Exports-R&D investment complementarity and economic performance: Are companies located in peripheral countries different?

by

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Master Dissertation in Economia e Gestão da Inovação

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July 2014

Biographic note

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Acknowledgements

I would like to express my deepest gratitude to all of those who helped me to complete this thesis.

Firstly, I want to thank my thesis advisors, Aurora Teixeira and Sandra Silva, for their valuable comments and for their great availability. I do not hesitate to recommend them to advise any other theses on the matter.

I would also like to thank Bank of Portugal which provided me the data that allowed me to do this thesis.

Finally, I would like to thank my family, my girlfriend and my friends, for the support they gave me during the last year.

Resumo

Existe um grande número de estudos sobre a relação entre a Investigação e Desenvolvimento (I&D) e as exportações. No entanto, os resultados nem sempre são claros: não obstante a maioria deles confirmarem uma relação significativa, positiva e bidirecional, outros não encontram relação significativa, e um número relativamente pequeno sugere uma associação negativa entre estas variáveis.

O presente estudo visa avaliar se, no caso de um país pequeno, aberto e periférico, em que as exportações são o motor do crescimento económico, mas que padece de um notório atraso no que respeita ao investimento em I&D, a I&D tem impacto e/ou influência sobre as exportações e a inter-relação entre a I&D e as exportações tem impacto sobre o desempenho económico das empresas.

A avaliação é efetuada através da estimação de modelos probit bivariáveis, que permitem a estimação simultânea das duas decisões (I&D e Exportação), levando em conta a correlação existente entre os erros de estimação das equações relativas ao I&D e às exportações, e de um modelo em painel que estima o impacto das decisões de I&D e exportação no desempenho económico das empresas. As estimações envolvem mais de 340 mil empresas não financeiras com sede em Portugal, no período 2006-2012.

Os resultados confirmam a existência de complementaridade entre a I&D e as exportações, o que significa que o desenvolvimento de atividades de I&D irá aumentar a probabilidade de a empresa também se envolver em atividades de exportação e que o envolvimento em atividades de exportação aumentará a probabilidade de também desenvolver I&D. Os resultados também evidenciam as empresas mais produtivas se auto selecionam para as atividades de exportação, retirando destas atividades importantes aprendizagens. Finalmente, comprovou-se que a I&D e as exportações têm um efeito positivo no crescimento das vendas, que é reforçada quando as duas atividades são desenvolvidas simultaneamente.

Os resultados obtidos têm importantes implicações de política. Em concreto, há evidência suficiente para sugerir uma alteração no paradigma de apoios públicos à I&D e exportação, frequentemente atribuídos de uma forma desarticulada e isolada. É, assim, imperativo que as políticas de inovação e de promoção das exportações sejam articuladas privilegiando, na atribuição e selecção de empresas para apoios públicos, as empresas que desenvolvem (ou têm intenções de desenvolver) em conjunto atividades de I&D e exportação. Tal exige ainda uma alteração institucional das políticas públicas de apoio às actividades de inovação e exportação que são, regra geral, definidas e implementadas por diferentes e não relacionados departamentos governamentais.

Códigos-JEL: F14; L25; O32

Palavras-chave: Exportações; I&D; Inovação; Desempenho Económico; Crescimento das vendas

Abstract

There is a vast number of studies about the relationship between R&D and exports. However, results are not always clear-cut: the majority of them confirm a significant, positive and bidirectional relationship, other studies find no significant relationship, and a very small number suggests a negative association between exports and R&D investments.

The present study seeks to evaluate whether, in the case of a small, open and peripheral country in which exports are the engine of economic growth despite the noticeable laggardness in terms of R&D, R&D impacts on and/or influences exports; and, additionally, whether the interrelation between R&D and exports impacts on the performance of companies.

The evaluation is performed through the estimation of bivariate probit models, which allow the simultaneous estimation of the two decisions (R&D and Export), taking into account the correlation between the estimation errors of the equations for the R&D and exports, and a panel model that estimates the impact of decisions on R&D and export on economic performance of firms. The estimates involve more than 340 thousands non-financial companies based in Portugal, in the period 2006-2012.

The results confirm the existence of complementarity between R&D and exports, which mean that engaging in R&D activities will increase the probability of a firm also engage in exports activities and that engaging in export activities, will increase the probability of also engaging in R&D. The results also provide support for the hypothesis that more productive firms self-select into exporting activities and also provide support for the learning-by-exporting hypothesis. It is further found that R&D and exports have a positive effect on sales growth, which is enhanced when both activities occur simultaneously.

The results have important policy implications. Specifically, there is enough evidence to suggest a change in the paradigm of public R&D and export support, often granted in a disjointed and isolated way. It is therefore imperative that innovation policies and export promotion are articulated. They should assure that public support is driven to firms that develop (or intend to develop) R&D and export activities jointly. This also requires an institutional change of public policies to support innovation and export activities which are generally defined and implemented by different and unrelated government departments.

JEL Code: F14; L25; O32

Keywords: Exports, R&D, Innovation, Economic Performance, Sales Growth

Index

List of Tables

List of Figures

1. Introduction

The export capacity of a company is often considered an indicator of competitiveness and success (Esteve-Pérez and Rodríguez, 2013), with the implicit idea that an exporting firm tends to be more productive than a non-exporter (Silva *et al*., 2013).

The differences between exporters and non-exporters have recently been associated with the respective willingness to invest in intangibles, including Research & Development (R&D). Specifically, Aw *et al.* (2011) identified investment in R&D and the adoption of technology as relevant factors in explaining the higher productivity of exporters compared to non-exporters. These authors consider that the decisions to export and invest in R&D or technology are interdependent and both influence the future profitability of companies.

Underneath the relationship between exports and R&D stands the theoretical literature that describes the process of firms learning through internationalization, including the impact of such learning on innovation (Girma *et al*., 2008). According to Girma *et al*. (2008), in order to compete in international markets exporters have to invest in technology to meet the needs of a more sophisticated demand. Exporting companies also have access to sources of knowledge that are not available in the domestic market (Alvarez and Robertson, 2004). These factors lead exporters to improve their knowledge base and hence increase their innovative capacity and ability to create better quality innovations (Golovko and Valentini, 2011). Regarding R&D, the higher is the firms' investment, the more likely it is that their products and/or services become innovative and competitive, positively impacting on exports, and thus that they gain competitive advantage (Lachenmairer and Woessmann, 2006; Cassiman and Martínez-Ros, 2007). Furthermore, the influence of R&D on productivity is also widely analyzed. Many studies show that R&D and innovation are important sources of productivity differences between firms, identifying a positive relationship between R&D and productivity and firms' growth (Griffith *et al*., 2006). These productivity gains in firms that invest in R&D will then be reflected in the self-selection of the exporting process, i.e., the more productive firms are those that are more likely to become exporters.

There is already a wide range of empirical literature that examines the relationship between exports and innovation, more specifically, the activities of R&D. Most of

this literature explains only one of these variables based on the other (*e.g.*, Wakelin, 1998; Bleaneyand Wakelin, 2002; Roper and Love, 2002; Caldera, 2010; Cassiman *et al.*, 2010; Cassiman and Golovko, 2011; Harris and Li, 2011). However, recently, exports and R&D have been understood as complementary and interdependent (Esteve-Pérez and Rodríguez, 2013). According to some authors (*e.g.*, Golovko and Valentini, 2011), this complementarity explains the higher levels of performance (sales growth) of Spanish manufacturing small and medium-sized firms (SMEs). However, there is no consensus that there is a complementarity between the both strategies R&D and exports, which in previous studies emerged as alternatives that should not be carried out jointly (Golovko and Valentini, 2011). Indeed, Roper and Love (2002) suggest that in the case of German manufacturing plants where levels of innovation intensity are high but the proportion of sales attributable to new products is low, there was a trade-off between investment in innovation and exports, rather than a complementarity, because of the rival utilization of limited organization resources (human and financial). Although they find evidence of complementarity between the two activities for Irish firms, Girma *et al*. (2008) fail to find such evidence for British firms, which reinforces the lack of consensus on this issue.

