# Product Innovation and Exports
## Evidence from Spanish Manufacturing[♣]

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**Preliminary**

**Abstract**

Firm decisions affect performance and survival. Unfortunately, due to severe selection problems it is hard to study this causality. Export decisions, however, have been related to better performing firms, where causality seems to run from good performance to entering export markets. Using the fact that we observe both exporting and non-exporting firms we analyze the effect of innovation on the decision of firms to export. We find for a panel of Spanish manufacturing firms for the period 1990-1999 that product innovation is a very important driver of exports for small non-exporting firms. Our results suggest that product innovation rather than process innovation affects firm productivity, which in turn induces firms to select into the export market.

Keywords: exports, innovation, product innovation, process innovation, productivity.

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## 1. Introduction

Firms are born, make decisions, thrive or they die. This dynamic process of firm lifecycles generates a tremendous amount of heterogeneity among firms not only across industries, but more interestingly, also within industries (Bartelsman and Doms, 2000). While theoretically such heterogeneity and dynamics is hard to handle, empirically it provides a wealth of interesting facts. Nevertheless, little is known about the connection between individual firm decisions and their dynamic consequences.

Most theoretical models dealing with firm dynamics assume that firms are born with an innate ability – their productivity. Over time they learn about this ability and firms with high ability survive and grow in the market while firms with ability below a certain threshold exit (Jovanovic, 1982; Hopenhayn, 1992). Unfortunately, such models relate firm survival to luck-of-draw. Unlucky firms, i.e. firms with low productivity, exit, while lucky firms survive and grow. Firm decisions play little role in these models except with respect to timely exit from the industry. Pakes and Ericson (1995) do improve on these models by allowing firms to make investment decisions that potentially enhance the likelihood of survival.

The empirical literature examining firm productivity dynamics has concentrated on measuring productivity correctly. Few have studied how individual firm decisions actually affect productivity and survival dynamics. Starting with the careful studies on firm level productivity by Griliches (See Griliches, 1998 for an overview), Olley and Pakes (1995) use more sophisticated measurement techniques, but overall, the different productivity measurement techniques each have their advantages and disadvantages (Van Biesebroek, 2005). In the end, if productivity is measured consistently, we really are interested in explaining differences in these measures across firms.

In this paper we take an indirect approach to this issue in trying to relate the export market entry decision of the firm to other prior firm level decisions and outcomes, in particular innovation decisions. Exporters have been found to display higher productivity compared to non-exporters in the same industry. Interestingly, neither industry effects, nor factor intensity shares (capital/labor) seem to explain this significant difference in productivity between exporters and non-exporters (Bernard et al., 2003). Furthermore, most of the literature agrees on the fact that in more developed countries the more productive firms select into the export market, confirming the sunk cost hypothesis where entering the export market requires sinking in a considerable amount of money to start operating (Roberts and Tybout, 1997). This suggests that a closer examination of prior firm decisions might be in order to understand this important selection. In this context the export-no export dichotomy allows us to observe the firms that do not export, unlike the new firm entering a market for which often times no prior information is available.

Following Vernon (1966) in his very influential paper on the internationalization of US business, we argue that the first step in such an internationalization process of the firm is the decision to start exporting. Young firms possess a new product in the early phase of the product lifecycle based on proprietary knowledge. As the domestic market is limited in the early innovation stage the firm moves to enter into the export market to exploit their market power (Hirsch and Bijaoui, 1985). At this stage of the product lifecycle the product is new and needs a close interaction between product development and manufacturing for which production remains in the (main) domestic market (Antras, 2005). Furthermore, as Klepper (1996) has shown, product innovation dominates the early stage of the product lifecycle, while process innovation enters in later stages when production volumes have picked up and make this latter type of innovation relatively more attractive. Following the product lifecycle logic we, therefore, believe that successful product innovation will induce the firm to enter the export market.

A potential underlying mechanism for the selection of more productive firms into the export market is, therefore, that successful (product) innovation improves the firm’s productivity, and, hence, the more productive firm selects into the export market. Nevertheless, anything affecting productivity – not only product innovation – could induce the firm to enter the export market. Recent work on untangling technical productivity versus demand shocks in the productivity literature, however, has found evidence that suggests that firm specific demand shocks – rather than production efficiencies – are responsible for positive productivity shocks and firm survival in general (Foster et al., 2005). This suggests that product innovation linked to positive demand shocks rather than process innovation linked to production efficiency could be at the basis of increased productivity and, thus, entry into the export markets.

We test our hypothesis about the positive effect of product innovation on the export decision of firms on a large representative sample of Spanish manufacturing firms. Indeed, we find strong evidence that product innovation – and not process innovation – induces small non-exporting firms to enter the export market. Such finding has important policy implications for the relative importance of export promotion policies versus innovation promotion policies to simulate productivity growth in the economy. Clearly, the fact that the more productive firms select into the export market already invalidated many arguments in favour of export promotion activities. Nevertheless, as the firm decisions driving these productivity effects were not explicated, alternative policies were not advanced. Our results suggest that a stronger focus on innovation should provide a more productive investment for policy makers.

Next we tie together the related literature from international business, economics and management on the relation between innovation and exports. Section 3 presents our basic empirical model, our data, variables and methodology used. Section 4 discusses our results and section 5 concludes.

## 2. Literature Review

Following Jovanovic (1982) and Hopenhayn (1992), the international trade literature has started to address the issues of industry dynamics and firm heterogeneity in international trade. Recent work by Melitz (2003) and Bernard et al. (2003) attempts to formulate theories consistent with the empirical facts connecting export behaviour and productivity of firms. Both theories start with firms receiving a draw from a distribution that determines their productivity. Melitz (2003) assumes a sunk cost of entry in the export market. Bernard et al. (2003) assume Bertrand competition between homogenous producers which only allows the most productive producers to incur the transportation costs associated with international trade. Therefore, both theories find that the more productive firms self-select into the export market and display considerable persistence in doing so (Roberts and Tybout, 1997). These theories fall short, however, of explaining why these firms are more productive and select into the export market, i.e. there is not a causal theory about the relation between firm decisions and entry into the export market.

Early macro trade theory linked the technology endowments of the North to exports with high innovation content (Krugman, 1979). In this model the North continuously innovates and exports to the South to maintain the terms of trade as the South over time learns to produce these same goods through imitation. While innovation drives exports, innovation by the North is assumed exogenously at the macro level. But in the end, the firm's export decision is an important decision at the firm level and needs to be treated as such.

