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Firm productivity and export markets: a non-parametric approach

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Abstract

This paper examines total factor productivity differences between exporting and non-exporting firms. These differences are documented on the basis of a sample of Spanish manufacturing firms over the period 1991–1996. The paper also examines two complementary explanations for the greater productivity of exporting firms: (1) the market selection hypothesis, and (2) the learning hypothesis. Non-parametric tests are proposed and implemented for testing these hypotheses. Results indicate clearly higher levels of productivity for exporting firms than for non-exporting firms. With respect to the relative merits of the selection and the learning hypotheses, we find evidence supporting the self-selection of more productive firms in the export market. The evidence in favor of learning-by-exporting is rather weak, and limited to younger exporters.

Keywords: Total factor productivity; Exports; Stochastic dominance; Non-parametric tests

JEL classification: D24; F10; M20; L10

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1. Introduction

The link between efficiency and exports is one of the many features which the literature concerning productivity growth has focused on. A widespread and robust finding supported by this literature is the existence of significant differences in productivity among firms. Furthermore, it has also been observed that these differences persist (see Griliches and Regev, 1995, and many others; for a review article see Tybout, 1997). One of the firms' characteristics that contributes to this observed heterogeneity is the entry of firms into the export market. Studies by Aw and Hwang (1995), Bernard and Jensen (1995), Jensen and Wagner (1997), Aw et al. (1997), Clerides et al. (1998) and Aw et al. (2000), provide evidence on the fact that export-oriented firms are closer to the efficiency frontier than non-exporters.

The purpose of this paper is to measure total factor productivity differences between exporting and non-exporting firms. First, the paper documents these productivity differences on the basis of a panel sample of Spanish manufacturing firms over the period 1991–1996. Therefore, we contribute to the growing body of empirical literature that examines the relationship between productivity and exports, adding another national perspective to the available evidence. The proposed methodological approach is the second contribution of the paper. We compare the entire distribution of productivities rather than just marginal moments. In particular, we compare the cumulative distribution functions of total factor productivity for different groups of firms: exporters, non-exporters, entering exporters and exiting exporters. These distributions are ranked using the concept of stochastic dominance, and their differences are formally tested using Kolmogorov–Smirnov one and two-sided tests, which are consistent in the direction of general non-parametric alternatives. Third, the paper makes an attempt at sorting out the selection versus the learning explanations for the superior productivity of exporting firms. The paper explores and tests for these two different, but non-mutually exclusive explanations by comparing productivity levels as well as productivity growth for groups of firms with different trajectories between the export and domestic markets.

Our empirical findings confirm higher levels of productivity for exporting firms versus non-exporting firms. With respect to the relative merits of the selection and the learning hypotheses proposed to explain the greater productivity of exporters, we find evidence supporting the self-selection of more productive firms into the export market. The evidence in favor of the learning-by-exporting hypothesis is rather weak, and limited to younger exporters. These results are very much in line with those reported by Clerides et al. (1998), Bernard and Jensen (1999), and Aw et al. (2000). Although the methodology used differs throughout their research, they all come to a similar conclusion: market selection rather than learning-by-exporting is the factor that leads to higher productivity of exporting firms with respect to non-exporting firms.

The rest of the paper is organized as follows. Section 2 summarizes the analytical arguments for the observed link between productivity and exports, and presents the testing procedures that have been used throughout the paper. Section 3 describes the data set, the index used for measuring total factor productivity and some general estimation issues. Section 4 reports the main empirical results. Conclusions are placed in Section 5.

2. Analytical framework

2.1. Productivity differentials and exports

To explain why exporters are more efficient than non-exporters, the analytical literature on productivity has outlined two arguments: (1) firms participating in international markets are exposed to more intensive competition; and (2) exporters have higher sunk entry costs than domestic firms. Both explanations share the idea that export markets select the most efficient firms among the set of potential entrants into the export market. The first argument is present in the literature concerning development economics and relies on the idea that product market competition in export markets is greater than competition in domestic markets and, therefore, affords fewer opportunities for inefficient firms (see Aw and Hwang, 1995, for further details on these arguments.) Empirical studies on trade reform (see Feenstra, 1997, for a survey) confirm the existence of a positive relationship between competition and productivity.

The second argument to the explanation of superior productivity of exporting firms comes from models of industry dynamics by Jovanovic (1982), Hopenhayn (1992) and Ericson and Pakes (1995). These models predict the existence of a systematic relationship between patterns of entry and exit and productivity differences at the firm level. As Aw et al. (1997) argue, a similar statement applies to the relationship between export markets and productivity. Even if we consider that the competitive pressure in the domestic market and the export market is similar, differences in sunk entry costs can explain productivity differences between exporters and domestic-oriented firms. The basic assumption underlying this argument is that a non-exporter must incur a sunk entry cost in order to enter the export market. Recent studies confirm this assumption empirically: Roberts and Tybout (1997) find that firm's previous export status is an important determinant of the decision to export and they interpret this as a favorable evidence to the existence of sunk entry costs in the export market. In particular, Campa (1998) finds that exporting sunk entry costs are important for Spanish manufacturing firms.