Existing studies in this area focus mainly on more developed countries – Britain, Germany, the Republic of Ireland -, closer to the technological frontier and with solid and internationalized national and regional innovation systems (Bleaney and Wakelin, 2002; Roper and Love, 2002; Girma *et al*., 2008; Ganotakis and Love, 2011). In smaller and open countries, where exports are one of the key engines of the economy, but innovation performance lags behind the technological frontier, the existence and significance of exports-R&D complementarity has not yet been assessed at the microeconomic level.

The present dissertation, aims at filling this gap by using a large firm database of more than 340 thousand non-financial corporation's located in Portugal over the period 2006-2012. It contributes to the relevant literature by focusing on a small, open and peripheral country - Portugal - in which exports are the engine of economic growth, despite the noticeable laggardness in innovation, in general, and R&D, in particular. Specifically, the dissertation raises two main questions: (1) Is there any complementarity between investment in R&D and exports at the company level?;

and (2) What is the individual and joint impact of exports and R&D investment on the economic performance of companies?

The empirical analysis is carried out using company data from the Central Balance Sheet of the Bank of Portugal that covers the universe of non-financial corporations in Portugal (more than 340 thousand companies/year) over the period 2006-2012. Such data are based on the Simplified Business Information (SBI) which corresponds to a deposed accountability that annually each non-financial company has to make to the Ministry of Justice.

To answer the two research questions, and in line with similar studies (*e.g.*, Girma *et al.*, 2008; Golovko and Valentini, 2011; Esteve-Peréz and Rodrigues, 2013), we resort to econometric techniques. Regarding the first question - the complementarity between investment in R&D and exports - we estimate a bivariate probit model. Regarding the second question - the joint impact of exports and R&D investment on the economic performance of companies - we follow the methodology implemented by Golovko and Valentini (2011), which encompasses a fixed-effects panel model with AR(1).

The present dissertation is organized as follows. The next section presents a review of the existing literature on the relevant subjects, the relationship between exports and investment in R&D and the impact of R&D and export on the performance of companies. Section 3 briefly details the methodology. Section 4 presents the results, and Section 5 the conclusions.

2. A critical review of literature

2.1. The relationship between exports and investment in R&D

The relation between exports and investment in R&D includes three major issues: whether innovation (R&D) leads a company to export; whether the export activity leads the company to be more innovative; and whether the causal relationship is bidirectional and there is complementarity between the two activities.

There is already fairly extensive research on these issues. Earlier studies treat the two first's issues: whether innovation (R&D) leads a company to export and whether export activity leads the company to be more innovative (Wakelin, 1998; Bleaneyand Wakelin, 2002; Roper and Love, 2002; Caldera, 2010; Cassiman *et al.*, 2010; Cassiman and Golovko, 2011; Harris and Li, 2011). Only the more recent studies test the third issue, *i.e*., a bidirectional relationship of mutual causality: implicit complementarity and interdependence (Girma *et al.*, 2008; Damijan *et al*., 2010; Golovko and Valentini, 2011; Esteve-Pérez and Rodríguez, 2013). However, there is no consensus in these studies; there are cases of positive evidence of causality (*e.g*., Girma *et al.* (2008) for Irish companies; Caldera, 2010; Golovko and Valentini, 2011; Esteve-Pérez and Rodríguez, 2013) but there are also cases in which this causality is not significant (Girma *et al.* (2008) for UK companies; Damijan *et al*., 2010), and even cases where the relationship is negative (*e.g*., Roper and Love, 2002) in the case of German manufacturing plants.

2.1.1. The influence of R&D in exports

Early theoretical literature defends a one-way relationship between innovation and exports. Innovation is identified as one of the determinants of exports (Vernon, 1966; Krugman, 1979). The intuition behind these early models of the product cycle is that product differentiation and/or innovation generate competitive advantages that enable companies to compete in international markets (Girma *et al*., 2008). The latest generation of neo-technological models also supports this causal link (Greenhalgh, 1990; Greenhalgh and Taylor, 1994). More recently, Grossman and Helpman (1995) modeled a macroeconomic scenario where firms improve the quality of their products (synonymous with innovation). The result is an outward shift in the demand curve of the country's export. One possible explanation for this result is that the more a country/firm invest in R&D, the more innovative and competitive become its

products and/or services and in this way a competitive advantage emerges, with positive effects on exports (Lachenmaier and Woessmann, 2006; Cassiman and Martinez-Ros, 2007). Aw *et al*. (2011) also identified investment in R&D and the adoption of technology as relevant factors in explaining the higher productivity of exporters compared to non-exporters. According to Aw *et al*. (2011), investment in R&D affects future productivity endogenously. [1] The influence of R&D in productivity is also widely studied and many studies show that innovation and R&D are important sources of productivity differences between firms, identifying a positive relationship between R&D and productivity and firms' growth (Griffith *et al*., 2006).

2.1.2 The influence of exports in R&D

There exists a theoretical body of literature that explains how companies learn to internationalize and specifically explains the influence of exports on innovation. The central idea is that in order to compete in international markets exporters have invest in new technology, which is often required to meet the needs of a more sophisticated demand (Girma *et al*., 2008). Exporting companies also have access to sources of knowledge which are not available in the domestic market (Alvarez and Robertson, 2004). These factors imply that exporters improve their knowledge base and thus increase their innovative capacity, being able to create innovations of better quality (Golovko and Valentini, 2011). Thus, the export activity of a business can have a positive influence on its R&D and innovative capacity (Salomon and Shaver, 2005b; Girma *et al*., 2008).

The above mentioned phenomenon is named 'learning-by-exporting effect'. This effect is theoretically demonstrated by Hobday (1995) who develops a technology-gap model to demonstrate that external demand, and thus export activity, increase the rate of innovation. The author proves that knowledge is cumulative and that its progression leads to a path of growth in companies. The overwhelming conclusion of

[1] In addition to endogenous growth theory which is a strand of the literature stressing the importance of R&D for productivity growth (see, *e.g.*, Romer, 1990), there are more two strands supporting a positive relationship between R&D and firm's productivity growth (Mañez *et al*., 2013). The first is based on the R&D capital stock model of Griliches (1979, 1980), and analyses the relationship between R&D and productivity growth. The second is the active learning model (Ericson and Pakes, 1995), according to which investments in R&D contributes to improve firms' productivity over time.

the model is that exports positively influence the technological and innovative capacity of firms.

