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By S. Barrios, H. Görg and E. Strobl

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Abstract

We examine the importance of a firm's own R&D activity and intra-sectoral spillovers on the decision to export and the export intensity using firm level panel data for Spain for the period 1990 to 1998. Our results are in line with preceding findings on the role played by firm-specific variables such as age, firm size, productivity and workers' skills. In addition, we show that export and R&D spillovers, either from MNEs or domestic firms in the sector, have a different impact on Spanish and foreign firms, the latter generally benefiting from positive spillovers. Further evidence shows a larger marginal impact of R&D spillovers on export intensity of Spanish firms exporting to other OECD countries than those exporting to non-OECD nations.

Outline

Non-Technical Summary

While there is a large literature on measuring productivity spillovers from MNEs, few studies have specifically examined the importance of spillovers from MNEs and other domestic firms on firms export performance. Our paper provides a further attempt to measure the importance of firm characteristics and export and R&D spillovers on firms export behaviour. We examine the firms decision of whether or not to export and the determinants of the export ratio (measured as exports over total sales) using firm level data for Spanish manufacturing industries for the period 1990 to 1998.

Spain arguably provides an interesting case study in this regard. Since its accession to the European Community in 1986, Spain has experienced a considerable deterioration in its trade balance as foreign trade and investment were liberalised. The low level of international competitiveness of Spanish firms has been blamed as the main factor behind this growing trade deficit, which appears to have partially constrained economic growth. With ever increasing competition from other European countries, especially in modern industries, an improvement in competitiveness to European efficiency levels and a strong domestic export base remains a high priority among policy makers and economists.

Besides providing evidence for another country this paper extends the existing literature in a number of ways. First, we not only consider the importance of spillovers but also measure the effect of own firm R&D expenditure on its export activity. Second, we examine the effect of spillovers from MNEs separately for both foreign and domestic firms, providing evidence for significant differences between the two firm-types. Third, we allow not only for spillovers emanating from MNEs but also from other domestic firms operating in the same sector. Fourth, we test the influence of R&D spillovers on firms export ratio by considering different export destinations, namely the EU and other OECD countries vis-a-vis the rest of the world.

Our empirical results show that a firm s own R&D activity is an important determinant of whether or not this firm becomes an exporter, and how much a firm exports. R&D spillovers, either from MNEs or domestic firms, do not appear to affect the likelihood of whether domestic firms become exporters, although there is evidence that foreign firms benefit from R&D spillovers from other MNEs located in the same sector. Our results do suggest, however, that R&D spillovers exert positive effects on firms export ratios for both domestic and foreign firms. Furthermore, our evidence shows that the marginal impact of R&D spillovers on firms export ratios is larger for firms exporting to EU or OECD countries (which are assumed to be technology intensive markets) rather than to the rest of the world. We do not find very strong evidence to suggest that Spanish firms benefit from spillovers through the export activities of other firms. While there is some evidence that firms are more likely to become exporters in industries in which there is a large presence of domestic exporters, this does not appear to impact on the export ratio. We also find no evidence that domestic firms benefit from spillovers from MNEs, although other foreign firms do appear to benefit from the export activities of other MNEs located in the same sector.

1. Introduction

A strong export base is generally regarded as a key component to economic growth. Exporters are usually considered to be high-performance firms for two reasons. When competing in foreign markets exporting firms generally incur higher trade barriers and face different consumer tastes and tougher competition. Secondly, exporting additionally makes firms more easily aware of potential innovations taking place abroad and they may assimilate these in order to improve their position both in domestic and foreign markets. This *learning by competing effect* may also spread over local firms and benefit them indirectly. However, in order to compete successfully in foreign markets and avail of the benefits firms must have or acquire the appropriate knowledge and technological capability, for example through a firm's own Research and Development (R&D) activities or spillovers arising from other firms, both domestic and foreign. Identifying the determinants of export behaviour can thus arguably provide important policy tools for stimulating economic growth.

While there is a large literature on measuring productivity spillovers from MNEs,[1] few studies have specifically examined the importance of spillovers from MNEs and other domestic firms on firms' export performance. For example, Aitken et al. (1997) in a study of Mexico for the period 1986 to 1990 find that export activities of MNEs have positive effects on the probability of whether a firm located in the same sector, either foreign or domestic, is an exporter. In a more recent paper Bernard and Jensen (2001) examine for the US between 1984 and 1992 if sectoral export activity has any effects on whether US firms are exporters or not and do not find any strong evidence for spillovers, although they do not distinguish between export activity in MNEs and domestic firms. It is also noteworthy that both of these papers only examine the decision of whether or not to export, and consider only regional and industry export spillovers specifically arising from MNEs.

Using firm level panel data for the UK for the period 1992 to 1996, Sousa et al. (2000) investigate whether spillovers affect a firm's export intensity. They consider two channels for MNE spillovers, viz., MNEs' export activities and MNEs' R&D activities in the sector. They find that MNEs' exports have a positive effect on domestic firms' probability of being

[1] See Görg and Strobl (2001) and Blomström and Kokko (1998) for critical surveys of this literature. In a recent paper, Barrios and Strobl (2001) find some evidence for productivity spillovers related to the presence of multinational enterprises (MNEs) in Spanish manufacturing, although only for firms which have sufficient levels of absorptive capacity that enables them to usefully assimilate the kind of externalities generally associated with foreign presence.

exporters but do not find evidence that such spillovers impact on the export ratio of domestic firms. On the other hand, there are R&D spillovers from multinationals to domestic firms that affect positively both the decision of to export and the choice of export ratio.[2]

Our paper provides a further attempt to measure the importance of firm characteristics and export and R&D spillovers on export behaviour. We examine the firm's decision of whether or not to export and the determinants of the export ratio (measured as exports over total sales) using firm level data for Spanish manufacturing industries for the period 1990 to 1998. Besides providing evidence for another country this paper extends the existing literature in a number of ways. First, we not only consider the importance of spillovers but also measure the effect of own firm R&D expenditure on its export activity. Second, we examine the effect of spillovers from MNEs separately for both foreign and domestic firms, providing evidence for significant differences between the two firm-types. Third, we allow not only for spillovers emanating from MNEs but also from other domestic firms operating in the same sector. Fourth, we test the influence of R&D spillovers on firms' export ratio by considering different export destinations, namely the EU and other OECD countries *vis-a-vis* the rest of the world. We show in particular that R&D spillovers have a positive and significant impact on the export ratio when exports are destined to the first two groups of countries, while no significant relationship between these variables appears for the exports destined to the rest of the world. These results provide evidence for a larger marginal impact of R&D spillovers on export over domestic sales when Spanish firms compete with countries with a (generally) superior technological capability.