A firm's internationalization is driven by the existence of hard to trade proprietary resources that the firm leverages and exploits in international markets (Markusen, 1995).

Often knowledge is argued to be the resource in question that due to the lack of existing markets cannot be traded. Vernon (1966) was one of the first to hypothesize a natural evolution from innovation in the domestic market, to exports, to eventually imports of the same product into the home market. Following the product life cycle theory, he argued that US companies would be better placed to develop new products for relatively high income consumers that would have a labor savings effect on the production process as capital is more freely available. In early stages of the product life cycle it is important to be close to the local market for making adjustment to product characteristics (Antras, 2005). Having exhausted its market power domestically, the firms start exporting the innovation to exploit their market power as products at this stage are still highly differentiated. Finally, as product characteristics get more standardized and a dominant design develops, more firms enter into production and competition and focus shifts to manufacturing efficiency rather than developing new product characteristics. Firms start to locate plants in low wage regions and eventually export production back to the US. According to this product life cycle theory product innovation should be intimately linked to the decision of a firm to start exporting in the early stage of the product life cycle.

In general, one finds that innovation, measured by inputs (R&D expenditure) or outputs (number of innovations) plays an important role in explaining the export performance. One of the first papers to analyze the relation between exports and innovation is Hirsch and Bijaoui (1985) where they consider the relationship between R&D expenditures and export behavior for Israeli firms. Innovation confers some monopoly power on the owners of the innovation. As a result the firm discriminates between the domestic and foreign markets. This is not true for non-innovating firms that are assumed to be price takers and, hence, have less incentive to export. They find that innovating firms in a sector had a higher propensity to export than the sector average. They also found that lagged R&D expenditure was significant in explaining the rate of change of exports in a cross-section.

Several papers have followed this line of research confirming the relation between innovation and export. Sterlacchini (1999) argues that a broader definition of innovation is necessary to capture the full effect on exports. Even in non-R&D intensive industries innovation is an important determinant of small firm's export performance. Therefore, care must be taken not only to measure innovation through R&D. Including the acquisition of innovative capital goods and design, engineering and pre-production development has been found to be relatively more important for these firms. Lefebvre, Lefebvre and

Bourgault (1998) and Becchetti and Rossi (2000) both find that R&D intensity has no impact on the export propensity, but that other innovation indicators such as the percentage of employees with technical and scientific backgrounds and the presence of R&D collaborations with external partners have positive effects. This suggests that R&D intensity might be misleading and that maybe an output measure for innovation – consolidating the effect of these different measures – is preferable. Furthermore, Brouwer and Kleinknecht (1993) find a positive effect of R&D on export activity but emphasize that it is product –as opposed to total – R&D that is relevant for this effect. Similarly, Bernard and Jensen (1999, 2004) find that for a large sample of American plants, the introduction of new products (changes in primary SIC codes for manufacturing plants) significantly enhances the probability of exporting. Both these observations together with the probable superior explanatory performance of an innovation output measure suggests that product innovation should have an important effect on the export decision of firms.[1]

While there exists a substantial literature on the relation between innovation and exports, this literature lacks a convincing theory to explain this relation. However, the debate on the relation between firm productivity and exports suggests that more productive firms select into the export market (Clerides, Lach and Tybout, 1998; Bernard and Jensen, 1999; Delgado, Fariñas and Ruano, 2002). The key explanation for this result is the existence of sunk costs for becoming an exporter (Roberts and Tybout, 1997). Persistence in the export decision then serves as confirming evidence for these sunk costs. At the same time a number of empirical studies have documented the positive and significant effect of R&D and innovation on firm productivity and productivity growth. Crepon et al. (1998) estimating a structural model that links productivity, innovation output and innovation inputs, find that firm productivity correlates positively with higher innovation output. In line with their result, Jefferson et al. (2001) for Chinese firms show that

[1] Several other papers reveal this consistent relation between innovation and exports. Basile (2001) shows that Italian firms that introduce product and/or process innovations either through R&D activity or through investments in new capital equipment are more likely to export. Kumar and Siddhartan (1994) analyze the relationship between R&D expenditure and exports for 640 Indian firms from 1988 to 1990. They find R&D expenditure to be an important factor in low and medium technology industries. Braunerhjelm (1996) provides evidence from Sweden that R&D expenditures and investment in skilled labor both have a positive effect on a firm's export share, while conventional cost factors have no effect. Sterlacchini (1999) finds that the extent of a firm's innovative activity plays relatively little part in explaining the probability of exporting, but is important in explaining the extent of firm's export activity. Wakelin (1998) finds a similar result. Non-innovating UK firms are more likely to export compared to innovating firms of the same size, but the innovators export a higher share of their sales. In line with this Roper and Love (2002) show that there are significant differences in the impact of the independent variables on the probability of exporting and plant's export share conditional on exporting. However, unlike Wakelin (1998), they find that once the exporting decision has been made, innovators and non-innovators do not differ in the determinants of their export share. Finally, Anderton (1999a,b) considers the impact of R&D and patenting activity on trade volumes and prices arguing that both technology indicators act as proxies for the quality and/or variety of goods being produced. However, not all evidence points in the same direction. Ito and Pucik (1993) for a sample of 266 Japanese manufacturing firms found that R&D intensity was a significant determinant of their export performance only when the size variable was dropped from the regression. Schlegelmilch and Crook (1988) also found no relation between innovation and exports in a similar study of 130 British mechanical engineering firms.

new product sales are positively associated with productivity. Huergo and Jaumandreu (2004) using a panel of Spanish firms find that process innovation is an important determinant of productivity growth at the firm level. Investigating and comparing the relationship between innovation and productivity in four European countries, Griffith et al. (2005) find consistent with the previous studies results that both product and process innovations have a positive significant effect on firm-level productivity in three out the four countries. Therefore, connecting innovation, productivity and exports, we argue that innovation will affect the decision of firms to start exporting. Furthermore, the recent work by Foster et al. (2005) reveals that demand shocks rather than efficiency shocks explain productivity differentials, suggesting that product innovation rather than process innovation drives productivity, and, hence, the export decision of firms.[2]

## 3. Empirical Model, Data and Variables

### 3.1 Empirical Model

The evidence of previous empirical studies suggests that any explanation of export activity by the firm needs to take into account an innovation indicator. Different input and output indicators have been used and might reflect different relations. Innovation has been measured as R&D intensity, a dummy for innovations, or, the number of innovations (Wakelin, 1998). Roper and Love (2002) use the fact of whether the plant has an R&D department or not, if new or improved products were introduced, and, the number of product changes made by each plant per employee. Brouwer and Kleinknecht (1993) show that product related R&D seems to be a better proxy for the effect of innovation on exports. One would really like to capture the innovation capacity of an organization. Therefore, we will separate the sample according to whether firms realized product or process innovations.