Models of industry dynamics have two consequences for the analysis of productivity differences between exporting and non-exporting firms. First, higher entry costs for firms entering the export market with respect to those firms selling in the domestic market imply higher productivity levels for exporting firms. Second, patterns of entry and exit in the export market are related to productivity differences at the firm level. On one hand, the productivity distribution of continuing exporters should stochastically dominate the distribution of entering and exiting exporters. On the other hand, entering exporters should have higher initial productivity relative to firms that remain outside of the export market.

The two outlined arguments are consistent with the hypothesis of selection. A third argument, not mutually exclusive with respect to the two previous ones, is based on the idea of exporting as a learning mechanism that allows firms to improve their productivity. The management literature describing the internationalization process either as a sequence of stages for the firm or as an innovation for the firm, has emphasized the notion of exporting as a learning process.

To organize our empirical work we rely on the previous arguments, which suggest the following hypotheses be tested based on the concept of stochastic dominance:

(i) If productivity differences reflect selection and/or learning forces at work in export markets, the productivity distribution of exporting firms should dominate the productivity distribution of non-exporting firms.

(ii) Self-selection implies that differences between exporting and non-exporting firms precede their entry in the export market. Therefore, in the period prior to their entry, the productivity distribution of entering exporters should dominate the productivity distribution of non-exporters.

(iii) Selection on the exit side of the market implies that the productivity distribution of continuing exporters should dominate the distribution of exiting exporters.

(iv) Finally, if the empirical consequences of learning-by-exporting are considered as well, differences between productivity levels for exporting and non-exporting firms should increase after the entry of exporters in the export market. Therefore, the productivity growth distribution of entering exporters should dominate the distribution of non-exporting firms.

In the next section we describe a testing procedure for examining productivity differentials between groups of firms with different trajectories between the domestic and the export market.

2.2. Testing procedure

This section develops a procedure for comparing the productivity distributions of different groups of firms. The panel structure of the sample of firms allows a classification of firms according to their trajectories between the export and the domestic market over a given period. We have designed different tests to explore whether or not transitions from domestic to export markets are consistent with firms' productivity differences summarized in Section 2.1.

Most of the empirical questions we are interested in can be formulated as comparisons between the distributions of firm productivity level or firm productivity growth corresponding to different groups in the population. Our procedure for testing differences between distribution functions relies on the concept of first order stochastic dominance and permits us to establish a ranking for the compared distributions. Let F and G denote the cumulative distribution functions of productivity corresponding to two groups of firms that have to be compared, then (first order) stochastic dominance of F relative to G is defined by the following condition: $F(z) - G(z) \leq 0$ uniformly in $z \in \mathbb{R}$, with strict inequality for some z.

Let $Z_1, \ldots, Z_n$, be a random sample of size n, which corresponds to a group of firms, from the distribution function F, and let $Z_{n+1}, \ldots, Z_{n+m}$, denote a random sample of size m, independent of the first one, which corresponds to a different group of firms, from the distribution function G; where Z_i represents either the productivity level or the productivity growth of firm i. We are interested in testing the following hypotheses:

(i) Two sided test

$$H_0\colon F(z) - G(z) = 0 \text{ all } z \in \mathbb{R} \quad \text{vs.} \quad H_1\colon F(z) - G(z) \neq 0 \text{ some } z \in \mathbb{R}$$

can be rejected.

(ii) One-sided test

$$H_0\colon F(z) - G(z) \leq 0 \text{ all } z \in \mathbb{R} \quad \text{vs.} \quad H_1\colon F(z) - G(z) > 0 \text{ some } z \in \mathbb{R}$$

cannot be rejected.

One and two-sided test can also be formulated as

$$H_0\colon \sup_{z \in \mathbb{R}} |F(z) - G(z)| = 0 \quad \text{vs.} \quad H_1\colon \sup_{z \in \mathbb{R}} |F(z) - G(z)| \neq 0$$

and

$$H_0\colon \sup_{z \in \mathbb{R}} \{F(z) - G(z)\} = 0 \quad \text{vs.} \quad H_1\colon \sup_{z \in \mathbb{R}} \{F(z) - G(z)\} > 0 ,$$

respectively. To give a more intuitive explanation let us suppose that F and G represent the productivity distributions for exporters and non-exporters, respectively. On one hand, the two-sided test allows us to determine whether both distributions are identical or not. On the other hand, the one-sided test permits us to determine whether or not a distribution dominates the other. Particularly, when the two-sided test is rejected and the one-sided test cannot be rejected, it indicates that F is to the right of G. In other words, it implies that exporters' productivity distribution stochastically dominates non-exporters' productivity distribution.

