	398	(12.3%)	1,359	(42.1%)	1,930	(59.8%)	2,839	(87.9%)	3,230
machine and equipment n.e.c.	411	(23.9%)	1,105	(64.3%)	1,376	(80.0%)	1,520	(88.4%)	1,719
transport equipment	101	(25.3%)	233	(58.3%)	273	(68.3%)	351	(87.8%)	400
manufacturing n.e.c	138	(14.2%)	502	(51.5%)	664	(68.1%)	840	(86.2%)	975
SIZE									
Small (< 50 empl.)	1,732	(16.9%)	5,211	(51.0%)	6,656	(65.1%)	8,966	(87.7%)	10,225
Medium (50 – 250 empl.)	2,184	(16.8%)	6,595	(50.6%)	8,455	(64.8%)	11,417	(87.6%)	13,038
Large (> 250 empl.)	146	(15.0%)	474	(48.8%)	616	(63.4%)	849	(87.3%)	972
Total	2,330	(16.6%)	7,069	(50.5%)	9,071	(64.7%)	12,266	(87.6%)	14,010

Table 2 - Cross-tabulations of firms by propensity to invest, R&D and exporting.

		DID UNDERTAKE R&D					
		No		Yes		Total	
DID RECEIVE R&D GRANT	No	6,941	(49.5%)	4,739	(33.8%)	11,680	(83.4%)
	Yes	0	(0.0%)	2,330	(16.6%)	2,330	(16.6%)
	Total	6,941	(49.5%)	7,069	(50.5%)	14,010	(100%)

		DID EXPORT BEFORE 2008					
		No		Yes		Total	
DID UNDERTAKE R&D	No	3,463	(24.7%)	3,478	(24.8%)	6,941	(49.5%)
	Yes	1,476	(10.5%)	5,593	(39.9%)	7,069	(50.5%)
	Total	4,939	(35.3%)	9,071	(64.7%)	14,010	(100%)

		DID UNDERTAKE INVESTMENTS					
		No		Yes		Total	
DID UNDERTAKE R&D	No	1,177	(8.4%)	5,764	(41.1%)	6,941	(49.5%)
	Yes	567	(4.0%)	6,502	(46.4%)	7,069	(50.5%)
	Total	1,744	(12.4%)	12,266	(87.6%)	14,010	(100%)

		DID UNDERTAKE INVESTMENTS					
		No		Yes		Total	
DID EXPORT BEFORE 2008	No	709	(5.1%)	4,230	(30.2%)	4,939	(35.3%)
	Yes	1,035	(7.4%)	8,036	(57.4%)	9,071	(64.7%)
	Total	1,744	(12.4%)	12,266	(87.6%)	14,010	(100%)

Table 3 - Investment and R&D intensities

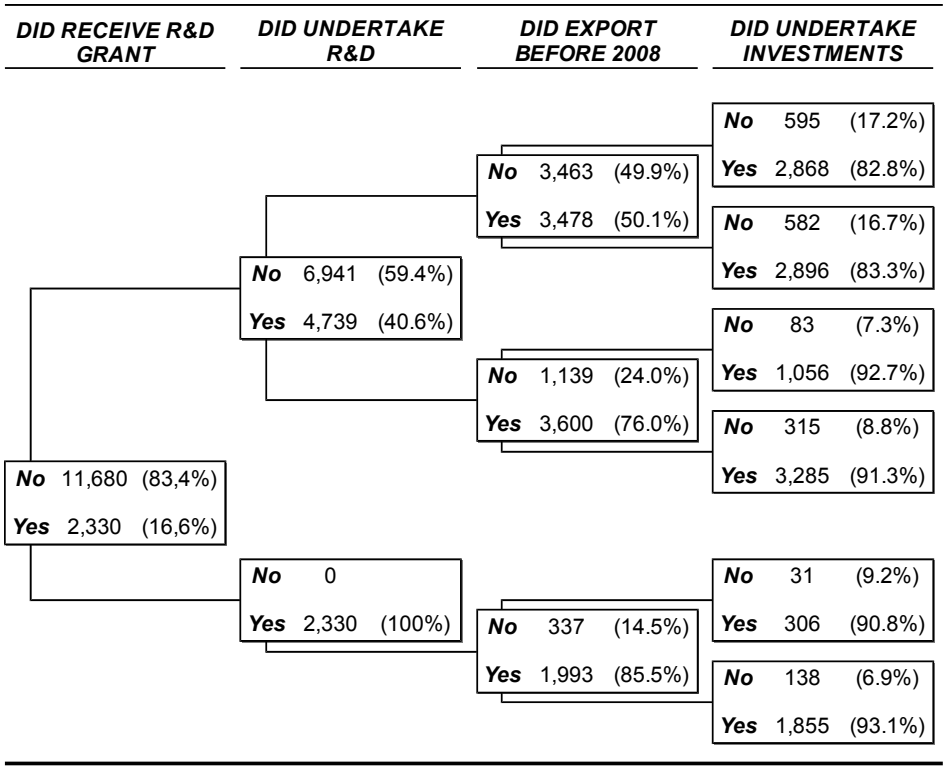

Table 4 – Descriptive statistics for control variables: mean (std. dev.)