Spain arguably provides an interesting case study in this regard. Since its accession to the European Community in 1986, Spain has experienced a considerable deterioration in its trade balance as foreign trade and investment were liberalised (see, for example, De la Dehesa et al., 1991; Herce et al., 1998). The low level of international competitiveness of Spanish firms has been blamed as the main factor behind this growing trade deficit (Martin, 2000), which appears to have partially constrained economic growth, as recently shown by Alonso (1999). With ever increasing competition from other European countries,

[2] Kokko et al. (2001) also investigate the effect of spillovers from MNEs on the decision to export by domestic firms in Uruguay using cross-sectional firm level data for 1998. Their measure of spillovers, however, is a simple measure of the presence of multinationals (not export activity) in terms of the output share of MNEs in an industry. It is, thus, not clear through which channel the presence of multinationals is supposed to lead to spillovers.

especially in modern industries, an improvement in competitiveness to European efficiency levels and a strong domestic export base remains a high priority among policy makers and economists.

The rest of the paper is structured as follows. In Section 2 we describe our theoretical background and Section 3 describes the dataset and provides summary statistics. The econometric analysis of export activity is contained in Section 4, while Section 5 presents a discussion of empirical results. Finally, Section 6 concludes.

2. Theoretical Background

Our theoretical framework follows closely that of Aitken et al. (1997). We assume the cost function of each firm to be decomposable into two components: production costs, *h*, and distribution costs, *m*. All output is produced in the home country (*d*) but can be sold on the domestic market or abroad (countries *d* and *f*). The total cost function can be expressed as follows:

$$C = h(q_d + q_f) + m_d(q_d) + m_f(q_f) \quad (1)$$

where *q* represents the quantity sold in each market. As in Aitken et al. (1997), we assume that distribution costs in foreign markets *f* are a decreasing function of total export activity (Γ_{EX}) in the sector.[3] In addition to Aitken et al., we furthermore assume those costs to be decreasing function of R&D expenditure at the sector level (Γ_R):

$$\frac{\partial m_f(q_f)}{\partial \Gamma_{EX}} \leq 0 \quad (2)$$

$$\frac{\partial m_f(q_f)}{\partial \Gamma_R} \leq 0 \quad (3)$$

$$\frac{\partial m_d(q_d)}{\partial \Gamma_R} \leq 0 \quad (4)$$

Equation (3) implies that firms benefit from the amount of technology and the knowledge intensity of other firms in the same sector in order to gain access to foreign market. Sector-level R&D expenditure is not considered as a direct link to foreign markets, but we assume it provides a way to improve product quality and general knowledge in order to compete successfully in foreign markets. In that sense, sector-level R&D also benefits local sales as

shown by equation (4). The overall effect or G_R is then ambiguous for the ratio of export to total sales, as we shall see below.

We argue that export and R&D activity in a sector affects a firm's distribution costs regardless of whether this activity is undertaken by MNEs or domestic firms in the sector. The positive effect from MNEs may, however, be stronger than from domestic firms for both channels of spillovers. In terms of export activities, multinationals, because of their very nature, can be assumed to have better knowledge of foreign markets and therefore may be more beneficial to other firms deciding to export. Also, multinationals are usually considered to be more technology intensive than domestic firms (e.g., Markusen, 1995) and may therefore provide a better source for R&D spillovers also.

Using simple quadratic functions, the terms of the cost function in equation (1) can be expressed as follows:

$$h(q_d + q_f) = \frac{a}{2}(q_d + q_f)^2 + g(q_d + q_f) \qquad (5)$$

$$m_i(q_i) = \frac{b}{2}q_i^{\,2} + c_i q_i \qquad \text{with } i = d, f \qquad (6)$$

where a, b are scalars and g and c_i ($i=d,f$) are functions of cost variables for the production and distribution cost functions respectively. Specifically, c and g can be expressed as follows:

$$g = g(X) \qquad (7)$$

$$c_d = c_d(X, Z_d, G_R) \qquad (8)$$

$$c_f = c_f(X, Z_f, G_{EX}, G_R) \qquad (9)$$

where X is the production cost incurred both in the home and foreign markets and Zi are the distribution costs incurred in the home and foreign market assuming $Z_d \leq Z_f$.

We consider distribution costs in foreign markets to be higher than distribution costs in local markets. The former include higher transport costs (e.g. tariff and non-tariff barriers), the product has to be adapted to foreign tastes and market conditions, exports channels have to be set up and companies have to compete with established firms. We leave the precise definitions of X and G for the empirical section.

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[3] Aitken et al. (1997) also argue that the presence of MNEs in a sector affects distribution costs. However, it is not clear how this spillover effect works and we therefore do not include it herein but focus on the two channels of spillovers, namely, export activity and R&D.

The maximization problem of the representative producer located in *h* is

$$\max_{qd,\,qf} \; p_d q_d + p_f q_f - h(q_d + q_f) - m_d(q_d) - m_f(q_f) \tag{10}$$

assuming that $q_d, q_f \geq 0$.

First order solutions give:

$$q_d = \frac{1}{a+b}\left(p_d - aq_f - g - c_d\right) \tag{11}$$

$$q_f = \frac{1}{a+b}\left(p_f - aq_d - g - c_f\right) \tag{12}$$

We consider two dependent variables: the decision whether or not to export and the ratio of foreign to total sales. Expression (12) provides the equation for the decision to export when $q_f = q_f^*$, where q_f^* is the optimal value given by the maximization of (10) and the solution (12). The ratio of export to total sales can be expressed using the solution given by (11) and (12). After rearranging we obtain the following expression for the export ratio (*ER*):

$$ER = \frac{q_f}{q_h + q_f} = \frac{p_f - aq_d - g - c_f}{p_f + p_d - a(q_d + q_f) - 2g - c_d - c_f} \tag{13}$$

Equations (11) - (13) can be rewritten in order to get estimable expressions:

$$q_{d,ij} = \alpha_1 p_d + \alpha_2 q_{f,ij} + \alpha_3 X_{ij} + \alpha_4 Z_{d,ij} + \alpha_5 \Gamma_{R,j} + u_{d,ij} \tag{14}$$

$$q_{f,ij} = \beta_1 p_f + \beta_2 q_{d,ij} + \beta_3 X_{ij} + \beta_4 Z_{f,ij} + \beta_5 \Gamma_{R,j} + \beta_6 \Gamma_{EX,j} + u_{f,ij} \tag{15}$$

$$ER_{ij} = \gamma_1 p_f + \gamma_2 X_{ij} + \gamma_3 Z_{f,ij} + \gamma_4 P_d + \gamma_5 Z_{d,ij} + \gamma_6 \Gamma_{R,j} + \gamma_7 \Gamma_{EX,j} + \varepsilon_{ij} \tag{16}$$

We assume $u_{d,ij}$, $u_{d,ij}$, ε_{ij} to be normally distributed error terms with zero mean and constant variance. Equations (14) and (15) form a system of simultaneous equations. We focus our analysis on the decision to export represented by (15) and the export ratio represented by equation (16). Further transformation of (15) is needed in order to obtain an estimable equation.