Theoretically there is also reason to believe that these indicators might perform differently. First, from Hirsch and Bijaoui (1985) and Brouwer and Kleinknecht (1993) we hypothesize that product innovations and process innovations have a different effect on export performance. Connecting the product life cycle theory (Klepper, 1996) with the international business literature following Vernon (1966), we argue that product

[2] There might exist another effect (simultaneous or not) of exports on innovation; that is, companies that decide to innovate may focus on opening to new markets as a strategy of innovation which is more closely aligned with Schumpeter's view. Salomon and Shaver (2005) focus on this reverse learning-through-exporting effect and find that exporting firms introduce more products and register more patents compared to other firms with fewer exports or no exports. This runs counter to the findings of studies on the relation between exports and firm productivity which find little effect of exports on the more general measure of productivity. In the empirical work we will carefully control for this reverse causality effect.

innovations dominate in the early stages of the product and industry life cycles. At smaller output levels firms have a larger incentive to develop product innovations improving margins, while at larger output levels process innovations are more profitable as they are applied to a large scale (Cohen and Klepper, 1996). Especially for smaller countries this implies that exports should be positively affected by *product* innovation, as demand in the domestic market is limited and not well developed yet and firms discriminate between domestic and international markets for these novel products for which they do have some market power. Therefore, we expect product innovations to affect the decision to export of firms. Furthermore, as product innovation occurs early in the product life cycle, we expect younger and hence typically smaller firms to decide to enter the export market after a recent product innovation.

In the case of *process* innovations we get a different effect as this type of innovation arrives at later stages in the product life cycle and in typically more mature markets after the dominant design for the product has been established. We, therefore, expect its effect on the decision to export to be less outspoken as older and more mature firms either will have entered the export markets already, or in case the firm is not exporting yet, they would encounter a more competitive international environment due to the more mature product, less likely triggering the export decision. Therefore, process innovations are unlikely to affect the decision to *start* exporting. Our data allows us to contrast the performance of these alternative innovation measures on the decision to start exporting.

The sunk cost nature of investments in establishing an export position has been found to be a key driver of the continuing export decision. Roberts and Tybout (1997) find that the likelihood of exporting in a given year, conditional on having exported in the year before, hovers around 90%. This hysteresis effect decays exponentially (Campa, 2004). Controlling for the export decision in the previous year is, therefore, important to capture this sunk cost effect while not attributing the export decision in later years to other motives, biasing coefficients.[3] Most studies in economics and management finding a positive relation between innovation and exports, however, have systematically neglected to control for this effect and therefore some of the findings on this relation between innovation and the export decision of firms might be due to spurious effects related to the hysteresis in the export decision.

[3] Mañez et al. (2006) using the same data find that a one year export lag is sufficient.

Following previous research, we control for a range of firm, market and macroeconomic characteristics that possibly affect the decision to export. First, a number of macroeconomic variables such as GNP, growth or exchange rate fluctuations (Basile, 2001) can affect the export decision of firms. Next, industry characteristics can clearly affect export performance. Wakelin (1998) controls for spillovers and technological opportunity of different industries by including variables on innovations used and innovations produced in the industry. Basile (2001), using the Pavitt (1984) classification of industries, finds that traditional sectors and specialized supplier sectors increase the likelihood of exporting relative to scale intensive sectors and science based sectors. Sterlacchini (1999) finds that this classification has important implications for the innovation activities that firms perform. If these alternative innovation activities go unmeasured, the effect of innovation on export behavior would be underestimated. As our true concern is about the effect of innovation on the export decision, we mainly control for these effects through time and industry dummies.

Different firm specific variables have also shown an important explanatory power for exports. Several papers confirmed a non-linear relation between firm size and exports indicating a threshold effect: size will be critical up to a level (Kumar and Siddharthan, 1994; Wagner, 1995; Brouwer and Kleinknecht, 1993; Wakelin, 1998; Bernard and Jensen, 1999; Sterlacchini, 1999). Larger firms have access to more resources with which to enter foreign markets. But as firms grow larger they might have an incentive to enter through foreign direct investment rather than exports. This predicts a positive first order, but a negative second order effect of size on exports. Furthermore, the export decision is likely to be made when the firm is still young and, hence, relatively small. Moreover, ownership structure, i.e. being part of international group might lower the threshold for exports or internal transfers that show up as exports (Roper and Love, 2002; Basile, 2001). In addition, Brouwer and Kleinknecht (1993) show that group structure might be an important explanatory factor for some firms that do export a lot, but have no R&D or innovate little. These firms likely enjoy the returns from innovation in other subsidiaries of the group.

Next, the relative competitive position of the firm in the home market might affect the incentives of the firm to engage in exports. The direction of the effect would be unclear. On the one hand, firms with market power have less incentive to move internationally as they have a more captive home market and the demand from the international market is surely more elastic (Hirsch and Bijaoui, 1985). Nevertheless, a more captive home market might help the firm sustain an international position (Krugman, 1984). On the other hand, a more competitive home market is a better learning environment for firms to compete internationally (Porter, 1990). The FDI literature claims that the competitiveness of the domestic industry, measured by the percentage of sales from foreign firms in domestic market, affects the export behavior of firms. Moreover, relative market growth together with a favorable exchange rate affects where it is more efficient to expand: international versus domestic.

Finally, classical trade theory argues that relative factor endowments affect trade flows. Therefore, capital intensity (or labor intensity) is an important control in the export decision of a firm as Spain compared to other developed countries probably abounded in labor. But Wakelin (1998) argues that the capital intensity of the firm proxies for the marginal cost of production. If the firm's marginal cost is low relative to other firms in the industry, this might actually be the embodiment of former innovations in process technology and improve the export performance of the firm. Sterlacchini (1999) finds that his variable on the technological level of the firm's capital stock positively affects exports. Average wages or direct measures of the skill level of the firm, in contrast, indicate a higher value added relative to transport costs, increasing the likelihood of exporting (Wakelin, 1998; Roper and Love, 2002).