The Kolmogorov–Smirnov test statistics for these one and two-sided tests are

$$\delta_N = \sqrt{\frac{n.m}{N}} \max_{1 \leq i \leq N} |T_N(Z_i)|$$

and

$$\eta_N = \sqrt{\frac{n.m}{N}} \max_{1 \le i \le N} \{T_N(Z_i)\},$$

respectively, where $T_N(Z_i) = F_n(Z_i) - G_m(Z_i)$ and $N = n + m$. F_n and G_m represent the empirical distribution functions for F and G, respectively. The limiting distributions of both test statistics, δ_N and η_N, are known under independence[1].

3. Measurement and estimation issues

3.1. The data

The data set considered in this study is drawn from the 'Encuesta sobre Estrategias Empresariales' (ESEE), an annual survey which refers to a representative sample of Spanish manufacturing firms. A first characteristic of the data set is that, in the base year, firms were chosen according to a selective sampling scheme with different probabilities of firm participation depending on their size category. All firms with more than 200 employees (large firms) were asked to participate, and the rate of participation reached approximately 70% of the population of firms within that size category. Firms that employed between 10 and 200 employees (small firms) were chosen according to a random sampling scheme, and the rate of participation was close to 5% of the number of firms in the population. The same selection scheme was applied to every industry. Therefore, the coverage of the data set is different depending on the size group of firms. Consequently, given the procedure used to incorporate firms into the survey, the characteristics of the distribution of Spanish manufacturing firms, for given size groups and industries, can be estimated from our sample.

A second characteristic of the data set is that in subsequent years the initial sample properties have been maintained. On one hand, newly created firms have been added annually with the same sampling criteria as in the base year (see Ministry of Industry, 1992, for technical details.) On the other hand, exiting firms have been recorded in the sample of firms surveyed each year. Therefore, due to this entry and exit process, the data set is an unbalanced panel of firms.

Over the period 1991–1996, the data set has collected 10,595 observations at the firm level that correspond to an average number of 1766 firms throughout the entire period. The yearly average distribution of firms can be classified, for descriptive purposes, into five groups according to their export participation along the time period: exporters, non-exporters, entering exporters, exiting exporters and

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[1]These test statistics were proposed by Smirnov (1939). Kolmogorov (1933) and Smirnov (1939) showed that, under the assumption that all the observations are independent, the limiting distributions of δ_N and η_N under H_0 are given by $\lim_{N\to\infty} P(\delta_N > \upsilon) = -2\Sigma_{k=1}^{\infty} (-1)^k \exp(-2k^2\upsilon^2)$ and $\lim_{N\to\infty} P(\eta_N > \upsilon) = \exp(-2\upsilon^2)$, respectively. For more details see Darling (1957).

switchers. For the first two groups – firms that export every year and firms that do not export along the time period – figures indicate that there is a positive relationship between the size of firms and their participation in the export market: 78% of large firms export regularly while the rate of participation for small firms is 27%. Firm turnover with respect to the export market corresponds to the group of entering exporters – firms becoming exporters during the period without further changes in the rest of the period – and to the group of exiting exporters – firms ceasing to export and not reswitching. Two features should be noted. First, the fraction of firms entering and exiting the export market implies a high turnover rate. The annual average rate for small firms is 16 and 11% for large firms. Second, during the period the average entry rate is higher than the average exit rate. This difference suggests that the large increase in Spanish exports during the nineties has been partly due to a net increase in the number of exporting firms. Finally, the group of switchers – firms that change their export status more than once during the period – represents 11 and 6% for small and large firms, respectively.

3.2. The measurement of firm productivity

This section presents an index for measuring firm productivity that follows the framework developed in Aw et al. (2000). The index is an extension of the multilateral total factor productivity index proposed by Caves et al. (1982) that uses the average firm of the firm's size group as a reference point and then chain-links the reference points to preserve transitiveness. This extension takes into account the characteristics of the data set, in particular, the fact that sampling proportions are different for small and large firms. A similar extension of the index can be found in Good et al. (1996). The main advantage of this kind of measure is that the parameters of the production function are not required to compute productivity.

The ESEE provides observations

$$\left\{\left(Y_{ft}, W_{ft}^k, X_{ft}^k, k=1,\ldots,K\right), f=1,\ldots,N, t=1,\ldots,T\right\},$$

where Y_{ft} is the output level of the firm f at time t, W_{ft}^k and X_{ft}^k are, respectively, the cost share and the quantity of input k corresponding to firm f at time t. The definition of the three inputs considered (labor, materials and capital) and output can be found in Appendix A. Capital letters denote the number of firms (N), the number of time periods (T) and the number of inputs (K). Firms are classified in two size groups and I different industries[2]. Let us introduce the dummy variables,

[2] Firms have been grouped in 18 industries corresponding to NACE-CLIO R-25 classification.