The decision to export can be represented by the dummy variable $y_{i,j}$:

$$\begin{cases} y_{i,j} = 1 & \text{if} \quad q_f > 0 \\ y_{i,j} = 0 & \text{otherwise} \end{cases} \tag{17}$$

Accordingly, the probability for firm *i* to export can be expressed as follows:

$$\Pr(y_{i,j} = 1) = \Pr[\beta_1 p_f + \beta_2(\alpha_1 p_d + \alpha_4 Z_{d,ij}) + \beta_4 Z_{f,ij} + (\beta_2 \alpha_3 + \beta_3) X_{ij}$$

$$+ \beta_6 \Gamma_{EX,ij} + (\beta_2 \alpha_5 + \beta_5)\Gamma_{R,ij} + v_{ij}] > 0 \qquad (18)$$

where $v_{ij} = \beta_2 u_{d,ij} + u_{f,ij}$ given the assumptions made on $u_{d,ij}$ and $u_{f,ij}$

Aitken et al. (1997) argue that export spillovers could also improve firms' positions in their local market; the term Γ_{EX} should then be added to (14). The coefficients on this variable in (16) and (18) will still display positive signs provided that the positive effect on exports outweighs the positive effect on domestic sales. The coefficient $(\beta_2\alpha_5 + \beta_5)$ in equation (18) is subject to a similar remark: the probability to export will rise when the positive effect on export of R&D spillovers exceed the positive effect on domestic sales, namely when $\beta_5 > -\beta_2\alpha_5$. Of course, the same applies for the coefficient γ_6 in equation (16).

Our model, thus, assumes that R&D spillovers improve both local and foreign market positions by raising firms' efficiency and product quality. When R&D spillovers arise, firms belonging to R&D intensive industries tend to adopt these new technologies. If we assume that foreign markets are more competitive than domestic markets (if, for example p_d is always higher than p_f) then the effect of R&D spillovers will be likely to have a greater marginal impact on firms' sales abroad than in their home market, as firms have to be more competitive and technologically advanced to penetrate markets abroad. The resulting impact of Γ_R on *ER* would then be positive.

The technological level of foreign competitors also matters. In the empirical case considered in the following sections, Spanish manufacturing firms are thought to compete mainly with other EU and OECD countries. The state of technology can be considered to be higher in those countries than in Spain where R&D expenditure, especially in the private sector, is much lower than in other industrialised economies (see OECD, 1999). Our data show that 65.2 percent of total Spanish manufacturing exports were destined to other EU countries in 1990, this percentage rising to 68.7 percent in 1994 and 78.4 percent in 1998.[4] Even if Spanish firms may find it difficult to export in R&D intensive activities the marginal effect of R&D spillovers can be larger than in the Spanish market. The overall effect on *ER* is therefore ambiguous and empirical evidence is called for in order to know whether the R&D spillovers positively affect exports more than local sales.

[4] The data on the destination of exports was only available for those years. Source: ESEE and authors' computations.

In the empirical estimation below we consider equation (16) for our test of the determinants of the export ratio and equation (18) for the test of the probability to export.

3. Data

We use data from the Encuesta Sobre Estrategias Empresariales (ESEE) of the Spanish Ministry of Industry and Energy (MINER) and the Fundación Empresa Pública (FUNEP, Madrid). The data is not exhaustive and covers around 22 percent of total Spanish employment in manufacturing industry. The coverage of this survey is also oriented towards large firms since almost all manufacturing firms with more than 200 employees are included while only a representative sample of firms with less than 200 employees are covered. The unit of observation is the firm level.

The total number of firms for which we have data is well over 2,000 over the period 1990-1998. An important feature of the survey is that we cannot distinguish between exits and random non-response rendering correction for sample selection difficult. Moreover, data on some of the variables were only available for three years, namely, 1990, 1994 and 1998. We therefore chose to include firms that have been in the survey for all these three years in order to avoid selectivity problems through entry and exit of firms and hence our results should be considered as descriptive of export behaviour of continuing firms only. Dropping firms that were not in the sample continuously and focusing only on three years left us with data on 2,188 firms. Note, however, that all sectoral variables included in the regressions below, such as R&D or export activity in the sector, were calculated using data on all firms, including those that entered or exited during the sample period in order to preserve the representativeness of the ESEE when using sector-level indicators.

Other variables of interest provided by the ESEE are the number of employees, different measures of skills, labour costs, sales, R&D activities, value added and external trade. As noted earlier, one of our main variables is R&D. The ESEE provides a broad definition of R&D activities that reflects appropriately our theoretical priors: R&D concerns *scientific activities, technical information*, *normalization and quality control, marketing*, *publicity* and *design of new products.* This information arguably reflects the technological activity as well as the effort made by firms in designing and promoting new products. Finally, all monetary variables were deflated using sectoral price indices, where each firm's economic activity was classified (by the data) into one of 18 sectors of the nomenclature CNAE 74, which is an altered version of the European Nace 70 Codes.

Table 1 shows that between 1990 and 1998 there has been an increase in export activity in Spanish manufacturing industries with overall export ratios rising in 17 out of 18 sectors. At the same time, the number of exporters has decreased in most of the manufacturing sectors. These two opposing trends went hand-in-hand with an increasing presence of multinationals (measured in terms of their employment share in a sector) in 10 out of 18 manufacturing sectors.[5] Whether the changes in export activity at the firm level are in some degree due to spillovers arising from MNEs is the main point of the empirical analysis in this paper.

[Table 1 here]

4. Econometric Analysis

In our estimations of (16) and (18) we consider both firm and sector specific variables which are assumed to impact on production costs X and/or distribution costs Z_f and Z_d . Our choice of variables is guided by the existing empirical literature on the determinants of exports.[6,7] Accordingly, firm-level determinants are age, size, a dummy equal to one if the firm is a multi-plant firm, productivity, average wage per head, and a firm's R&D intensity.[8]

We follow Roberts and Tybout (1997) by including age and size (measured in terms of total employment) in order to control for past success of the firm. As is frequently found in the empirical industrial organisation literature, older and larger plants are more likely to be good performers and may therefore also be more likely to have higher export activity than other firms (see also Bernard and Jensen, 1999). We allow the effect of age and size to be non-linear by including both variables squared. An additional indicator of past success is

[5] A firm is defined as a foreign MNE if foreign participation > 0. In practice, foreign participation is in most cases higher than 20 – 30 percent.