### 3.2 Data

We use a panel of Spanish manufacturing firms during the sample period 1990-99 from the ESEE survey[4] provided by the Spanish Ministry of Science and Technology. This is an unbalanced panel since some firms cease to provide information for several reasons (mergers, changes to non-industrial activity or cession of production, or, non-response). New companies enter the survey each year to maintain the representativeness of the industry over the whole population. The data is collected using direct interviewers with a questionnaire. It constitutes a mixed data set where a random sample is drawn for small companies (with less than 200 employees) keeping the sample representative of the industrial stratification. For large firms (more than 200 employees) the sample is exhaustive.[5] Several authors[6] have used this data set as it is representative of the Spanish manufacturing industry. In our sample we have about 18.000 observations and between 1600 and 2000 observations per year between 1990 and 1999, where an observation is in

[4] Encuesta Sobre Estrategias Empresariales.
[5] This aggregation and the threshold used for size are suitable for the typical Spanish industry structure.
[6] Campa, 2004; Delgado et al. 2002; Gonzalez, Jaumandreu et al. 2005; Merino and Rodríguez, 1997; Martínez-Ros and Labeaga, 2002; Salomon and Shaver, 2005; among others.

firm-years. For our analysis we restrict the sample to a balanced panel of about 811 firms that are observed every year, i.e. 8110 firm-year observations. Due to missing values we go down to 7060 firm-year observations (542 small firms and 164 large firms over 10 years). Table 1 compares the characteristics of the balanced panel with the unbalanced representative panel.

*Insert Table 1*

### 3.3 Variables

As our dependent variable we measure whether firm i exported in a given year t. $EXPORT_{it}$ takes on the value of 1 for year t whenever a positive amount of sales was exported by firm i. See Table 2 for a definition of all variables used. For our key independent variable affecting the export decision we construct the variables $PRODUCT\ INNOVATION_{it}$ and $PROCESS\ INNOVATION_{it}$ which indicate whether firm i came out with a product or process innovation in year t (0/1).

*Insert Table 2*

Due to the sampling methodology, we control for the size of firms by splitting the sample between small firms (less than 200 employees) and large firms (more than 200 employees). In addition, we include both *SIZE*, the number of employees, and, its square, *SIZE2* to test the non-linearity of the relation with exports. $Export_{it-1}$ controls for the empirically very important persistence in the decision to export. $FOREIGN_{it}$ is a dummy variable capturing the foreign ownership of the firm (more than 50% of capital owned by foreign entity). $CAPITAL\ INTENSITY_{it}$, capital per employee, and $WAGE\ INTENSITY_{it}$, total wage bill divided by total employment, control for the firms cost structure and skill level respectively. $INDEX_{it}$ controls for the attractiveness of export markets by constructing a firm specific relative export price index for the firm: the higher the index, the weaker the peseta relative to other currencies where the firm is exporting and the better the prospect to export.[7] We control for market structure and competitiveness of the industry by including a variable measuring the average yearly gross margin of firms in the industry ($LOW\ COMPETITION_{it}$). This variable is firm specific as it excludes the firm's own price-cost margin in the construction of the variable to avoid possible endogeneity problems (Martínez-Ros, 1997).

[7] Campa (2004) used the same variable in his analysis. See Appendix 2 for the construction of this variable.

Finally, we also include year and industry dummies to control for common macroeconomic and industry specific effects in exports. The Appendix provides the list of the industries we control for.

### 3.4 Methods

First, we estimate the base line pooled probit model where the decision to export ($EXPORT_{it}$) is a function of the potentially exogenous variables and the lagged variables of innovation ($PRODUCT\ INNOVATION_{it-1}$, $PROCESS\ INNOVATION_{it-1}$) and exports ($EXPORT_{it-1}$). Such a regression has several obvious problems. First, we are dealing with a panel of firms and the pooled model neglects heterogeneity. Second, the panel is dynamic as we are regressing on a lagged dependent variable and in the presence of random firm effects they are correlated with the lag. Third, the innovation variables are the result of decisions of the firm and unlikely to be exogenous, even when lagged due, for instance, to feedback effects. We attempt to address these problems in turn. Woolridge (2005) in a recent paper has developed a simple procedure to properly deal with a dynamic panel structure by adding all lags of the exogenous variables together with the initial dependent variable ($EXPORT_{i90}$) to the specifications. Next, we attempt to control for unobserved heterogeneity exploiting our panel structure by estimating a random effects probit, while accounting for the dynamic structure of the panel.[8] Finally, we deal with the potential endogeneity of the innovation variables using instruments for product and process innovation. As instruments for product and process innovation we use industry and time dummies together with the percentage of firms that obtained a product or process innovation, respectively, in that particular industry for that particular year. The instruments are constructed for large and small firms separately. In addition, we use an alternative independent source for the information on industry levels of product and process innovation, the PITEC data base.[9] However, the latter data is only available for one year, resulting in less variation of the instruments and more problems in identifying the effects of innovation variables on exporting decisions.

After using the full balanced panel, we repeat the analysis with only the firms that did not export in a particular year. The advantage of this analysis is that it conditions on

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[8] In the context of a dynamic panel a fixed effects specification produces almost surely inconsistent estimates. In a model with random effects it is necessary to assume that they are uncorrelated with the explanatory variables to get consistent parameter estimates. This assumption is also likely to be violated.

[9] "El Panel de Innovación Tecnológica" which is a new panel of Spanish manufacturing firms elaborated by the Spanish National Statistical Office with the Community Innovation Survey (CIS) as starting point.

the lagged dependent variable, avoiding the more complicated dynamic panel structure.[10] In addition, our hypothesis on the relation between innovation and exports really relates to the firms that switch into exporting, i.e. decide to start exporting. The disadvantage of this approach consists in not using all available information, in particular of firms that export in year t-1 and do not continue to export in year t.

## 4. Results

### 4.1 Descriptive Statistics

As Figure 1 indicates, the percentage of innovating firms remains relatively constant over the sample period while there appears to be a mild increase in the percentage of exporting firms over time.

*Insert Figure 1*

The following Tables 3, 4 and 5 confirm that our innovation measures are positively correlated with the export decision of firms. As Table 3a shows, of all the innovation active firms, 84% export the year after, while for non-innovating firms this is only 42%. Distinguishing between product and process innovation (Tables 3b and 3c) leads to similar observations: 78% of product innovators and 71% of process innovators export the year after. This result is even more pronounced for small and medium firms compared to large firms, confirming the findings of the previous literature where innovation and exports seemed highly related.