2.1.3 The complementarity between exports and R&D

The analysis of the influence of exports in R&D and *vice versa* raises the question of complementarity and interdependence between the two activities. Aw *et al*. (2011) found that decisions to export and invest in R&D or technology are interdependent and both influence the future profitability of firms. According to these authors, these investment decisions depend on the expected return of the sunk costs of entry in these activities. Aw *et al*. (2011) argue that, on one hand, the investment in R&D increases productivity, which leads to improved net profits expected from export; and, on the other hand, the global market share can increase the return on investment in R&D. Additionally, Bernard and Jensen (1999) argue that the implementation of one of these activities can reduce the costs of implementing the other. Specifically, innovation can reduce the costs of exporting. According to the authors, export entails some sunk costs, first in the beginning of the activity, but also later when it evolves. These sunk costs are packaging costs, improving product quality, establishment of marketing channels and the gathering of information on sources of demand (Robert and Tybout, 1999). Exporting companies also have administrative and additional shipping costs, which generate a disadvantage compared to domestic companies in the market where they are exporting (Golovko and Valentini, 2011). Consistently, the literature has shown that firms that start to export are more productive than those that do not export, because only then they are able to bear the additional costs that export imply (Bernard and Jensen, 1999). Specifically, Cassiman and Golovko (2011) demonstrate that innovation is the source of higher productivity and self-selection of more productive firms to export. Thus, by improving productivity, innovation reduces the costs associated with exports (Golovko and Valentini, 2011). Moreover, exporting firms have more incentives to invest in R&D, because this investment will be diluted by a larger output (Esteve-Pérez and Rodríguez, 2013) thus reducing the R&D/turnover ratio. Also exports can reduce the costs of R&D via capital markets. Investment in innovation, including R&D, involves the application of large financial resources in the short term with the expectation of positive returns in the future (Golovko and Valentini, 2011). If capital markets are completely efficient, and if the information is available to all parties, then companies should get

external financing for all profitable investment opportunities (Golovko and Valentini, 2011). However, if these conditions are not met, external financing may not be available, or may become too expensive, and so companies are subject to the internal constraints of generating financial flows to finance their investments (Golovko and Valentini, 2011). Thus, companies with variable cash flows are very conditioned to make investments in innovation that have a particularly uncertain return (Golovko and Valentini, 2011). According to Salomon and Shaver (2005a), exporting companies can stabilize cash flows, since business cycles are not perfectly correlated between national economies. Thus, exporting companies can have more resources to invest in innovation (Golovko and Valentini, 2011). And they can also have cheaper access to external financing, as exports give more guarantees to markets that companies have liquidity to meet their obligations (Shaver, 2011).

According to the cognitive approach, both strategies are considered as key channels for the accumulation of knowledge, improving firms' capabilities and their competitive advantages and hence their profitability (Esteve-Pérez and Rodríguez, 2013). The size of the generation and accumulation of knowledge in R&D is well known since the seminal paper by Cohen and Levintal (1989). For exports, the cognitive dimension was recognized only more recently and is less consensual (Esteve-Pérez and Rodríguez, 2013). According to Esteve-Pérez and Rodríguez (2013), participation in international markets generates knowledge flows through three channels: (1) interaction with foreign competitors; (2) increase of the scale of production; and (3) increased competition rising incentives for innovation. The complementarity between the two activities in terms of knowledge accumulation exists for two reasons. First, the internal knowledge generated by R&D activities helps to build technological capabilities which enable the absorption of external knowledge acquired in the export market, thus generating a higher return of exports for companies that have accumulated knowledge through internal R&D (Esteve-Pérez and Rodríguez, 2013). Second, experience in exports generates knowledge flows that increase the innovative capacity of firms and their R&D activities (Esteve-Pérez and Rodríguez, 2013). These knowledge flows are derived from contact with the richest sources of technology, with the best international practices and with tougher competitors (Girma, *et al*., 2008; Esteve-Pérez and Rodríguez, 2013).

Thus, according to the literature, and despite the lack of consensus of empirical studies, it is expected that some complementarity between investment in R&D and exports exist at the company level.

2.2. The impact of R&D and export on the performance of companies

The literature review conducted in previous chapters suggests that R&D and exports should be complementary in assessing their impact on the economic. The two activities complement each other in terms of accumulation of knowledge, lowering costs and potentiating firms' profits. R&D through its impact on productivity and on new and better products; and exports, directly amplifying the positive effect of R&D. Confirming this intuition, Golovko and Valentini (2011) show that the positive effect of innovation on firms' growth is higher if firms export and vice versa. Filatotchev and Piesse (2009) also examine the interrelationship between R&D, exporting and sales growth of newly listed firms in the UK, Germany, Italy and France, and they find that both R&D and export intensities have a positive effect on sales growth.

2.2.1 The isolated impact of exports and R&D investment on the performance of the companies

In addition to the clear and obvious effect of exports in sales (Shrader *et al*., 2000), a positive effect of exports on the growth of companies is due to the indirect gains from revenue diversification (*e.g*., Shaver, 2011) and the development of new capabilities promoted by internationalization, which increase the ability of the company to pursue new growth opportunities (*e.g*., Sapienza *et al*., 2006).

Innovation in general and R&D in particular can have several positive impacts on the performance of companies. Innovation can create new product markets or increase the willingness of consumers to pay for new or improved product features (e.g., Choand Pucik, 2005). Also innovative companies are better prepared to take advantage of spillovers and are more resistant to macroeconomic shocks (Geroski *et al*., 1993).

2.2.2 The R&D investment and exports complementarity impact on the performance of companies

The analysis of the previous sections suggests a positive interdependence between exports and investment in R&D. The contribution of exports to sales growth depends

on the amount that can be exported and on the price at which firms can sell in international markets (Golovko and Valentini, 2011). There is strong evidence that the "law of one price" - i.e., the same products are sold at the same price in different countries - does not hold (Golovko and Valentini, 2011). Moreover, it is clear that the deviation in the law of one price is not an artifact of non-identical goods (Goldberg and Knetter, 1997). More specifically, foreign markets often generate lower mark-ups compared to the domestic market (*e.g*., Bughin, 1996). Competition and the costs related to exports are among the drivers of the lower mark-ups observed (Golovko and Valentini, 2011).

Most differences between the domestic price and the export price are due to price differences between companies in the same market. Differences between markets are relatively less important (Golovko and Valentini, 2011). These variations within the same market reflect differences in the attributes and quality of the products (Aw *et al*., 2001) explained by investment in innovation (Golovko and Valentini, 2011). More specifically, Braymen *et al*. (2011), analyzing newly founded North-American companies, demonstrate how investment in R&D enables companies to produce better varieties of products that have global demand. McGuinness and Little (1981) also conclude that improvement of the products' unique features and the differentiation of existing products increase export performance and sales growth. Moreover, investing in innovation for exports can also bring positive spillovers to the domestic market (Golovko and Valentini, 2011). Specifically, producers exporting a particular variety of a product can achieve a premium price for sales of the same variety in the domestic market, which is associated with an increase in investment activity when the new variety is released (Iacovone and Javorcik, 2012).

Thus, it is expected that the complementarity between exports and R&D impacts on sales growth because the innovative exporting companies can increase their sales by selling the best products on export markets (managing to sell a larger quantity or getting more favorable price) while price can also benefit from positive spillovers of sales in the domestic market that will be of better quality (Golovko and Valentini, 2011).

As already mentioned in the previous section, there is also a complementarity between R&D and exports regarding the accumulation of knowledge. The greater complementarity, and the greater the knowledge accumulated by companies and their

ability to learn, the greater will be the benefit to companies undertaking both activities simultaneously. Logically, complementarity in terms of costs, leads companies to be more competitive and thus to achieve higher sales growth both internally and externally.

Based on the above arguments, it is expected that, apart from a positive impact of R&D and export on sales growth individually considered, there will be an additional positive impact related to the complementarity of R&D and exports.

3. Methodological considerations

3.1. Brief overview of the literature on the relevant methodologies and proxies

To answer the first question of the dissertation about the interdependence between investment in R&D and exports, and similarly to Aw *et al*. (2007), Girma *et al*. (2008), Golovko and Valentini (2011) and Esteve-Pérez and Rodríguez (2013) – see Table 1 -, we will implement a bivariate probit model. This method explicitly takes into account a possible correlation between export and R&D activities (Golovko and Valentini, 2011; Esteve-Pérez and Rodríguez, 2013).