[6] Our analysis of firm's export activity is static and does not take into account the importance of sunk costs in exporting and past exporting performance, as in Roberts and Tybout (1997) and Bernard and Jensen (2001). This is due to the nature of our data with only three years within a nine year period. This also implies that, theoretically, we expect the effect of all explanatory variables to be instantaneous.

[7] While the equations derived in the theoretical part include prices as well we do not include price indices for three reasons. Firstly, empirically it would be recommendable to use firm-level price indices since the use of industry-level price indices may introduce aggregation bias in our estimates. Secondly, since nominal variables were deflated with these indices, the use of price indices as additional explanatory variables may introduce co-linearity problems. Third, ideally, we would need export prices in order to consider relative prices, however such data are not available to us.

[8] Table 2 provides a list of variables and details of variable definitions.

productivity which also features in the empirical model of Bernard and Jensen (2001).[9] A multiplant dummy is included in order to control for the effects of organisational structure on export activity. However, the firm characteristic of most interest to us is the firm's R&D intensity. This variable is measured as the ratio of R&D expenditure over total sales. We would expect that the higher the R&D intensity is, the higher the plant's export activity will be (see Bleaney and Wakelin, 2001).

We also include four sector specific variables as well as a set of industry dummies to control for time invariant sectoral effects. Our choice of sector-specific variables is based on measures of exports and R&D spillovers by making the distinction between foreign and domestic firms activities.

[Table 2 here]

The first sector-specific variable is an index of domestic export activity which indicates the relative importance of domestic exports in sector *j* in total exports in *j*, relative to the importance of domestic exports in total exports. From our theoretical framework we would expect this variable to capture any positive spillovers from the export performance of domestic firms in the same sector as firm *i*.[10] The second export-spillover variable is the export activity of multinational enterprises. Following Aitken et al. (1997) this variable is calculated as the ratio of MNE exports in sector *j* over total exports in *j*, relative to the importance of MNE exports in total exports.[11] MNEs generally exploit different channels for trading internationally, especially through intra-firm trade. Domestic firms may benefit from these links for example if they are chosen as providers of intermediate products (see Blomström and Kokko, 1998). We thus need to make the distinction between domestic and MNEs export spillovers.

[9] Note, however, that we do not intend to infer the direction of causality between our proxies for "success" and exports. As Bernard and Jensen (1999) discuss, the causality can go both ways.

[10] However, from a more general trade theoretic viewpoint the variable proxies factors that determine a sector's export profile, such as the role of factor endowments and, thus, the export structure of the host country. In any case we would expect firms located in sectors with high domestic export activity also to be active exporters.

[11] The definitions of the spillover variables should minimise possible endogeneity problems which would arise if a firm's export activity and the spillover variables were determined simultaneously. For the export spillover variable, our empirical model should pick up any shocks common to firms and which might lead to endogeneity in the domestic export variable and in industry specific dummies. Also, the effect that MNEs might be more likely to locate in export and/or R&D intensive industries should be controlled for by the inclusion of the domestic variables and sectoral dummies.

We also measure two possibilities for R&D spillovers. First, as in Sousa et al. (2000) we consider R&D undertaken by multinationals located in the same sector. Furthermore, we also consider R&D realized by domestic firms. The rationale for this is based on descriptive statistics reported in Table 3 showing that Spanish and foreign firms display different levels of R&D expenditure per employee depending on the sector and, occasionally, the year considered. For some sectors like chemicals, metal products or industrial machinery domestic firms have higher level of R&D per employee than their foreign counterparts based in Spain. For other sectors like computing, electrical machinery and transport industries, foreign affiliates display higher, sometimes much higher ratios. Foreign presence is also high in these sectors as shown in Table 1. In the theoretical literature, it is generally assumed that the largest part of R&D by multinationals is undertaken in the home country. Foreign affiliates then exploit the R&D services provided by the headquarters at a low marginal cost. Those R&D services are akin to a public good within the firm that benefits the different affiliates around the world (see Markusen, 1995). As a consequence, domestic firms' and foreign affiliates' R&D activities may have different effects on other firms' innovative activities and export performance.

Both for our export and R&D spillovers, we allow the MNEs-related spillovers variables to have different impacts on domestic and foreign firms by including interaction terms which are set to zero if firm *i* is domestic and equal to the MNE spillover variable if the firm is foreign-owned. The rational behind this is that one may expect foreign firms to be better able to assimilate the spillovers emanating from MNEs if they have a better absorptive capacity than domestic firms.

[Table 3 here]

5. Empirical Results

As discussed in the theoretical section, we measure the export activity of firm *i* in two ways. The first measure is a dummy variable equal to one if the firm is an exporter at time *t* (and zero if not) while the second is the firm's export ratio, defined as exports as a percentage of total sales by firm *i* in time *t*. We first report results of a probit estimation of the determinants of whether a firm is an exporter or not in Table 4. This allows us to compare our results with those by Aitken et al. (1997) for Mexico, which pertain only to how spillovers affect firms' decisions to export.

Columns (i) to (iii) present results for a simple probit estimation using the total sample of firms pooled over the three years.[12] However if there are significant unobserved time invariant firm specific effects that are correlated with the explanatory variables then the simple pooled regression may produce biased and inconsistent estimates. Since we pool data for 1990, 1994 and 1998 where we have a significant time gap between the years the presence of time-invariant firm specific effects may not pose too much of a problem. However, in order to control for the possibility of the presence of such effects we also estimated a random effects probit model (see Guilkey and Murphy, 1993), the results of which are reported in columns (iv) and (vi) of Table 4. The likelihood ratio test reported in the table indicates that the panel-level variance component is not unimportant and, hence, the pooled estimation is not identical to the panel estimation. However, overall, the results of the pooled probit and random effects probit are reasonably similar in terms of magnitudes and statistical significance of the coefficients.

Inspection of the results shows that, as expected, firms are more likely to be exporters the older and larger they get; a finding that is in line with the results obtained by Roberts and Tybout (1997) in their analysis of the decision to export by Colombian firms. In our case, however, we allow the effects of age and size to be non-linear and our statistically significant coefficients provide support for this assumption. In line with Bernard and Jensen (2001) we also find that more productive firms are more likely to be exporters, while being a multiplant firm does, contrary to expectations, not make a firm more likely to export.

We also find evidence that wages per head positively affect a firm's decision to export, which is a result also found by Aitken et al. (1997). They argue that wages might then be interpreted as a measure of firms' skill intensity of production. In order to check whether this assumption is reasonable we replaced wages per head by two more direct measures of skill, namely, the ratio of non-production to total employees and the percentage of technical employees. While the coefficients for these estimations are positive in all four cases there is only one case (for the percentage of technical employees as skill measure) where it displays statistically significantly different from zero results at the five percent level. This result, however, is also similar to the finding of Bernard and Jensen (2001) that provide

[12] The number of observations used is not equal to (3*2,188=) 6,564 as export data are missing for some firms and years. Since the data are missing randomly this should not lead to any selectivity problems.

only weak evidence for a positive effect of skills (measured as percentage of non-production employees) on the decision of US firms to export.