Tables 4 and 5 however point to an important omission in much of this literature, namely the past export status of the firm. As shown by Roberts and Tybout (1997) the past export status of the firm is a key explanatory variable capturing the sunk cost effect of previous investments in exporting. Table 4 shows the transition probabilities for the different states of past to present export status. For small firms (Table 4a) more than 90% of the firms remain in the same state: exporters continue to export and non-exporters continue as non-exporters. About 8% of non-exporters become exporters. For large firms (Table 4b), about 25% of non-exporters become exporters in the next period, but we only have few observations in this case. We want to understand what affects this transition from non-exporter to exporter and conjecture that innovation might jump start firms into exporting.

[10] Implicitly we assume a Markov pocess in the transition from one exporter state in t-1 to another exporter state in t and product innovation affects this transition.

Table 5 examines the effect of product and process innovation on the transition probability from non-exporter to exporter. For small firms (Table 5a) 13% of product innovators make the transition, while 11% of the process innovators switch from non-exporting to exporting. In the case of large firms (Table 4b) 36.5% of product innovators make the transition and 27.7% of process innovators, but again with few firm-year observations. Interestingly product innovation also seems to affect the reverse direction – from exporter to non-exporter. Exporters that have a product innovation are less likely to regress towards being a non-exporter, especially in the case of small firms. These descriptive statistics show that innovation – in particular product innovation – affects the decision to start exporting. In what follows we try to carefully corroborate these findings controlling for other elements.

*Insert Tables 3, 4 and 5*

4.2 Regression Results

Table 6 reports our regression results for small and medium firms and large firms separately. For small firms, the first regression corresponds to the base line pooled probit regression using the one year lag of the export and innovation variables (regression (1)). Starting with the second specification we control for the dynamic panel properties by applying Woolridge (2005). We only report the coefficient of the initial export status of the firm (*Export90*) for these regressions, but control for all past values of the assumed exogenous variables. If *Export90* shows to be significant it is important to control for the dynamic nature of the specification as the initial conditions do matter. The third specification, in addition, controls for random effects (regression (3)). Next we instrument the innovation variables in the pooled specification without random effects (regression (4)) and in the specification with random effects (regression (5)) using the ESEE averages for product and process innovation as explained before. Finally, regression (6) replicates regression (5) but using the PITEC instruments. For large firms we follow the same sequence of regressions (regressions (7)-(12)).

*Insert Table 6*

As hypothesized, when both product and process innovation are entered in the same equation, only product innovation seems to matter for the decision to start exporting. This effect is important for small firms. The coefficient on product innovation significantly increases when instrumenting the innovation variables (regressions (4)-(6)), pointing possibly either to important endogeneity issues or a misspecification of the model. Calculating the marginal effects for regression (5) shows that a product innovation in the year before increases the likelihood of becoming an exporter the following year by 25%. For large firms, using regression (11), the probability of becoming an exporter increases by only 8%.

Across large as well as small firms we confirm the sunk cost hypothesis for exports by Roberts and Tybout (1997) as the past export decision has an important impact on the decision of the next year. This coefficient is large and significant across all specifications, but drops as expected when controlling for the dynamic panel (regression (2)) and random effects (regression (3)). Previous studies not controlling for the effect of past exports are likely to have biased coefficients on the innovation variable used because of the correlation between innovation and past exports. For small firms (less than 200 employees) we find that there is an important non-linearity in size. Furthermore, smaller foreign owned companies are more likely to export as they might have lower sunk costs of exporting due to their international network. Finally, contrary to expectation, small firms with higher skilled labor (higher wage intensity) seem less likely to decide to export.

As we are really interested in the effect of different innovation outputs on actual switches between non-exporting and exporting, i.e. the decision to *start* exporting, we next estimate the same equations separately for *firms that did not export the previous year*.[11],[12] The underlying assumption for such a model is that the firm's decision to export is described by a markov process. Interestingly, as Table 7 shows, we find very comparable results for small firms as in the full sample regression. The marginal effect for product innovation using regression (4) indicates that the probability of becoming an exporter after a product innovation increases by 22%. Furthermore, after correcting for possible endogeneity of the innovation variables (regressions (3)-(5)), product innovation remains a significant explanatory variable in the export decision of the switchers. The other

[11] Results are available for firms that did export in the previous year. These show that innovation, in particular product innovation, keeps firms from regressing to the non-exporter status. Nevertheless, the marginal impact of innovation is lower in this case compared to the reverse case.

[12] Regression (1) is a pooled probit; regression (2) random effects probit; regression (3) pooled probit with instruments ESEE; regression (4) random effects probit with instruments ESEE; regression (5) random effects probit with instruments PITEC.

explanatory variables are very similar as well. As expected, among the large firms we find too few switchers to get really significant results on the variables of interest.

Results in Table 7 constitute a test on the robustness of results in Table 6, since we have a lagged dependent variable in specifications with random effects in the latter case and, given the sample selection the lagged dependent variable should not be included in specifications of Table 7. Moreover, the coefficients corresponding to the other explanatory variables remain almost unchanged.

*Insert Table 7*

Table 8 (preliminary) includes a number of additional robustness checks including R&D, Productivity (TFP), and an interaction between product and process innovation in our original specifications, and a split of the sample based on the age of the firm. In all cases the product innovation coefficient remains significant and is in line with the findings of the specifications in Table 6.[13]

## 5. Conclusions

This paper explores the relation between innovation and exports. Our results suggest that innovation and more specifically – product innovation – is a very important driver of exports. We also find a strong non-linear relation between firm size and export behavior for smaller firms, indicating an optimal size for export performance. Foreign owned firms are more likely export as they are already integrated into an international network of firms. Our results have important policy implications requiring moving from a heavy dependence on export promotion to more policies focused on promoting product innovation, which as a derived effect lead to exporting.