	Did receive R&D grant		Did undertake R&D		Did export before 2008		Did undertake investments	
	No	Yes	No	Yes	No	Yes	No	Yes
Observations	11,680	2,330	6,941	7,069	4,939	9,071	1,744	12,266
EMPL	3.58	3.56	3.60	3.56	3.60	3.57	3.59	3.58
	(1.03)	(1.03)	(1.03)	(1.02)	(1.04)	(1.02)	(1.02)	(1.03)
INV_internal-finan	3.10	3.32	2.95	3.31	3.00	3.21	1.05	3.43
	(1.55)	(1.41)	(1.59)	(1.44)	(1.55)	(1.51)	(.40)	(1.39)
AGE	3.20	3.26	3.16	3.26	3.07	3.29	3.11	3.23
	(.87)	(.84)	(.86)	(.87)	(.89)	(.84)	(.83)	(.87)
RATION	0.15	0.22	0.15	0.18	0.14	0.18	0.14	0.17
	(.36)	(.42)	(.35)	(.39)	(.35)	(.38)	(.35)	(.37)
INT_FIN_high_RATION	0.16	0.27	0.14	0.21	0.13	0.21	0.01	0.20
	(.83)	(1.07)	(.79)	(.95)	(.74)	(.94)	(.19)	(.93)
SIZE_large	0.07	0.06	0.07	0.07	0.07	0.07	0.07	0.07
	(.26)	(.24)	(.26)	(.25)	(.26)	(.25)	(.26)	(.25)
GROUP_foreign	0.09	0.09	0.09	0.08	0.09	0.09	0.12	0.08
	(.28)	(.29)	(.29)	(.28)	(.29)	(.28)	(.33)	(.28)
GROUP_national	0.13	0.14	0.13	0.14	0.13	0.14	0.18	0.13
	(.34)	(.34)	(.34)	(.34)	(.34)	(.34)	(.39)	(.33)

Table 5 – R&D and Export propensity equations

	(2a)			(2b)		
Dependent variarle	*D_R&D*			*D_EXP*		
Estimation tecnique	OLS			IVOLS		
Endogenous variable	-			D_R&D		
Instrument used	-			*(predicted values from eq. 2[a])*		
DU_fiscal_grant	0.524	(0.010)	***			
D_R&D				0.311	(0.020)	***
EMPL	0.056	(0.004)	***	0.056	(0.004)	***
INV_internal-finan	0.029	(0.002)	***	0.004	(0.003)	
AGE	0.009	(0.004)	*	0.054	(0.004)	***
RATION	0.042	(0.010)	***	0.026	(0.010)	*
Germany	0.011	(0.013)		-0.033	(0.013)	*
Austria	-0.054	(0.023)	*	0.119	(0.023)	***
Spain	-0.096	(0.013)	***	0.034	(0.014)	*
Italy	0.022	(0.012)		0.086	(0.013)	***
Hungary	-0.262	(0.022)	***	0.140	(0.024)	***
France	-0.026	(0.013)	*	-0.023	(0.013)	
constant term	0.143	(0.024)	***	0.117	(0.025)	***
Industry dummies	Yes			Yes		
Test for all industry dummies = 0	31.17	***		299.89	***	
F	220.24	***				
chi2				2005.45	***	
Test of endog, (chi2)				21.14	***	
Observations	14,010			14,010		

s.e. in parethesis.

** p<0.05, ** p<0.01, *** p<0.001*

Table 6 - Investment behaviour and the decision to carry out R&D (eq. 1a)