In terms of R&D activity we find strong evidence that a firm's own R&D intensity is an important determinant of whether the firm exports. R&D spillovers, whether from domestic or multinational firms do not appear to encourage export activity by domestic firms. The interaction term, however indicates that spillovers from MNEs do benefit foreign firms, i.e., foreign firms benefit from R&D activity of MNEs in the same sector while domestic firms do apparently not. This may perhaps indicate that foreign firms have a better *absorptive capacity* to assimilate and utilise the knowledge that spills over from the R&D activity of other MNEs in the same industry.

As regards export activity in the sector our results provide evidence that firms located in export oriented sectors (as measured by the export orientation of domestic firms) are more likely to be exporters. The probit results do not provide any evidence that there are spillovers from the export activities of MNEs on domestic firms in the same sector; a finding that contrasts with Aitken et al. (1997) and Sousa et al (2000) who find statistically significant spillovers from export activities of MNEs in Mexico and the United Kingdom, respectively.[13] Our statistically significant and positive interaction terms do, again, indicate that foreign firms benefit from the export activities of MNEs in the same sector. Again, this suggests that foreign firms have a better ability to take in the knowledge (in terms of exporting) than domestic firms.

[Table 4 here]

While many of the variables included in the probit model are statistically significant it is not clear what their economic significance is. In order to try and assess this we calculate the change in probability (at the mean of the independent variables) associated with a marginal change in the variable for the results reported in column (i). Accordingly, we find that the predicted probability that firms export is 0.64. The coefficient on the R&D interaction term then indicates that a marginal increase in the MNE R&D presence would lead to an increase in the probability to export for foreign firms by $0.7e^{-09}$. This compares with an effect of the MNE export interaction term where a marginal increase in the

[13] Note that our result is in line with Bernard and Jensen (2001) who also fail to detect spillovers from other firms' export activity. They, however, do only consider spillovers from total export activity in the sector and do not distinguish spillovers from MNEs and other domestic firms.

interaction term leads to an increase in probability by 0.18. This shows that R&D spillovers, while statistically significant, seem to play only a minor economic role in explaining export behaviour of foreign firms.

By far the most important factors influencing whether a firm, either domestic or foreign is an exporter are the own firm's R&D intensity and the export orientation of domestic firms. The marginal effect of the former is 1.29, while the corresponding increase in probability associated with the latter variables is 0.07 percent. The marginal contributions of all other explanatory variables are less than 0.01 for each variable.

In this paper we are not only interested in what determines whether a firm exports or not, but also in the determinants of the export ratio, i.e., how much a firm exports. The export ratio, by definition, varies between 0 and 1 and, therefore, OLS estimation is not appropriate. Rather, we employ a tobit model which allows for left and right censoring of the data.[14] As in the probit estimations above, we first estimate a simple tobit model on the pooled data, ignoring any possible firm specific time invariant effects. These estimations are reported in columns (i) to (iii) of Table 5. In order to control for possible firm specific effects we also estimated a random effects tobit model, the results of which are in columns (iv) to (vi). The likelihood ratio test indicates that the panel estimations are not identical to the pooled tobit model; however, inspection of the results in Table 5 shows that they are roughly similar in terms of size and significance of the coefficients.

As in the probit estimations we find that older and larger firms tend to export more, although these effects are non-linear. There is also some evidence that highly productive firms also have higher export ratios, while the organisational structure, i.e., whether a firm is a multiplant or single-plant firm, does not appear to matter. In terms of wages and skills we find a positive effect on the export ratio in three specifications. However, one result (in column (ii)) indicates that the higher the ratio of non-production to total workers, the lower the export ratio.

[14] One problem in the estimation of the determinants of the export ratio is that there may be selectivity bias if we were to include only firms with positive exports. The tobit model, however, includes all firms, i.e., also those with zero exports. We also focus on firms which were in the sample in all three years, therefore avoiding selectivity bias due to entry and exit of firms. Nevertheless, we also estimated a Heckman (1979) two-step model in order to account for possible selectivity bias. These estimations do not provide evidence that selectivity problems exist; we cannot reject the hypothesis that Heckman's lamda equals zero in any of the two-step estimations.

In terms of the impact of R&D our results suggest, first, that firms export more the higher their R&D intensity (although the coefficients are only statistically significant in the pooled tobit estimations); a finding that is in line with Bleaney and Wakelin (2001) who analyse the export performance of UK manufacturing plants. In contrast to the probit estimations reported above we also find evidence for positive spillovers from R&D undertaken in the same industry as the coefficients on both the domestic R&D and MNE R&D are positive. The coefficients are, however, only statistically significant for the random effects tobit estimation in the case of the former variable. This suggests that R&D spillovers, though apparently not affecting a firm's decision of whether or not to export, do stimulate firms to export more abroad. In line with the probit estimations we also find a positive R&D interaction term, implying that R&D spillovers are stronger for foreign than for domestic firms.

As regards export activity in the sector results are fairly similar to the probit estimations, although the evidence for a positive effect of domestic export activity in the sector is weaker in terms of statistical significance. There is still no evidence for spillovers from MNE export activity benefiting exports by domestic firms. In contrast, we find a positive interaction term, i.e., there is a positive spillover of MNE export activity to foreign firms located in the same sector as the MNEs.

[Table 5 here]

We are cautious to point out that the coefficients on R&D activity are low; for example, in column (iv) we find that an increase in the domestic sectoral R&D intensity by one unit, i.e., one percentage point, leads to an increase in the firm's export ratio by $1.8e^{-09}$ percentage points (units). Similarly the marginal effect for R&D spillovers from MNEs is to raise the export ratio by $2.1e^{-09}$ percentage points. In contrast, an increase in the firm's own R&D intensity by one percentage point leads to an increase in the export ratio by 0.1 percentage points.

In the theoretical section above we argued that we would expect the effect of R&D to matter more for exports to technologically advanced countries, such as other EU and OECD countries. This is because exporters have to improve their own technology first in order to be able to compete on those markets successfully, while lower levels of technological sophistication may suffice for exports to less advanced countries or indeed local sales. In

order to see whether we can find any evidence supporting this conjecture we estimate separately the determinants of the ratio of exports to EU and OECD countries over total sales, and the propensity to export to other countries (assuming that "other" countries are less technologically advanced). The results of these estimations are reported in Table 6. Focusing on the coefficients on the R&D variables we find that, at first sight, the coefficients seem to be consistently higher in the case of exports to EU and OECD countries. Domestic R&D activity and spillovers from R&D undertaken by MNEs are only statistically significant determinants for the propensity to export to EU/OECD countries. This finding is in line with our theoretical assertion.