Our results are consistent with the product-life-cycle hypothesis of internationalization advanced by Vernon (1966). Exporting is the first step in this process initiated by product innovation for the home market but with appeal to other foreign markets. In addition, we linked our findings with an interesting and growing literature on productivity dynamics at the firm level, which has found that productivity dynamics are mainly driven by firm specific demand shocks. This investigation of the relation between innovation and exports, therefore, adds to our understanding of a more in-depth relation

[13] Coefficients are not directly comparable across columns due to the different estimation methods for the specifications. Each specification does find its counter part in Table 6. Other assumed exogenous variables are included but not shown.

between innovation, exports and productivity, where we show that it is product innovation that really matters. In a related paper Cassiman and Golovko (2006) study this link between innovation, exports and productivity directly and find consistent evidence that product innovation drives productivity. Once controlling for innovation, exports and productivity are not related for the subsample of innovating firms.

While these results are suggestive, we await further confirmation and robustness checks for our findings. In particular, accounting for the dynamic nature of these interactions between firm decisions and firm performance needs to be investigated further both from a theoretical and an empirical perspective.

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| Table 1: Variable Definitions | |
|---|---|
| **Variables** | **Description** |
| *EXPORT*$_{it}$ | Dummy variable equals to 1 if company i exports in year t. |
| *PRODUCT INNOVATION*$_{it}$ | Dummy variable equals to 1 if firm i realized a product innovation in year t. |
| *PROCCESS INNOVATION*$_{it}$ | Dummy variable equals to 1 if firm i realized a process innovation in year t. |
| *SIZE*$_{it}$ | Number of employees of firm i on 31 of December of year t |
| *SIZE2*$_{it}$ | The square of SIZE |
| *LOW COMPETITION*$_{it}$ | Average industry gross margins excluding the margin of firm i |
| *FOREIGN*$_{it}$ | Dummy variable equals to 1 if firm i is participated by more than 50% of foreign capital. |
| *CAPITAL INTENSITY*$_{it}$ | Physical capital over total employment of firm i in year t |
| *WAGE INTENSITY*$_{it}$ | Total Wage Bill over total employment of firm i in year t |
| *INDEX*$_{it}$ | Exchange rates index of firm i in year t (See Apendix 2). |

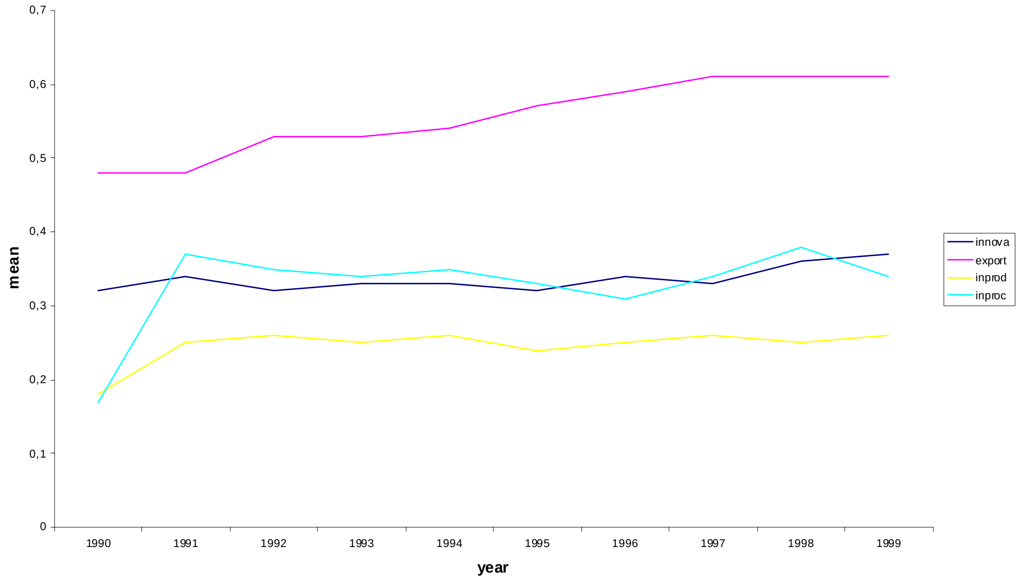


**Figure 1: Innovations and exports.**

| Table 3a: Past Innovation and Exports | | | |
|---|---|---|---|
| | Not Export$_t$ | Export$_t$ | Total |
| Not Innovate$_{t-1}$ | **2807** **(58%)** | 2070 (42%) | 4877 (100%) |
| Innovate$_{t-1}$ | 389 (16%) | **2033** **(84%)** | 2422 (100%) |
| Total | 3196 (44%) | 4103 (56%) | 7299 (100%) |

| Table 3b: Past Product Innovation and Exports | | | |
|---|---|---|---|
| | Not Export$_t$ | Export$_t$ | Total |
| No Product Innovation$_{t-1}$ | **2799** **(51%)** | 2720 (49%) | 5519 (100%) |
| Product Innovation$_{t-1}$ | 397 (22%) | **1383** **(78%)** | 1780 (100%) |
| Total | 3196 (44%) | 4103 (56%) | 7299 (100%) |

| Table 3c: Past Process Innovation and Exports | | | |
|---|---|---|---|
| | Not Export$_t$ | Export$_t$ | Total |
| No Process Innovation$_{t-1}$ | **2505** **(51%)** | 2405 (49%) | 4910 (100%) |
| Process Innovation$_{t-1}$ | 691 (29%) | **1698** **(71%)** | 2389 (100%) |
| Total | 3196 (44%) | 4103 (56%) | 7299 (100%) |

Table 4a

Transition Probabilities Exports Small Firms

| | | $Export_t$ | | |
|---|---|---|---|---|
| | | 0 | 1 | Total |
| $Export_{t-1}$ | 0 | 2864<br>(91.9%) | **254<br>(8.15%)** | 3118<br>(100%) |
| | 1 | 167<br>(7.2%) | 2140<br>(92.8%) | 2307<br>(100%) |
| | Total | 3031 | 2394 | 5425 |

Table 4b

Transition Probabilities Exports Large Firms

| | | $Export_t$ | | |
|---|---|---|---|---|
| | | 0 | 1 | Total |
| $Export_{t-1}$ | 0 | 139<br>(74.3%) | **48<br>(25.7%)** | 187<br>(100%) |
| | 1 | 26<br>(1.54%) | 1661<br>(98.5%) | 1687<br>(100%) |
| | Total | 165 | 1709 | 1874 |