To test whether the complementarity between exports and R&D investment impacts on firms' economic performance (i.e., sales growth), we follow the methodology of Golovko and Valentini (2011). We estimate a growth regression using a fixed-effects model in order to account for the possible endogeneity of export and innovation decisions and performance measure in this model - such method allows controlling for time-invariant unobserved firm heterogeneity (Golovko and Valentini, 2011). And we use a First-Order Autoregressive (AR(1)) process for the errors in order to control for the presence of the serial correlation in the model (Golovko and Valentini, 2011).

Table 1: Methodology of studies of complementarity between investment in R&D and exports

Authors (Year)	Sample	Method	Dependent Variables	Relevant Explanatory Variables
Golovko and Valentini (2011)	8802 firms (SMEs) 1990-1999 Spain	Bivariate Probit Model	***Exports*** (Dummy); ***Innovation*** (R&D Dummy)	***Lagged Innovation (t-1)*** (R&D Dummy); ***Lagged Exports (t-1)*** (Dummy); ***Lagged R&D Intensity(t-1)***(R&D Expenditure normalized on firm Sales); ***Lagged Size (t-1)*** (logarithm of sales) ***Lagged Advertising Intensity (t-1)*** (share of spending on advertising and public relations in firm sales)

(…)

Authors (Year)	Sample	Method	Dependent Variables	Relevant Explanatory Variables
Girma *et al*. (2008)	10361 firms from Britain; 8364 firms from Republic of Ireland2000-2003	Bivariate Probit Model	***Exports*** (Dummy); ***Innovation*** (R&D Dummy)	***Lagged Innovation(t-1)*** (R&D Dummy); ***Lagged Exports(t-1)*** (Dummy); ***Lagged Productivity*** (sales/worker); ***Lagged Wage Rate*** (avg. wage/worker); ***Lagged Employment*** (full time employees);
Esteve-Pérez and Rodríguez (2013)	1016 firms (SMEs) 1990-2006 Spain		***Exports*** (Dummy); ***Innovation*** (R&D Dummy)	***Lagged Innovation(t-1)*** (R&D Dummy); ***Lagged Exports(t-1)*** (Dummy); ***Lagged Productivity*** (Total Factor Productivity(TFP)); ***Lagged Size (t-1)*** (Discrete – 1,2,3,4 – in function of number of employees); ***Lagged Advertising (t-1)*** (Dummy);
Damijan *et al*. (2010)	9148 firms 1996-2002 Slovenia	Propensity-Score Matching Techniques	***Exports*** (Dummy); ***Innovation*** (Process and product innovation (Dummy))	***Lagged Innovation (t-1)*** (Process and product innovation); ***Lagged Exports (t-1)***; ***Lagged Produtivity (t-1)*** (value added/employee); ***Lagged Employment (t-1)***; ***Lagged Capital Intensity (t-1)***; ***Lagged R&D (t-1)***; ***Lagged Imports (t-1)***(Dummy);

3.2. Econometric specification for testing the complementarity between exports and R&D

As previously discussed, for testing the complementarity between exports and R&D expenditures a bivariate probit model will be implemented. This model takes into account the possible correlation between the error terms of each of the model's equations, which may arise given the high serially correlation and the interdependence between exports and R&D (Esteve-Pérez and Rodríguez, 2013). Following Esteve-Pérez and Rodríguez (2013), the specification of the bivariate model is (for simplification firm's indexes are suppressed):

$$y_{jt} = \begin{cases} 1 & y_{jt} * > 0 \quad j = 1,2 \\ 0 & else \; t = 2, \dots, T \end{cases} (1)$$

$$y_{1t} * = \gamma_{11} y_{1,t-1} + \gamma_{12} y_{2,t-1} + x_{t-1}' \beta_1 + \mu_1 + \mu_{1t} (2)$$

$$y_{2t} * = \gamma_{21} y_{1,t-1} + \gamma_{22} y_{2,t-1} + x_{t-1}' \beta_2 + \mu_2 + \mu_{2t} (3)$$

The dependent variables are binary variables associated with exports (y_{1t}) and R&D expenditures (y_{2t}). $y_{1t}$is a binary variable equal to 1 if firm is a exporter in the current year, zero if not. y_{2t} is a binary variable equal to 1 if firm has any positive R&D expenditure in *t*, 0 if not (Girma *et al*., 2008). Following Esteve-Pérez and Rodríguez (2013) the same independent variables will be used in the two equations, including initial conditions and within-individual means. It is assumed that (μ_1, μ_2) is distributed as a bivariate normal with variances $\sigma_{\mu_1}^2$ and $\sigma_{\mu_2}^2$and covariance $\sigma_{\mu_1} \sigma_{\mu_2} \rho_\mu$ (Esteve-Pérez and Rodríguez, 2013). It is also assumed that error terms (μ_{1t}, μ_{2t}) are bivariate standard normal with covariance ρ and are independent over time. Finally, it is assumed that (μ_1, μ_2), u_{jt} and x_{t-1} are independent (Esteve-Pérez and Rodríguez, 2013).

The output of this model is the probability of exporting and of investing in R&D in year *t*, based on lagged firms' characteristics (Esteve-Pérez and Rodríguez, 2013). The lagged value of R&D is the key variable in the equation of exports and the lagged value of exports is the key variable in the equation of R&D, because the relationship between exports and R&D is the central research issue. The presence of the lagged R&D variable in the equation of exports aims at testing whether engaging in R&D will increase firms exports and whether engaging in exports will increase firms R&D (Esteve-Pérez and Rodríguez, 2013).

Esteve-Pérez and Rodríguez (2013) argue that, within the cognitive approach, these lagged variables are proxies for the *stock* of knowledge (internally accumulated – R&D; externally accumulated – exports). The lagged exports in the equation of R&D also test the so called learning-by-exporting effect (that captures the potential positive impact of previous export activity on new R&D expenditure as explained in (Girma *et al*., 2008). In order to test the persistence and cross-persistence of exports and R&D, we include lagged variables for both in each equation (Esteve-Pérez and

Rodríguez, 2013). The inclusion of the variable exports also accounts for the importance of sunk costs in the internationalization process (Girma *et al*., 2008).

In accordance with previous studies that implement a similar model (Aw *et al*., 2007; Girma *et al*., 2008; Golovko and Valentini, 2011; Esteve-Pérez and Rodríguez, 2013), we include a set of additional explanatory variables included in the x-vector as control variables, presented in Table 2.

Table 2: Additional Explanatory Variables

Variables	Type	Definition
Size	Continuous	Logarithm of employees
Advertising Intensity	Continuous	Logarithm of share of spending on advertising and public relations in firm sales
Productivity	Continuous	Logarithm of value added/Employee
Age	Continuous	Logarithm of number of years since the firm was created
Foreign	Binary	1 if the firm's social capital was directly or indirectly participated by foreign capital at *t*
Capital Intensity	Continuous	Logarithm of share of office/technical equipment and construction spending in firms' sales

The lagged productivity is included as a proxy of firms' efficiency in line with existing studies and to take account for the self-selection of more efficient firms regarding the export activity (Aw *et al*., 2007, Silva *et al*., 2013). The expected relationship between the previous productivity level and returns from both R&D and exports is positive (Aw *et al*., 2011).