[Table 6 here]

To provide a more formal evaluation we also conducted t-tests of whether the coefficients are equal in the two separate estimations. This is, we compare the coefficients on the R&D variables in column (i) with (iii), and (ii) and (iv) where the null hypothesis is that $\beta_i = \beta_{iii}$. The results, which are reported in Table 7, show that the difference between the coefficients is only statistically significant in the case of R&D spillovers from MNEs. MNE spillovers, therefore, have a greater effect on exports to EU and OECD countries, which is in line with our theoretical argument.

[Table 7 here]

6. Conclusion

This paper uses firm level data of Spanish manufacturing for 1990 to 1998 to reconsider the importance of firms' own R&D activity and intra-sectoral spillovers on firms' export behaviour. We distinguish two channels for spillovers, namely other firms export activity and other firms R&D activity. We also allow for different spillovers emanating from domestic firms and multinational enterprises located in the same industry. Our empirical results show that a firm's own R&D activity is an important determinant of whether or not this firm becomes an exporter, and how much a firm exports. R&D spillovers, either from MNEs or domestic firms, do not appear to affect the likelihood of whether domestic firms become exporters, although there is evidence that foreign firms benefit from R&D spillovers from other MNEs located in the same sector. Our results do suggest, however, that R&D spillovers exert positive effects on firms' export ratios for both domestic and foreign firms. Furthermore, our evidence shows that the marginal impact of R&D

spillovers on firms‘ export ratios is larger for firms exporting to EU or OECD countries (which are assumed to be technology intensive markets) rather than to the rest of the world.

We do not find very strong evidence to suggest that Spanish firms benefit from spillovers through the export activities of other firms. While there is some evidence that firms are more likely to become exporters in industries in which there is a large presence of domestic exporters, this does not appear to impact on the export ratio. We also find no evidence that domestic firms benefit from spillovers from MNEs, although other foreign firms do appear to benefit from the export activities of other MNEs located in the same sector. This scant evidence for spillovers from MNEs' export activity is in contrast to Aitken et al. (1997) who found that Mexican manufacturing firms benefited from export spillovers from MNEs.

References

Aitken, Brian, Gordon H. Hanson and Ann E. Harrison (1997): "Spillovers, foreign investment, and export behavior", *Journal of International Economics*, Vol. 43, pp. 103-132.

Aitken, Brian, Ann Harrison and Robert E. Lipsey (1996): "Wages and foreign ownership: a comparative study of Mexico, Venezuela, and the United States", *Journal of International Economics*, Vol. 40, pp. 345-371.

Alonso, J.A., (1999): "Growth and the external constraint: lessons from the Spanish case", *Applied Economics*, Vol. 31, pp. 245-253.

Barrios, Salvador and Eric Strobl (2001): "Foreign direct investment and productivity spillovers: evidence from the Spanish experience", mimeo, University of Manchester.

Bernard, Andrew B. and J. Bradford Jensen (2001): "Why some firms export", NBER Working Paper No. 8349.

Bernard, Andrew B. and J. Bradford Jensen (1999): "Exceptional exporter performance: cause, effect, or both?", *Journal of International Economics*, Vol. 47, pp. 1-25.

Bleaney, Michael and Katharine Wakelin (2001): "Efficiency, Innovation and Exports", *Oxford Bulletin of Economics and Statistics*, forthcoming.

Blomström, Magnus and Ari Kokko (1998): "Multinational corporations and spillovers", *Journal of Economic Surveys*, Vol. 12, pp. 247-277.

De la Dehesa, G, J.J. Ruiz and A. Torres (1991): "Liberalizing foreign trade: Spain" in: Papageorgiou, D., M. Michaely and M. Armeane (eds.), *Liberalizing foreign trade: The experience of New Zealand, Spain, and Turkey*, Oxford: Blackwell, pp. 137-162.

Girma, Sourafel, David Greenaway and Katharine Wakelin (2001): "Who benefits from foreign direct investment in the UK?", *Scottish Journal of Political Economy*, Vol. 48, pp. 119-133.

Görg, Holger and Eric Strobl (2001): "Multinational companies and productivity spillovers: a meta-analysis", *Economic Journal*, forthcoming.

Guilkey, David K. and James L. Murphy (1993): "Estimation and testing in the random effects probit model", *Journal of Econometrics*, Vol. 59, pp. 301-17.

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

Herce, J.A., J.F. Jimeno and S. Sosvilla (1998): *Flujos de capital e integración financiera: el caso de España*, Madrid: FEDEA.

Kokko, Ari, Mario Zejan and Ruben Tansini (2001): "Trade regimes and spillover effects of FDI: evidence from Uruguay", *Weltwirtschaftliches Archiv*, Vol. 137, pp. 124-149.

Markusen, James R. (1995): "The boundaries of multinational enterprises and the theory of international trade", *Journal of Economic Perspectives*, Vol. 9, pp.169-189.

Martin, Carmela (2000): *The Spanish economy in the new Europe*. New York: St. Martin's Press.

OECD (1999): *Research and development in industry: expenditure and researchers, scientists and engineers, 1976-1997*, Paris: Organisation for Economic Co-operation and Development.

Roberts, Mark J. and James R. Tybout (1997): "The decision to export in Colombia: an empirical model of entry with sunk costs", *American Economic Review*, Vol. 87, pp. 545-564.

Sousa, Nuno, David Greenaway and Katharine Wakelin (2000): "Multinationals and export spillovers", GEP Research Paper 00/14, University of Nottingham.

Table 1: Descriptive statistics on exports and foreign presence

	Export ratio		No. of exporters		Foreign presence	
	1990	1998	1990	1998	1990	1998
1.Ferrous and non-ferrous metals	0.26	0.24	36	24	0.26	0.54
2.Non-metallic mineral products	0.11	0.21	67	46	0.48	0.55
3.Chemicals	0.19	0.27	103	66	0.61	0.78
4.Metal products	0.21	0.40	95	69	0.31	0.40
5.Industrial machinery	0.29	0.36	81	54	0.60	0.73
6.Computing	0.22	0.37	18	7	0.80	0.71
7.Electrical machinery	0.14	0.37	111	72	0.68	0.79
8.Vehicles	0.16	0.64	62	54	0.92	0.95
9.Other transport industry	0.37	0.61	30	25	0.45	0.39
10.Meat and preserved food	0.02	0.10	16	23	0.18	0.31
11.Food and tobacco	0.05	0.16	83	65	0.77	0.73
12.Beverages	0.04	0.08	18	17	0.59	0.49
13.Textiles	0.13	0.27	92	72	0.31	0.31
14.Leather and footwear	0.37	0.44	42	22	0.11	0.01
15.Wood and furniture	0.08	0.14	39	28	0.10	0.09
16.Paper and printing	0.15	0.31	55	41	0.26	0.46
17.Rubber and plastics	0.16	0.30	44	45	0.72	0.58
18.Other manufacturing	0.32	0.34	34	22	0.20	0.35