	(1)	(2)	(3)	(4)
Dependent variarle	*D_INV*	*D_INV*	*D_INV*	*D_INV*
Estimation tecnique	OLS	PROBIT	IVOLS	BIPROBIT
Endogenous variable	-	-	*D_R&D*	*D_R&D*
Instrument used	-	-	*(predicted values from eq. 2a)*	*(predicted values from eq. 2a)*
D_R&D	0.043 ***	0.305 ***	0.062 ***	0.270 **
	(0.005)	(0.042)	(0.013)	(0.105)
EMPL	0.017 ***	0.178 ***	0.015 ***	0.182 ***
	(0.002)	(0.023)	(0.003)	(0.026)
INV_internal-finan	0.114 ***	0.947 ***	0.113 ***	0.949 ***
	(0.002)	(0.029)	(0.002)	(0.029)
AGE	-0.002	0.011	-0.002	0.012
	(0.003)	(0.024)	(0.003)	(0.024)
RATION	0.106 ***	0.401 ***	0.105 ***	0.404 ***
	(0.007)	(0.052)	(0.007)	(0.053)
INT_FIN_high_RATION	-0.028 ***	-0.266 ***	-0.028 ***	-0.266 ***
	(0.003)	(0.053)	(0.003)	(0.053)
SIZE_large	-0.017	-0.127	-0.017	-0.128
	(0.009)	(0.078)	(0.009)	(0.078)
GROUP_foreign	-0.039 ***	-0.265 ***	-0.039 ***	-0.264 ***
	(0.008)	(0.063)	(0.008)	(0.063)
GROUP_national	-0.042 ***	-0.300 ***	-0.042 ***	-0.300 ***
	(0.007)	(0.053)	(0.007)	(0.053)
Germany	0.111 ***	1.251 ***	0.111 ***	1.252 ***
	(0.008)	(0.085)	(0.008)	(0.085)
Austria	0.082 ***	0.751 ***	0.082 ***	0.749 ***
	(0.014)	(0.149)	(0.014)	(0.149)
Spain	0.052 ***	0.302 ***	0.053 ***	0.298 ***
	(0.009)	(0.074)	(0.009)	(0.075)
Italy	0.026 **	0.308 ***	0.025 **	0.309 ***
	(0.008)	(0.062)	(0.008)	(0.062)
Hungary	-0.012	-0.272 *	-0.006	-0.284 *
	(0.014)	(0.126)	(0.015)	(0.130)
France	0.052 ***	0.431 ***	0.052 ***	0.430 ***
	(0.008)	(0.063)	(0.008)	(0.063)
constant term	0.383 ***	-1.893 ***	0.382 ***	-1.894 ***
	(0.016)	(0.137)	(0.016)	(0.137)
Industry dummies	Yes	Yes	Yes	Yes
Test for all industry dummies = 0	8.74***	64.36***	88.66***	55.97***
chi2		4908.72***	6129.56***	3939.08***
F	247.06***			
Tests of endogeneity			2.64	.127
Marginal effect of *D_R&D*		0.034***		.030**
Observations	14,010	14,010	14,010	14,010

s.e. in parethesis.
** p<0.05, ** p<0.01, *** p<0.001*

Table 7 - Investment behaviour and the decision to export (eq. 1b)

	(1)	(2)	(3)	(4)
Dependent variarle	*D_INV*	*D_INV*	*D_INV*	*D_INV*
Estimation tecnique	OLS	PROBIT	IVOLS	BIPROBIT
Endogenous variable	-	-	*D_EXP*	*D_EXP*
Instrument used	-	-	*(predicted values from eq. 2b)*	*(predicted values from eq. 2b)*
D_EXP	-0.001	-0.032	0.191 ***	0.780 ***
	(0.005)	(0.041)	(0.023)	(0.099)
EMPL	0.021 ***	0.212 ***	0.005	0.138 ***
	(0.002)	(0.023)	(0.003)	(0.024)
INV_internal-finan	0.116 ***	0.961 ***	0.113 ***	0.878 ***
	(0.002)	(0.029)	(0.002)	(0.032)
AGE	-0.002	0.015	-0.013 ***	-0.024
	(0.003)	(0.024)	(0.003)	(0.022)
RATION	0.110 ***	0.423 ***	0.102 ***	0.356 ***
	(0.007)	(0.052)	(0.008)	(0.050)
INT_FIN_high_RATION	-0.028 ***	-0.275 ***	-0.029 ***	-0.247 ***
	(0.003)	(0.052)	(0.003)	(0.049)
SIZE_large	-0.017	-0.136	-0.014	-0.119
	(0.009)	(0.078)	(0.010)	(0.072)
GROUP_foreign	-0.040 ***	-0.268 ***	-0.038 ***	-0.243 ***
	(0.008)	(0.063)	(0.009)	(0.059)
GROUP_national	-0.041 ***	-0.300 ***	-0.043 ***	-0.279 ***
	(0.007)	(0.053)	(0.007)	(0.049)
Germany	0.109 ***	1.231 ***	0.117 ***	1.174 ***
	(0.008)	(0.084)	(0.008)	(0.080)
Austria	0.081 ***	0.736 ***	0.059 ***	0.622 ***
	(0.014)	(0.147)	(0.015)	(0.139)
Spain	0.049 ***	0.261 ***	0.046 ***	0.247 ***
	(0.009)	(0.074)	(0.009)	(0.068)
Italy	0.028 ***	0.324 ***	0.009 **	0.225 ***
	(0.008)	(0.062)	(0.003)	(0.059)
Hungary	-0.025	-0.369 **	-0.034 *	-0.365 **
	(0.014)	(0.125)	(0.015)	(0.116)
France	0.053 ***	0.428 ***	0.056 ***	0.411 ***
	(0.008)	(0.063)	(0.008)	(0.059)
constant term	0.385 ***	-1.872 ***	0.360 ***	-1.914 ***
	(0.016)	(0.137)	(0.017)	(0.127)
Industry dummies	Yes	Yes	Yes	Yes
Test for all industry dummies = 0	6.79***	48.83***	114.21***	79.87***
chi2		4855.68***	5603.52***	4116.53***
F	242.67***			
Tests of endogeneity			81.34***	48.74***
Marginal effect of *D_EXP*		-.004		.090***
Observations	14,010	14,010	14,010	14,010

s.e. in parethesis.
** p<0.05, ** p<0.01, *** p<0.001*

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