Firms' size is an important control variable that may affect both exports and R&D decisions (Golovko and Valentini, 2011). The expected relationship between firms' size and exports and between firms' size and R&D is positive (Esteve-Pérez and Rodríguez, 2013). However, there are some authors like Bernard and Jensen (1999) that find a non-linear relationship between size and exporting, showing that the positive effect of size only emerges after a certain threshold. On average, larger firms have access to more resources to invest in R&D (Golovko and Valentini, 2011). These resources, necessary to carry out investment decisions that involve uncertainty and sunk costs, are more accessible to larger firms because they are more likely to obtain loans as well as non-financial resources (managerial, scale economies)

(Esteve-Pérez and Rodríguez, 2013). Nevertheless, small firms may have an advantage, especially in innovative activities, because they are more flexible in adapting to changing competitive environments, and can have more flexible management structures (Esteve-Pérez and Rodríguez, 2013). Small firms also are associated with less bureaucracy and, thus, may positively influence the efficiency in innovating (Acs and Audretsch, 1987).

The foreign participation in firms' capital is included because this participation can facilitate the process of becoming an exporter (Basile, 2001). In addition, foreign-owned firms may have better access to financial resources, knowledge and technology (Esteve-Pérez and Rodríguez, 2013). Thus, a positive effect of foreign participation in export activities is expected. The effect of this participation on R&D investment is unclear because innovative activities may take place in the parent firm or the firm may take advantage of the stock of knowledge and financial resources of the parent firm to carry on its own R&D activities (Esteve-Pérez and Rodríguez, 2013).

Advertising expenditures are included due to their expectable positive effect on exports. In fact, advertising helps to build up brands or trade names (Esteve-Pérez and Rodríguez, 2013).

Capital intensity is included with advertising intensity as proxies for complementary assets (Teece, 1986). These complementary assets include firms' capabilities like manufacturing capabilities or sales' expertise (Golovko and Valentini, 2011). The presence of complementary assets has a positive expected impact both on exports and innovation activities, since these capabilities are used to bring new product/process innovations to the market (Golovko and Valentini, 2011).

Age has an unclear effect both on exports and R&D. On one hand, older firms are more likely to have the required resources (financial and knowledge) to implement these activities; on the other hand, if younger firms are more flexible, aggressive and proactive a negative relationship could be expected (Esteve-Pérez and Rodríguez, 2013).

In addition, section of the NACE and year dummies to control for the industry heterogeneity and macroeconomic conditions common to all firms are included (Golovko and Valentini, 2011).

3.3. Econometric specification and proxies for testing the individual and complementary impact of exports and R&D on the performance of companies

The other central research question of this study is to measure the individual and the complementary impact of exports and R&D on the performance of companies, more precisely on sales' growth. The choice of sales' growth to measure performance is in line with previous studies, consensually used in data that contain firms from different industries (*e.g.*, Golovko and Valentini, 2011), as in our study.

To test whether the complementarity between exports and R&D investment impacts on firms' economic performance, the following growth regression will be estimated (as in Golovko and Valentini, 2011). The model includes four exclusive dummies for exporting/R&D activities that will be estimated in order to link them to firms' growth (Golovko and Valentini, 2011):

$$y_{it} = \gamma_1 D_{it-1} + x_{it-1}^{\prime\beta_2} + \mu \qquad (4)$$

The dependent variable is firm *i*'s sales growth rate at time *t* (with respect to time *t*-1). Following Golovko and Valentini(2011), an exponential sales growth trend will be considered:

$$y_t = \log[\frac{sales(t)}{sales(t-1)}] \qquad (5)$$

In this model the simple export and R&D dummies are excluded and a vector of exclusive dummy variables *D* for the choice of the combination of the export and R&D activities in year *t-1*is used (Golovko and Valentini, 2011):

$$D = \{(NoR\&D\ and\ NoExport); (OnlyR\&D); (OnlyExport); (R\&D\ ans\ Export)\}$$

When R&D and exports are complementary, the estimation of the parameter associated with variable ($R\&D\ and\ Export$) is positive and statistically significant. We include as control variables the explanatory variables used in the bivariate probit model plus *wage rate*, measure as logarithm of average Wage/Employee, to test if the complementarity between R&D and exports has effect on the growth rate: *size* to account for the link between firm size and growth (Lu and Beamish, 2006); *foreign* as potentially responsible for differences in growth and in exports between domestic and foreign firms (Golovko and Valentini, 2011), and *wage rate* as a proxy for employees' skill intensity (Bleaney and Wakelin, 2002).

3.4. Data description

The data used in this study are from the Central Balance Sheet of the Bank of Portugal that covers the universe of non-financial corporations in Portugal over the period 2006-2012.

Table 3: Number of observations in the data

Year	2006	2007	2008	2009	2010	2011	2012
Observations	345 817	361 298	371 374	371 125	365 547	377 026	370 708

Source: Own computations based on the Bank of Portugal's Simplified Business Information (SBI).

Such data are based on the Simplified Business Information (SBI) which corresponds to a deposit account that annually each non-financial company has to make to the Ministry of Justice. These data also are used by the Bank of Portugal and the National Institute of Statistics for statistics proposals and for the Ministry of Finances to fiscal proposals. This report provides exhaustive accounting standard information at the firm level.

A problem with the data is that there was a change in the Portuguese accounting system in 2010. For the major part of the data that we need to support our study that change is not a problem; however, regarding the data on innovative activities this is a problem that could mean a break series. The main issue is that in the first accounting system the data of R&D includes software expenditures and, beyond problems of non response, it is rather difficult to exclude those values from R&D expenditures. This issue causes problems of comparability of the data in the two parts of the series. In the first part, as we can see in Table 4[2] we have more firms with R&D expenditures but with smaller values and, in the second part, we have few firms with R&D but with higher values. The series of exports is consistent in terms of the number of firms exporting and the values of exports in the both periods. The other series of variables are also consistent in both periods.

[2] Table 4 contains some descriptive statistics from the dataset in order to highlight the impact of the change of the accounting system that is used to report the information of the database.

Table 4: Descriptive statistics

Variables	2006-2009		2010-2012	
	Number of observations/year	Mean	Number of observations/year	Mean
R&D	6 181	51 590	2 709	200 696
Exports	41527	1 413 857	48 274	1 370 405
Sales	362 557	925 966	371 173	879 532
Advertising	146 460	23 300	127 872	21 425
Productivity	280 078	19 666	291 887	17 894
Wage Rate	280 078	9 275	294 765	9 186
Age	362 521	11 years	370 643	12 years
Foreign	3 273	-	3 384	-
Capital Intensity	305 407	0.96	303 893	1.02

Source: Own computations based on the Bank of Portugal's Simplified Business Information (SBI).

Table 5 shows the difference regarding main descriptive statistics between firms that have R&D expenditures and that do not have. Table 6 describes this difference for firms that export and firms that do not export. Firms with R&D and with exports, on average, have more sales, are older, have higher advertising investment and higher capital intensity, are more productive, and offer higher wages, i.e., are endowed with better human capital. In terms of foreign capital, the firms that have R&D expenditures have also, on average, higher weights than the other group; however, this difference is very small (1.27% *vs*. 1%). In the case of firms with exports the difference is considerably higher (2.97% *vs*. 0.72%). Finally, in relation to our key variables, in Table 5 we can see that firms with R&D expenditures have a much higher percentage of exporters than firms without R&D (33.65% *vs*. 11.85%). In Table 6 we have a similar conclusion since firms with exporting activities have a relatively higher percentage of firms with R&D expenditures (3.56% *vs*. 0.97%).