Table 2: Description of explanatory variables

Variable	Description
Age and age^2	Current year – year of birth
Size and size^2	Current employment size
Productivity	Value added / number of employees
Multiplant	Dummy = 1 if firm has more than one plant
Wage	Wage per employee
$Skills_1$	Non-production workers / total number of workers
$Skills_2$	Technical workers / total number of workers
R&D intensity	R&D expenditure / sales
Domestic R&D	R&D expenditure by domestic firms in sector *j* / sales by domestic firms in *j*
MNE R&D	R&D expenditure by MNEs in sector *j* / sales by MNEs in *j*
R&D interaction	R&D spillover * dummy = 1 if firm is foreign owned
Domestic exports	(Exports by domestic firms in *j* / total exports in *j*) / (total exports by domestic firms / total exports)
MNE exports	(Exports by MNEs in *j* / total exports in *j*) / (total exports by MNEs / total exports)
Export interaction	Export spillover * dummy = 1 if firm is foreign owned

Table 3: Average R&D expenditure per employee

	1990		1994		1998	
	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign
1.Ferrous and non-ferrous metals	64.1	101.4	99.8	113.0	157.2	93.8
2.Non-metallic mineral products	74.2	66.4	73.7	137.7	139.0	309.1
3.Chemicals	519.5	326.0	805.8	541.5	1282.3	796.7
4.Metal products	84.1	108.5	134.5	129.0	235.2	232.0
5.Industrial machinery	308.8	152.5	270.7	271.5	464.5	347.0
6.Computing	549.4	630.5	219.5	265.7	405.9	2073.1
7.Electrical machinery	270.5	529.0	287.9	1013.1	433.4	1232.7
8.Vehicles	315.8	329.1	184.1	1020.0	342.3	1149.8
9.Other transport industry	126.9	1174.2	295.8	1761.8	1488.4	2572.9
10.Meat and preserved food	34.2	22.7	68.9	16.5	159.8	114.0
11.Food and tobacco	64.6	81.6	38.5	105.0	117.1	158.1
12.Beverages	33.8	70.0	25.8	119.2	66.3	52.2
13.Textiles	40.4	32.0	50.6	67.3	83.7	96.0
14.Leather and footwear	75.6	-	112.4	-	111.2	-
15.Wood and furniture	50.0	65.3	26.5	31.9	36.7	97.6
16.Paper and printing	69.9	62.4	57.9	49.2	113.6	137.3
17.Rubber and plastics	135.6	113.0	236.7	140.3	163.5	291.9
18.Other manufacturing	129.5	176.0	214.6	135.0	227.7	90.4

Notes: figures refer to weighted average of annual expenditure expressed in 1000 pesetas (1990). The weights are given by total employment at firm level. Foreign firms are those with foreign participation greater than zero.

Source: ESEE and authors' computations.

Table 4: Results of probit estimations

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Age	0.016 (0.003)***	0.017 (0.003)***	0.018 (0.003)***	0.042 (0.007)***	0.044 (0.007)***	0.044 (0.007)***
Age^2	-6.0e-04 (2.4e-04)***	-6.5e-04 (2.4e-04)***	-6.8e-04 (2.4e-04)***	-1.6e-03 (0.4e-03)***	-1.7e-03 (0.5e-03)***	-1.7e-03 (0.5e-03)***
Size	0.002 (0.001)***	0.002 (0.001)***	0.002 (0.001)***	0.004 (0.001)***	0.004 (0.001)***	0.004 (0.001)***
$Size^2$	-1.1e-07 (0.2e-07)***	-1.2e-07 (0.2e-07)***	-1.2e-07 (0.2e-07)***	-2.2e-07 (0.3e-07)***	-2.2e-07 (0.3e-07)***	-2.2e-07 (0.2e-07)***
Productivity	1.3e-04 (0.8e-05)***	2.3e-04 (0.7e-05)***	2.1e-04 (0.8e-05)***	2.8e-04 (1.2e-04)**	4.2e-04 (1.1e-04)***	4.0e-04 (1.1e-04)***
Multiplant	0.037 (0.082)	0.028 (0.082)	0.020 (0.082)	-0.012 (0.182)	-0.054 (0.181)	-0.052 (0.180)
Wage	6.2e-04 (2.4e-04)***			1.4e-03 (0.4e-03)***		
$Skills_1$		0.097 (0.161)			0.222 (0.290)	
$Skills_2$			0.595 (0.306)**			0.606 (0.501)
R&D intensity	3.445 (1.650)**	3.496 (1.681)**	3.191 (1.641)**	3.323 (1.548)**	3.257 (1.500)**	3.228 (1.505)**
Domestic R&D	1.7e-09 (2.9e-09)	1.6e-09 (2.9e-09)	1.4e-09 (2.9e-09)	2.9e-09 (6.0e-09)	2.9e-09 (5.9e-09)	2.5e-09 (5.9e-09)
MNE R&D	2.4e-09 (2.5e-09)	3.0e-09 (2.5e-09)	2.7e-09 (2.5e-09)	4.5e-09 (5.3e-09)	6.2e-09 (5.2e-09)	5.7e-09 (5.2e-09)
R&D interaction	1.8e-09 (0.8e-09)**	2.3e-09 (0.8e-09)***	2.6e-09 (0.8e-09)***	1.8e-09 (1.4e-09)	2.7e-09 (1.4e-09)*	2.9e-09 (1.4e-09)**
Domestic exports	0.186 (0.090)**	0.183 (0.090)**	0.185 (0.091)**	0.332 (0.173)*	0.327 (0.172)*	0.327 (0.172)*
MNE exports	0.369 (0.271)	0.392 (0.272)	0.399 (0.273)	0.758 (0.562)	0.793 (0.560)	0.792 (0.559)
Export interaction	0.493 (0.105)***	0.513 (0.108)***	0.506 (0.108)***	0.976 (0.205)***	0.994 (0.208)***	1.037 (0.206)***
Log likelihood	-2358.45	-2362.66	-2345.97	-1969.61	-1974.82	-1965.76
# of observations	4627	4624	4600	4627	4624	4600
LR test (rho=0)				777.68***	775.68***	760.42***

Notes: all regressions include sectoral and time dummies
***, **, * denotes statistical significance at 1, 5, 10 percent level
(i), (ii), (iii): pooled probit, standard errors adjusted for clustering on firm id in parentheses
(iv), (v), (vi): random effects probit, standard errors in parentheses