Table 5a

Transition Probabilities Conditional on Product or Process Innovations for Small and Medium Firms

| | | | $Export_t$ | |
|---|---|---|---|---|
| | | | 0 | 1 |
| $Export_{t-1}$ | 0 | Product 0 | 2537 (92.5%) | 205 (7.5%) |
| | | 1 | 327 (87.0%) | **49 (13.0%)** |
| | | Process 0 | 2296 (92.6%) | 184 (7.4%) |
| | | 1 | 568 (89.0%) | **70 (11.0%)** |
| | 1 | Product 0 | 138 (8.7%) | 1456 (91.3%) |
| | | 1 | 29 (4.1%) | 684 (95.9%) |
| | | Process 0 | 118 (7.6%) | 1439 (92.4%) |
| | | 1 | 49 (6.5%) | 701 (93.5%) |

Table 5b

Transition Probabilities Conditional on Product or Process Innovations for Large Firms

| | | | $Export_t$ | |
|---|---|---|---|---|
| | | | 0 | 1 |
| $Export_{t-1}$ | 0 | Product 0 | 106 (78.5%) | 29 (21.5%) |
| | | 1 | 33 (63.5%) | **19 (36.5%)** |
| | | Process 0 | 79 (76.0%) | 25 (24.0%) |
| | | 1 | 60 (72.3%) | **23 (27.7%)** |
| | 1 | Product 0 | 18 (1.7%) | 1030 (98.3%) |
| | | 1 | 8 (1.3%) | 631 (98.7%) |
| | | Process 0 | 12 (1.6%) | 757 (98.4%) |
| | | 1 | 14 (1.5%) | 904 (98.5%) |

**Table 6: Decision to Export at time t, Full Sample**

| | Small and Medium Firms (<200 workers) | | | | | | Large Firms (> 200 workers) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| Product Innovation (t-1) | **0.303*** (0.072)** | **0.268*** (0.075)** | **0.210** (0.105)** | **1.116*** (0.374)** | **1.997*** (0.636)** | **0.697** (0.347)** | 0.342* (0.175) | 0.450** (0.2) | 0.571* (0.343) | 0.815* (0.467) | 2.688 (1.683) | 1.404 (1.417) |
| Process Innovation (t-1) | 0.0344 (0.066) | 0.0545 (0.0677) | 0.091 (0.089) | -0.215 (0.391) | -0.658 (0.639) | -0.0058 (0.409) | -0.0964 (0.163) | -0.0729 (0.177) | 0.149 (0.324) | -0.792 (0.563) | 2.972 (1.88) | -1.606 (1.344) |
| Exports (t-1) | **2.65*** (0.057)** | **2.255*** (0.067)** | **1.475*** (0.100)** | **2.273*** (0.067)** | **1.462*** (0.100)** | **1.463*** (0.100)** | **2.904*** (0.166)** | **3.004*** (0.221)** | **2.322*** (0.318)** | **2.99*** (0.225)** | **2.349*** (0.33)** | **2.455*** (0.299)** |
| Size (/10) | 0.156*** (0.029) | 0.111 (0.095) | 0.232* (0.128) | 0.118 (0.093) | 0.25* (0.013) | 0.245* (0.129) | -0.0029 (0.007) | -0.0188 (0.046) | -0.067 (0.064) | -0.017 (0.045) | -0.044 (0.063) | -0.035 (0.062) |
| SizeSq (/10000) | -0.795*** (0.195) | -1.159* (0.718) | -2.056** (1.019) | -1.226* (0.713) | -2.181** (1.029) | -2.147** (1.024) | 0.002 (0.003) | -0.001 (0.003) | 0.019 (0.08) | -0.001 (0.003) | 0.02 (0.134) | 0.002 (0.05) |
| Foreign | 0.296** (0.135) | 0.300** (0.141) | 0.374 (0.265) | 0.269** (0.140) | 0.327 (0.267) | 0.319 (0.263) | 0.095 (0.16) | -0.0127 (0.174) | 1.100*** (0.409) | 0.0576 (0.176) | 0.644* (0.345) | 0.318 (0.405) |
| Capital Intensity | -0.00002 (0.00003) | -0.0001 (0.0001) | -0.0001 (0.0001) | -0.0001 (0.0001) | -0.0001 (0.0001) | -0.0001 (0.0001) | -0.00003 (0.00004) | -0.0001 (0.00004) | -0.0001 (0.0001) | -0.0001 (0.0001) | -0.0001 (0.0001) | -0.00005 (0.0001) |
| Wage Intensity | -0.885*** (0.236) | -0.627 (0.584) | -0.823 (0.748) | -0.925* (0.576) | -1.378* (0.758) | -0.710 (0.752) | 0.045 (0.035) | -0.277 (1.582) | -0.414 (2.857) | -0.209 (1.588) | -2.175 (3.312) | -1.034 (2.335) |
| Low Competition | 0.003 (0.002) | 0.002 (0.002) | 0.002 (0.003) | 0.001 (0.002) | 0.002 (0.003) | 0.002 (0.003) | 0.003* (0.002) | -0.002 (0.006) | -0.0416* (0.023) | -0.002 (0.006) | -0.0703*** (0.019) | -0.015 (0.013) |
| Index | 7.24e-06 (0.00002) | 9.44e-06 (0.00002) | 0.00003 (0.00004) | 5.80e-06 (0.0002) | 0.00004 (0.00004) | 0.00003 (0.00004) | 0.0001* (0.00006) | 0.00009 (0.00005) | 0.0001 (0.0001) | 0.0001 (0.0001) | 0.0001 (0.0001) | .0001423 .000124 |
| Intercept | -1.878*** (0.363) | -1.647*** (0.406) | -2.375*** (0.649) | -1.736*** (0.420) | -2.652*** (0.69) | -1.7** (0 .72) | -1.95*** (0773) | -2.83*** (1.083) | -1.984 (2.226) | -0.327 (1.352) | -3.026 (2.547) | -0.969 (2.510) |
| Export90 | - | 0.811*** (0.075) | 2.379*** (0.245) | 0.800*** (0.075) | 2.44*** (0.253) | 2.44*** (0.254) | - | 0.267 (0.223) | 2.738*** (0.674) | 0.213 (0.222) | 3.781*** (0.787) | 1.556** (0.747) |
| Industry & Time Dummies | Included | Included | Included | Included | Included | Included | Included | Included | Included | Included | Included | Included |
| Observations | 4878 | 4878 | 4878 | 4878 | 4878 | 4878 | 1476 | 1476 | 1476 | 1476 | 1476 | 1476 |