Table 5: Descriptive statistics Firms with R&D vs. Firms without R&D

Variables	R&D		No R&D	
	Number of observations/year	Mean	Number of observations/year	Mean
R&D	4 693	115 610	-	-
Exports	1 579	5 655 397	42 837	1 254 260
Sales	4 693	7 551 878	361 435	825 562
Advertising	3 340	120 630	135 154	20 140
Productivity	4 343	25 413	280 797	18 805
Wage Rate	4 344	12 000	282 029	9 194
Age	4 692	13 years	361 188	12 years
Foreign	56	-	3 264	-
Capital Intensity	4 413	1.68	300 346	0.98

Source: Own computations based on the Bank of Portugal's Simplified Business Information (SBI).

Table 6: Descriptive statistics Firms with Exports vs. Firms without Exports

Variables	Exports		No Exports	
	Number of observations/year	Mean	Number of observations/year	Mean
R&D	1 579	202 748	3 114	68 605
Exports	44 416	1 395 320	-	-
Sales	44 416	4 442 166	321 712	420 715
Advertising	25 878	84 543	112 616	8 267
Productivity	42 083	33 210	243 057	16 419
Wage Rate	42 083	13 343	244 290	8 527
Age	44 408	14 years	321 473	12 years
Foreign	1 290	-	2 030	-
Capital Intensity	44 368	1.08	260 391	0.46

Source: Own computations based on the Bank of Portugal's Simplified Business Information (SBI).

Figure 1 shows the evolution of firms' participation in export and R&D activities over the period in study. Firms are categorized in the following way: no participation in both exports and R&D; participation in export activities, participation in R&D activities, and participation in both activities.

In the first part of the dataset the percentages of firms that engage in R&D, in exports and in both activities have a somewhat similar evolution, with an increase in the respective weights between 2006 and 2009. The decrease in 2010 may be caused by the international crisis. In the second part of the dataset, with the new accounting system, the percentage of firms with R&D activities is smaller and with a negative trend, whereas the percentage of firms with just export activities increase up to 13.44% in 2012.

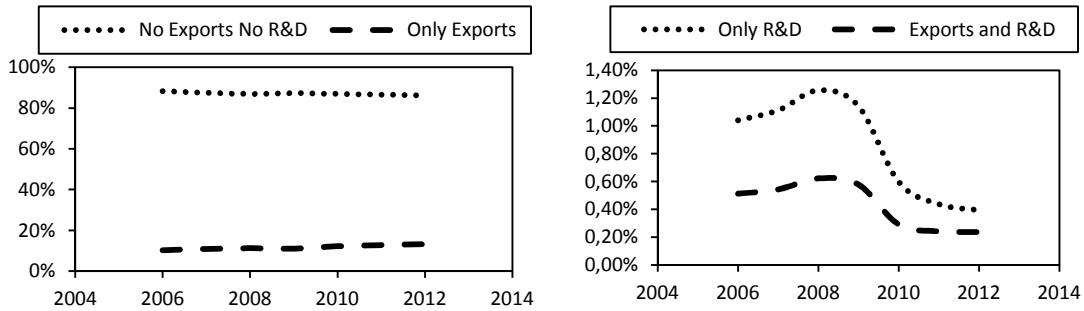

Figure 1: Export and R&D Activities
Source: Own computations based on the Bank of Portugal's Simplified Business Information (SBI).

In this figure we cannot see a positive relationship between exporting and R&D activities. However, this figure does not show the individual dynamics of the firms and we do not know whether it is the same group of firms that implement R&D investments and/or compete in export markets. Hence, we construct Table 5 that

shows the joint dynamics of these two investment decisions and highlights that they the same firms or whether we have a large percentage of new firms in these activities.

Table 7 provides preliminary evidence on the dynamics of the two-way relationship between export and R&D activities. This information is about year-to-year transition probabilities over the period 2006-2012. The two highlights of this analysis are: firstly, these activities are persistent, in particular the export activity is highly persistent. The probability of being an exporter in *t* is more than 72 percentage points higher for exports than for non-exporters at *t*-1. More specifically, it is 64% (68.38-4.03) for non R&D performers and 85% (85.77-5.72) for R&D performers. For R&D activity the persistent is not so high but also exists. Firms that engaged on R&D in *t*-1 are more likely (26 percentage points (p.p.)) to also undertake R&D at *t*, compared to those that do not engaged in R&D; secondly, there is cross-persistence between R&D and export activity, *i.e.*, the probability of engaging in R&D at *t* is larger for exporters in *t*-1 than for non-exporters (18 p.p.) and *vice versa* (10 p.p.). So, we have preliminary evidence that there is cross-dependence between export and R&D activities and also that past decisions influence current investment decisions.

Table 7: Transition rates of export and R&D status (percentage probabilities)

Status *t*-1		**Status *t***	
Export	**R&D**	**Export**	**R&D**
No	No	4.03%	0.68%
No	Yes	5.72%	15.18%
Yes	No	68.38%	1.68%
Yes	Yes	85.77%	40.22%

Source: Own computations based on the Bank of Portugal's Simplified Business Information (SBI).

Figure 2 shows the distribution of firms by NACE.[3] For all the dataset and for sales we observe that section "G – Wholesale and retail trade; repair of motor vehicles and motorcycles" is the most important category, with a very large weight comparing with that of the other activities. Sections "F – Construction" and "C – Manufacturing" follows G in the rank. In terms of exports, section "C – Manufacturing" dominates, followed by "G – Wholesale and retail trade; repair of motor vehicles and motorcycles", "F – Construction" and "H - Transporting and

[3]NACE is derived from the French "***N**omenclature Statistique des **A**ctivités économiques dans la **C**ommunauté **E**uropéenne*" (Statistical Classification of Economic Activities in the European Community).

storage". Finally, regarding firms with R&D expenditures, section C also emerges as the most important. In this latter case, however, a more balanced distribution exists among the sections, with section "J - Information and communication" being also very important. In the third position emerges section G, which is the most important section in terms of sales.

The main outcome of this analysis is that firms with R&D and exports are not only different between them, but are also different from the remaining firms included in the dataset.