Table 5: Results of tobit estimations

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Age	0.004 (0.001)***	0.004 (0.001)***	0.004 (0.001)***	0.004 (0.001)***	0.004 (0.001)***	0.004 (0.001)***
Age^2	-1.7e-04 (0.4e-05)***	-1.9e-04 (0.4e-05)***	-1.9e-04 (0.4e-05)***	-2.1e-04 (0.5e-05)***	-2.0e-04 (0.4e-05)***	-1.9e-04 (0.4e-05)***
Size	1.1e-03 (0.1e-03)***	1.1e-03 (0.1e-03)***	1.1e-03 (0.1e-03)***	7.3e-04 (1.2e-04)***	0.6e-03 (0.1e-03)***	6.5e-04 (1.1e-04)***
$Size^2$	8.4e-09 (1.3e-09)***	-9.1e-09 (1.3e-09)***	-9.3e-09 (1.3e-09)***	-2.3e-09 (0.7e09)***	-2.6e-09 (0.6e-09)***	-1.9e-09 (0.7e-09)***
Productivity	-9.2e-07 (13.0e-07)	3.9e-06 (1.2e-06)***	2.6e-06 (1.2e-06)**	-6.6e-07 (9.0e-07)	1.5e-06 (0.9e-06)*	1.2e-06 (0.9e-06)
Multiplant	0.001 (0.014)	-0.010 (0.014)	-0.006 (0.014)	-0.016 (0.017)	-0.029 (0.016)*	-0.027 (0.016)
Wage	2.4e-04 (0.4e-05)***			1.4e-04 (0.3e-05)***		
$Skills_1$		-0.144 (0.033)***			-0.022 (0.029)	
$Skills_2$			0.104 (0.057)*			0.073 (0.046)
R&D intensity	0.972 (0.218)***	1.215 (0.219)***	0.984 (0.223)***	0.118 (0.171)	0.143 (0.171)	0.116 (0.171)
Domestic R&D	1.1e-09 (0.8e-09)	1.2e-09 (0.8e-09)	1.2e-09 (0.8e-09)	1.8e-09 (0.5e-09)***	1.8e-09 (0.5e-09)***	1.9e-09 (0.5e-09)***
MNE R&D	1.4e-09 (0.7e-09)**	1.8e-09 (0.8e-09)**	1.7e-09 (0.7e-09)**	2.1e-09 (0.4e-09)***	2.2e-09 (0.4e-09)***	2.3e-09 (0.4e-09)***
R&D interaction	0.3e-09 (0.2e-09)*	0.4e-09 (0.2e-09)***	0.4e-09 (0.2e-09)***	0.1e-09 (0.1e-09)	0.2e-09 (0.1e-10)**	0.3e-09 (0.1e-09)**
Domestic exports	0.024 (0.025)	0.025 (0.025)	0.027 (0.025)	0.024 (0.015)*	0.024 (0.015)	0.026 (0.015)*
MNE exports	-0.001 (0.083)	0.008 (0.083)	0.014 (0.083)	0.010 (0.048)	0.013 (0.048)	0.013 (0.048)
Export interaction	0.130 (0.019)***	0.149 (0.019)***	0.137 (0.020)***	0.092 (0.015)***	0.093 (0.015)***	0.088 (0.014)***
Log likelihood	-1900.40	-1909.23	-1908.45	-1129.24	-1139.93	-1127.93
# of observations	4627	4624	4600	4651	4648	4624
LR test (rho=0)				1875.73***	1884.82***	1900.39***

Notes: all regressions include sectoral and time dummies
***, **, * denotes statistical significance at 1, 5, 10 percent level
(i), (ii): pooled tobit, standard errors adjusted for clustering on firm id in parentheses
(iii), (iv): random effects tobit, standard errors in parentheses

Table 6: Results of tobit estimations for EU/OECD and other exports separately

	EU/OECD exports		Other exports	
	(i)	(ii)	(iii)	(iv)
Age	0.003 (0.001)***	0.005 (0.001)***	0.002 (0.001)***	0.004 (0.001)***
Age^2	-1.3e-04 (0.3e-05)***	-2.3e-04 (0.7e-05)***	-7.0e-06 (2.4e-06)***	-1.6e-04 (0.5e-05)***
Size	8.4e-04 (1.2e-04)***	6.3e-04 (1.2e-04)***	7.6e-04 (0.9e-05)***	5.4e-04 (1.3e-04)***
$Size^2$	7.0e-09 (1.1e-09)***	-2.6e-09 (0.8e-09)***	-6.8e-09 (0.9e-09)***	-1.0e-09 (0.8e-09)
Productivity	0.6e-06 (1.1e-06)***	-3.8e-07 (9.8e-07)	0.5e-07 (8.2e-07)	0.9e-06 (1.2e-06)
Multiplant	-0.002 (0.012)	-0.016 (0.018)	-0.010 (0.009)	-0.046 (0.018)**
Wage	2.1e-04 (0.3e-05)***	1.5e-04 (0.3e-05)***	9.0e-06 (2.5e-06)***	1.5e-04 (0.4e-05)***
R&D intensity	0.818 (0.189)***	0.312 (0.173)*	0.447 (0.135)***	0.289 (0.214)
Domestic R&D	1.4e-09 (0.7e-09)**	2.1e-09 (0.5e-09)***	2.6e-10 (5.5e-10)	1.0e-09 (0.7e-09)
MNE R&D	1.6e-09 (0.6e-09)***	2.1e-09 (0.4e-09)***	2.9e-10 (4.8e-10)	0.5e-09 (0.6e-09)
R&D interaction	0.3e-09 (0.1e-09)*	0.1e-09 (0.1e-09)	0.7e-10 (1.1e-10)	0.7e-10 (1.4e-10)
Domestic exports	0.028 (0.022)	0.031 (0.015)**	0.010 (0.016)	0.031 (0.021)
MNE exports	0.029 (0.072)	0.030 (0.050)	0.004 (0.056)	-0.004 (0.069)
Export interaction	0.114 (0.017)***	0.100 (0.016)***	0.034 (0.013)***	0.075 (0.019)***
Log likelihood	-1511.67	-1106.32	-816.98	-1144.06
# of observations	4615	4651	4615	4651
LR test (rho=0)		1365.64***		508.66***

Notes: all regressions include sectoral and time dummies
***, **, * denotes statistical significance at 1, 5, 10 percent level
(i), (iii): pooled tobit, standard errors adjusted for clustering on firm id in parentheses
(ii), (iv): random effects tobit, standard errors in parentheses

Table 7: t-test of equality of coefficients

	(i) and (iii)	(ii) and (iv)
R&D intensity	1.60	0.08
Domestic R&D	1.25	1.25
MNE R&D	1.67*	2.17**
R&D interaction	1.07	-0.01

Note: ***, **, * denotes statistical significance at 1, 5, 10 percent level