**Table 7: Decision to Export at time t by Non-Exporters in t-1**

| | Small and Medium Firms (<200 workers) | | | | | Large Firms (> 200 workers) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Product Innovation (t-1) | **0.208**** (0.099)** | **0.218* (0.128)** | **1.112** (0.466)** | **1.664** (0.706)** | **0.557* (0.345)** | 0.696** (0.314) | 0.696** (0.314) | 0.604 (1.668) | 0.179 (0.836) | 0.059 (1.027) |
| Process Innovation (t-1) | 0.084 (0.087) | 0.117 (0.111) | -0.516 (0.469) | -0.966 (0.702) | -0.107 (0.379) | -0.044 (0.295) | -0.044 (0.295) | 0.432 (2.165) | -0.092 (0.490) | -0.29 (1.224) |
| Size | 0.017*** (0.004) | 0.027*** (0.007) | 0.018*** (0.004) | 0.029*** (0.007) | 0.029*** (0.007) | 0.001 (0.002) | 0.001 (0.002) | 0.001 (0.002) | 0.001 (0.002) | 0.001 (0.002) |
| SizeSq (/1000) | -0.100*** (0.03) | -0.163*** (0.05) | -0.104*** (0.03) | -0.173*** (0.05) | -0.172*** (0.05) | -0.001 (0.001) | -0.001 (0.001) | -0.001 (0.0005) | -0.0004 (0.001) | -0.0005 (0.001) |
| Foreign | 0.317 (0.199) | 0.439 (0.305) | 0.250 (0.197) | 0.388 (0.308) | 0.374 (0.306) | -0.511* (0.308) | -0.511* (0.308) | -0.365 (0.314) | -0.325 (0.292) | -0.325 (0.311) |
| Capital Intensity | 0.00002 (0.00003) | 0.00004 (0.00004) | 0.00003 (0.00003) | 0.00005 (0.00004) | 0.00005 (0.00004) | 0.0001 (0.0001) | 0.0001 (0.0001) | 0.0001 (0.0001) | 0.0001 (0.0001) | 0.0001 (0.0001) |
| Wage Intensity | -1.248*** (0.302) | -1.478*** (0.411) | -1.210*** (0.298) | -1.522*** (0.413) | -1.467*** (0.414) | 0.1447 (0.157) | 0.1447 (0.157) | 0.132 (0.120) | 0.110 (0.171) | 0.138 (0.128) |
| Low Competition | 0.001 (0.003) | 0.003 (0.004) | 0.001 (0.003) | 0.002 (0.004) | 0.002 (0.004) | 0.010 (0.01) | 0.010 (0.01) | 0.014 (0.01) | 0.011 (0.01) | 0.012 (0.01) |
| Index | -0.00003 (0.00004) | 0.00001 (0.00005) | 0.00003 (0.00003) | 0.00002 (0.00005) | 0.00001 (0.00005) | 0.00006 (0.0001) | 0.00006 (0.0001) | 0.00001 (0.0001) | -0.00004 (0.0001) | 0.00001 (0.0001) |
| Intercept | -1.677*** (0.478) | -2.394*** (0.657) | -1.96*** (0.453) | -2.2*** (0.731) | -1.71 (0.672) | -2.50 (1.66) | -2.50 (1.66) | -1.852 (1.798) | -0.76 (1.541) | -1.501 (1.885) |
| Industry & Time Dummies | Included | Included | Included | Included | Included | Included | Included | Included | Included | Included |
| Observations | 2916 | 2916 | 2916 | 2916 | 2916 | 140 | 140 | 140 | 140 | 140 |

**Table 8: Robustness Decision to Export at time t (PRELIMINARY)**

| | R&D | Productivity | Product x Process | AGE | | | |
|---|---|---|---|---|---|---|---|
| | | | | <25 | >25 | <25 | >25 |
| Product Innovation (t-1) | **1.944*** (0.63)** | **0.500*** (0.12)** | **2.282*** (0.85)** | **0.290*** (0.098)** | **0.233* (0.12)** | **1.529* (0.82)** | **2.530** (1.10)** |
| Process Innovation (t-1) | -0.626 (0.64) | 0.0816 (0.11) | -.499 (0.71) | 0.0811 (0.09) | 0.064 (0.11) | -.695 (0.80) | -0.504 (1.19) |
| Exports (t-1) | 1.462*** (0.10) | 2.648*** (0.094) | 1.459*** (0.10) | 2.170*** (0.09) | 2.486*** (0.11) | 1.443*** (0.13) | 1.603*** (0.21) |
| R&D | 5.914** (2.43) | | | | | | |
| Productivity (t-1) | | 0.142 (0.22) | | | | | |
| Product x Process (t-1) | | | -.596 (1.19) | | | | |
| Number Observations | 4847 | 1748 | 4878 | 2982 | 1887 | 2982 | 1887 |
| | Wooldridge, IV, Random Effects | Pooled Probit | Wooldridge, IV, Random Effects | Wooldridge | Wooldridge | Wooldridge, IV, Random Effects | Wooldridge, IV, Random Effects |

**Appendix 1**

**Table A.1. Industries**

Metal products

Mineral products non-metallic

Chemical

Metallic products

Agricultural and industrial machines

Office machines

Electrical material

Vehicle and motors

Other transport material

Meat and canned food

Tobacco and food products

Drinks and beverages

Textile and wear

Leather

Wood

Paper

Rubber and Plastic

Other manufactured products

## Appendix 2

**Construction of Index variable:** $INDEX_{it}$.

**The construction have two phases:**

Phase 1.

Effective Exchange rate = w1*k1+w2*k2+w3*k3
w (weight) – % of exports to a particular market (EU countries, OECD countries, the rest of the world).
k – exchange rate: ptas/ecu for EU countries; ptas/USD for OECD countries; NEER (nominal effective exchange rate) for the rest of the world.
k is taken from the IFS database.

Phase 2.
For each firm, the weight is a constant for all the period 1990-1999.
Calculation:

1. for % of exports, the zeros have been changed for the missing values, if the firm did not export during 1990, 1994 or 1998
2. for the exporting firms, which had a missing value for the % of export to the rest of the world, the missing value was changed for (100-% to EU-% to OECD)
3. for the firms that exported during 1990 and/or 1994 and/or 1998, the average weight (for each destination) was calculated as an arithmetic mean of available weights.
4. if the firm did not export in 1990 and 1994 and 1998, then it was assigned the average industry weight (for each destination).