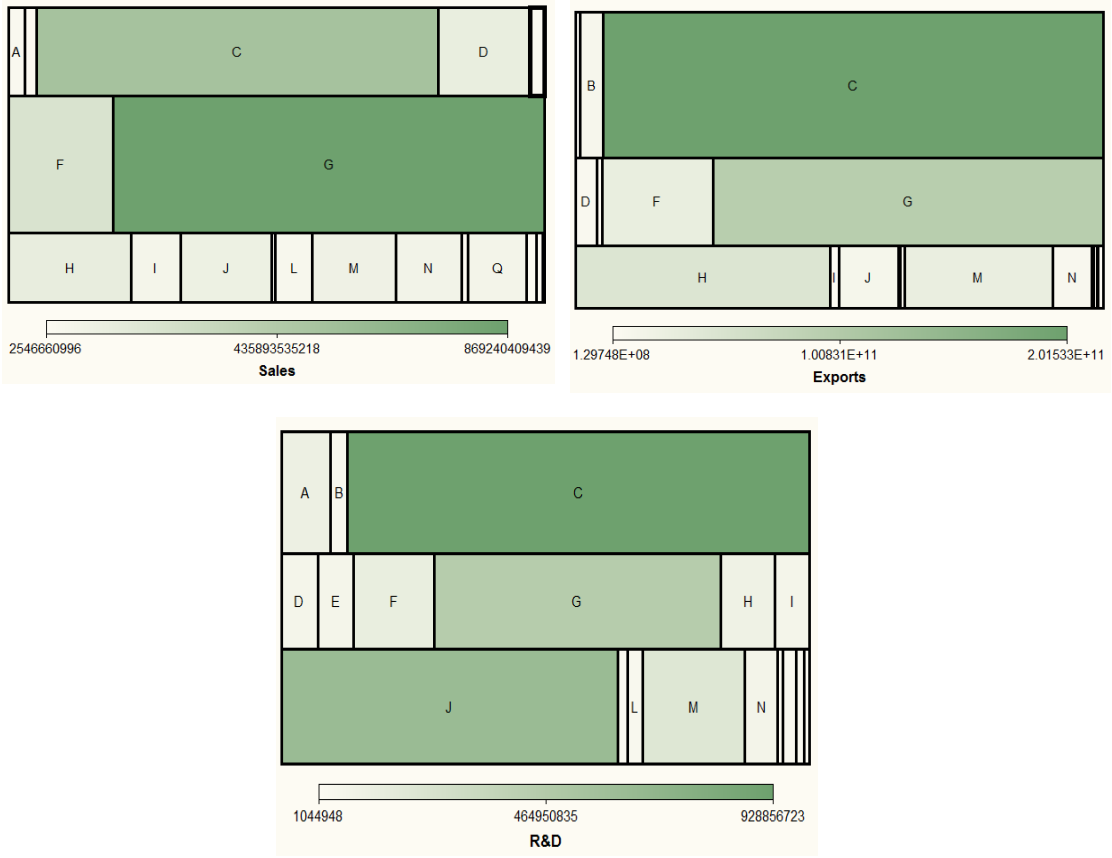

Figure 2: Distribution of firms in terms of Section of NACE
Source: Own computations based on the Bank of Portugal's Simplified Business Information (SBI).

4. Empirical results

4.1. The relationship between Exports and R&D

In the previous section we found preliminary evidence of cross-dependence and high persistence in both exports and R&D. In this section we undertake econometric analyses that examine the two-way dynamic relationship between exports and R&D activities. Following the previous methodological procedures we implement a bivariate probit model in order to investigate the sources of the two-way dynamic relationship. This specification permits the joint estimation of the two decisions taking into account the correlation between the error terms in the export and R&D equations (Esteve-Pérez and Rodríguez, 2013).

Table 8 presents the estimated coefficients using standard errors robust to intra-group (firms) correlation. In this model we include as explanatory variables the lagged values of R&D, exports, foreign ownership, age, productivity, advertising, capital intensity and size of the firm. We also include a set of sector and year dummies variables, which are always jointly significant, though their estimated coefficients are not reported. Except for variable capital intensity in the export equation, all the variables have a significant effect on the export and R&D decisions at 1% level of statistical significance.

The results of the export equation indicate that, conditional on average values of the rest of variables, firms engaged in R&D at *t*-1 have a 16.6% higher probability of exporting at *t* than those not engaged in R&D in the previous period. The results for the R&D equation also indicate that past export has a positive and significant effect on the probability of making R&D at *t*, this effect is almost the same (15.6%). These results confirm the cross-persistence between export and R&D and emphasize that the performance of one activity positively and significantly relates to the performance of the other. This means that the answer to the first question of our study - whether there is a complementarity between export and innovation - is positive.

As expected, in both equations, the lagged dependent variables (export and R&D) are positive and highly significant, which means that past engagement in export is associated with a higher probability of current engagement in export and that also past engagement in R&D increase the probability of current engagement in R&D.

Table 8: Exports and R&D: bivariate probit estimation

	Export	**R&D**
$Export_{t-1}$	2.061***	0.156***
	(0.004)	(0.008)
$R\&D_{t-1}$	0.166***	1.572***
	(0.011)	(0.010)
$Size_{t-1}$	0.235***	0.216***
	(0.002)	(0.003)
$Foreign_{t-1}$	0.281***	-0.171***
	(0.020)	(0.032)
Age_{t-1}	-0.091***	-0.046***
	(0.002)	(0.004)
$Productivity_{t-1}$	0.184***	0.096***
	(0.002)	(0.004)
$Advertising_{t-1}$	0.290***	0.134**
	(0.043)	(0.061)
Capital $Intensity_{t-1}$	-0.008	0.174***
	(0.005)	(0.006)
Corr ($\varepsilon_{1it,}\varepsilon_{2it,}$)	0.075	
Wald Chi^2 (*p*-value)	165.762 (0.000)	
Number of Observations	1 491 415	

Legend: ***, ** and * indicate statistical significance at 1, 5 and 10% levels, respectively. The model includes 18 sector dummies variables.
Source: Own computations based on the Bank of Portugal's Simplified Business Information (SBI).

The estimated effect of our control variables are in the most of the cases the expected effect. The size of the firm has a positive and significant effect on both decisions, to innovate and to export, which means that larger firms, in terms of employees, tend to present a higher probability of exporting and make R&D in the next period. The effect of foreign ownership is positively and significantly related to the decision to export, which means that the fact of having a foreign owner in *t-1* increase the probability of exporting in *t*. However, it has a negative effect on the decision of engage in R&D, meaning that national owned companies tends to be more prone to perform R&D activities. Age has a negative effect in both decisions. This result reflects that younger firms are more likely to export and perform R&D than their older counterparts, which conveys good news for the renewal of Portuguese businesses. Productivity has a positive effect in both exports and R&D, with the coefficient associated with exports being approximately twice that of R&D, which means that higher productive firms have more probabilities of export and engaging R&D, however these probabilities increase more in exports activities. This positive and significant effect of productivity on exports corroborates the self-selection theory

argument that most efficient firms self-select to export activity, being in line with results from previous literature (e.g., Aw *et al*., 2007, Silva *et al*., 2013). The impact of advertising is positive on both activities, presenting also a larger coefficient in exports (more than twice than that of R&D), which means that firms that invest heavily in advertising enhance the probability of engaging in exports and also in R&D, with the probability of exports increasing more. Finally, capital intensity fails to emerge statistically significant in the export equation but presents a positive expected effect on R&D. That means that for firms in Portugal past capital intensity do not influence directly the probability of exporting in the next period, but it does influence the probability of engaging in R&D activities. Given that R&D has a positive influence in the probability of being exporter then, indirectly, capital intensity also impacts on the probability of exporting, though that impact might emerge over the medium term rather than in the short term.

4.2. The impact of Exports and R&D on Firms Performance

To answer to the second question of investigation - what is the individual and joint impact of exports and R&D investment on the economic performance of companies? -, we implement a model that includes four exclusive dummies for exporting/R&D activities in order to link them to firms' growth. Specifically, we run two specifications one with 'size' as a control variable and other without 'size' (cf. table 9) because the number of firms that simultaneously performs R&D and export is very small, and are in general larger firms. In these specifications the lagged choices of R&D and exports distinguish three cases: firms that both exported and innovated (Export and R&D), firms that only exported (Only Export), and firms that only made R&D (Only R&D). The omitted or base case is a firm that does not do any of these activities. The Hausman test indicates fixed effects with AR(1) is the most adequate specification, which is in line with prior works (e.g., Golovko and Valentini, 2011).

Table 9 presents the two specifications with and without size as control variable. In the model (1) with size, only the dummy 'Only Exports' has a positive and significant effect on growth, the other two main variables of our study are not significant. This means that exporters in *t-1* have higher sales growth in *t*. However, the fact that companies do R&D emerges with no significant impact on sales growth in the following period. Similarly, firms that both export and R&D also do not have a statistically significant impact on sales.

In this specification the control variables have the expected signs and significance. Size, productivity, advertising, wage rate and capital intensity have a positive and significant effect on growth, reflecting that, all the rest being constant, on average, a large, more productive, with high expenditures on advertising, better wages and more capital intensive tend to be more dynamic in terms of sales. In contrast, foreign ownership does not emerge statistically significant, whereas age presents a negative effect, meaning that younger firms have higher growth in terms of sales. In model (2) without Size, the three dummies of our main variables ('Only Exports', 'Only R&D', 'Export an R&D') are positive and significant, which means that compared to the firms that does not export nor are involved in R&D activities, companies that only export or only do R&D activities or have the two activities simultaneously have a better performance in terms of sales. Those that simultaneously export and perform R&D activities achieve, on average, a stronger impact in terms of sales growth, reinforcing the result obtained previously regarding Export and R&D complementarity.

Table 9: Performance of Exports and R&D: AR(1) panel model with Fixed Effects

	(1)	**(2)**
Only Export$_{t-1}$	0.037***	0.061***
	(0.006)	(0.006)
Only R&D$_{t-1}$	0.014	0.024*
	(0.014)	(0.014)
Export and R&D$_{t-1}$	0.023	0.062***
	(0.019)	(0.019)
Size$_{t-1}$	1.231***	-
	(0.008)	
Foreign$_{t-1}$	0.037	0.060*
	(0.032)	(0.032)
Age$_{t-1}$	-2.042***	-2.284***
	(0.014)	(0.015)
Productivity$_{t-1}$	0.323***	0.224***
	(0.002)	(0.003)
Advertising$_{t-1}$	0.628***	0.804***
	(0.068)	(0.069)
Wage Rate$_{t-1}$	0.152***	0.127***
	(0.003)	(0.003)
Capital Intensity$_{t-1}$	0.143***	-0.016*
	(0.009)	(0.009)
R^2(within)	0.13	0.10
F test (*p*-value)	4210.74 (0.000)	3326.94 (0.000)
Number of observations	1 072 617	1 072 617

Legend: ***, ** and * indicate statistical significance at 1, 5 and 10% levels, respectively. Models include 18 sector dummies.
Source: Own computations based on the Bank of Portugal's Simplified Business Information (SBI).

The results above evidence that export *per se* and coupling export with R&D activities have a positive and highly significant impact on firms' sales growth. Thus, the answer to our second question (What is the individual and joint impact of exports and R&D investment on the economic performance of companies?) is clear cut: joint export and R&D produces the highest impact on firms growth, followed by 'only export' and then 'only R&D'. It is important to note that although R&D *per se* convey the weakest direct impact on firms' growth, it indirectly impacts on this latter via exports - indeed, as we observe in the previous subsection, R&D increases the likelihood of firms exporting in the next period (cf. Table 8), which then has a direct and positive effect on sales growth (cf. Table 9).

5. Conclusions

This study uses firm-level data from Portugal to analyze the two-way dynamic relationship between R&D and exporting activities and to explore the effect of R&D and exports on firms' sales growth. Our null hypotheses are that R&D and exports are complementary activities that reinforce each other, and which have a higher positive effect on sales growth if the two activities are take in place simultaneously.

Based on more than 340 thousands firms over the time span 2006-2012, the results indicate that there a strong cross-dependence in the firms' choices of export and R&D engagement. Thus, engaging in export activities increases firms' chances of engaging in R&D and engaging in R&D activities increases firms' chances of engaging in export, which in turn increases firms' chances of succeeding in the other activity again. Such results suggest that there are complementarities between export and R&D, a result in line with recent works in the area, most notably those from Ito and Lechevalier (2010), Golovko and Valentini (2011), and Esteve-Pérez and Rodríguez (2013).

These results are also consistent with the predictions of the theoretical frameworks described in Section 3. The findings provide support for the hypothesis that more productive firms self-select into exporting activities and also provide support for the learning-by-exporting hypothesis, which defends that previous export participation enhances investment in R&D due to the fact that larger export market provides higher returns to R&D.

Finally, the findings are also consistent with the cognitive approach that considers exporting and R&D activities as potential and complementary channels for knowledge acquisition (Esteve-Pérez and Rodríguez, 2013). These results are fairly robust given that the bivariate probit model takes into account the correlation between error terms in the two participation equations (Esteve-Pérez and Rodríguez, 2013).

Also the hypothesis of complementarity of the two activities in terms of impact in sales growth is verified in our study and this result is in line with previews works namely Filatochev and Piesse (2009) and Golovko and Valentini (2011). The hypothesis of complementarity of the two activities (export and R&D) in terms of impact in sales growth means that compared to the firms that does not export nor are

involved in R&D activities, companies that export and do R&D have a better performance in terms of sales this conclusion reinforce the result obtained previously regarding Export and R&D complementarity.

Although the results obtained are robust – the methodology undertaken – fixed effects with AR(1) – and the large sample used, encompassing more than 1 million observations – it is important to highlight some pitfalls or limitations. First, and although Golovko and Valentini (2011) argue, the exclusive use of dummies variables for describing R&D and exports activities has the good property of not imposing any specific functional form in the growth regression, amore fine-grained data on R&D and export (e.g., export and R&D intensity) could be profitably exploited. Second, due to unavailability of data, we do not control for where the export activity is directed to, assuming that export may be equally beneficial regardless the export market. Salomon (2006) shows that there is important benefits, in terms of incoming knowledge spillovers, when exporting to developed foreign markets. Thus, firms that export to more developed markets would present a stronger complementarity relationship between export and R&D (Golovko and Valentini, 2011). Third, we work with data from one single country. In this vein, we cannot assess the effect of differences in institutional, financial and governance regimes and test whether those factors could matter for the link between firms' strategic choices and growth (Sapienza *et al*., 2006).

Despite the limitations, our results are in line with previous studies for other countries such as Spain (e.g. Golovko and Valentini, 2011 and Esteve-Pérez and Rodríguez, 2013), Twain (Aw et al., 2011), Ireland (Girma *et al*., 2008), and (partially) for Slovenia (Damijan *et al*, 2010). In this latter case, Damijan *et al.* (2010) found evidence of the learning by exporting hypothesis for medium and large Slovenian firms i.e. positive effect of exports on R&D, but failed to observe a positive impact of R&D on exports. It is apparent therefore that our results might be extrapolated for countries with similar characteristics as Portugal, that is, a small, peripheral and open country.

Our results have some important implications for firms' management and for policy makers. Managers should withdraw from our study that although both activities (export and R&D) include high costs and risks, being considered often as substitute activities, insofar as they compete for finite resources that companies have (Roper

and Love, 2002), they should not ignore the potential of carrying out the two activities simultaneously. Indeed, as we have demonstrated, performing both activities simultaneously generates more benefits than adopting the two activities in isolation, suggesting that there is a positive interaction between them. However, as referred Golovko and Valentini (2011), the fact that there is complementarity between the two activities is not to say that such complementarity exists for every firm since it is assumed that this positive relationship depends on a large number of factors besides those included in the analyses.

The second main result from our study – carrying out the two activities (exports and R&D) generates synergies that positively affect sales growth – yield important policy implications. Specifically, innovation and export promotion policies should be articulated and carried out together, demanding a joint development of both activities rather than trying to implement separate policies for each activity, as it is often the case given that such activities are usually designed by different and non-related government offices. For Esteve-Pérez and Rodríguez (2013), these policies should be considered as part of a more comprehensive policy enhancing firms' market strength that requires combining initiatives in order to both reduce sunk start-up costs in these activities and also enhance firms' absorptive technological capabilities in order to fully achieve the complementarities between exports and R&D. In peripheral countries such as Portugal, where firms do not have easy access to financing for supporting export and R&D activities, it is essential to device proper policy measures that assure that the given set of selected firms accesses to funds for simultaneously develop these activities.

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