$s_{f\tau} = 1$ (firm f belongs to size group τ)
$i_{fr} = 1$ (firm f belongs to industry r),

where $1(A)$ is the indicator function of event A. It is assumed that observations for different firms, at a given period, are independent. It is also assumed that the distributions of the variables at different periods can be different, so we do not assume stationarity. The expression of total factor productivity index at time t, for the firm f, which belongs to the size group τ and to the industry r is

$$\begin{aligned}\ln \lambda_{ft} = {} & \ln Y_{ft} - \overline{\ln Y}_{\tau r} - \frac{1}{2}\sum_{k=1}^{K}\left(W_{ft}^{k} + \overline{W}_{\tau r}^{k}\right)\left(\ln X_{ft}^{k} - \overline{\ln X}_{\tau r}^{k}\right) \\ & + \overline{\ln Y}_{\tau r} - \overline{\ln Y}_{r} - \frac{1}{2}\sum_{k=1}^{K}\left(\overline{W}_{\tau r}^{k} + \overline{W}_{r}^{k}\right)\left(\overline{\ln X}_{\tau r}^{k} - \overline{\ln X}_{r}^{k}\right),\end{aligned}$$

where, for notational convenience, we drop reference to the size group, τ, and industry, r; and for a generic variable a_{ft}, which can be $\ln Y_{ft}$, W_{ft}^{k} or $\ln X_{ft}^{k}$

$$\overline{a}_{\tau r} = \frac{1}{NT}\sum_{f=1}^{N}\sum_{t=1}^{T} a_{ft} s_{f\tau} i_{fr} \quad \text{and} \quad \overline{a}_{r} = \frac{1}{NT}\sum_{f=1}^{N}\sum_{t=1}^{T} a_{ft} i_{fr}.$$

This index measures the proportional difference of total factor productivity for firm f at time t relative to a given reference firm. The reference firm varies across industries and, for a given industry r, it is defined as the firm such that: (i) its output is equal to the geometric mean of firms output quantities in industry r over the entire period; (ii) the quantities of inputs are equal to the geometric means of firms input quantities in industry r over the entire period; and (iii) the cost shares of inputs are equal to the arithmetic mean of firms cost shares in industry r over the entire period. Notice that the reference firm varies across industries and, therefore, when observations of different industries are pooled, productivity differences among industries are removed.

To clarify the meaning of the productivity index, we can interpret the terms on the right hand side separately. The first set of terms compares the firm with the average firm of the same size group, which is taken as reference. Hence, comparisons between observations corresponding to the same size group are transitive. The second set of terms measures productivity differences between the reference firm of a size group and a common reference firm, which is the average firm over the entire sample of firms in industry r. Thus, comparisons between observations corresponding to different size groups are also transitive. Consider, for example that firm f belongs to industry r and employs more than 200 workers. The first set of terms gives the proportional difference of total factor productivity for firm f at time t with respect to the average firm in the group of large firms producing in industry r. The second set of terms, adds the proportional difference between the reference firm for the group of large firms in industry r and the common reference firm for both size groups in this industry.

3.3. Implementation of the tests

In this section we discuss some issues related to the application of one and two-sided Kolmogorov–Smirnov tests to our data set. In particular, there are four questions that have to be considered.

First, the application of the testing procedure defined in Section 2.2 requires independence of the observations. Given the panel structure of our sample of firms, observations for different years correspond to firms that are repeated, and therefore cannot be considered either independent or stationary. Consequently, the application of Kolmogorov–Smirnov tests has to be done separately for each time period.

Second, testing for stochastic dominance requires the use of empirical distributions of the compared groups of firms. Given the sampling properties of our data set, we use cumulative distribution functions for the two size categories (small and large firms,). Comparisons between distribution functions for the whole population are avoided since this would have required the estimation of a mixture of two distributions. Therefore, we compare different groups of firms, i.e. exporters and non-exporters, within the same size category or between size-categories (the productivity index preserves transitiveness along the two size categories).

Third, it should be notice that our productivity measure, $\ln \lambda_{ft}$, can be interpreted as an estimate of a non-observable measure, say $\ln \lambda^*_{ft}$, with sample averages replaced by population means. The Kolmogorov–Smirnov's test is directly applicable to $\ln \lambda^*_{ft}$. However, the limiting process of the sample distribution of $\ln \lambda_{ft}$, which contains estimated parameters, depends on certain unknown features of the data generating process, and the empirical distribution function converges to a non-pivotal process (see e.g. Durbin, 1973). Bai (1996) has shown that structural stability tests, which are a type of two-sample test, for distribution functions based on residuals of linear regression models are distribution free. Also, Delgado and Mora (2000) have shown that independence tests based on the difference between the joint distribution and the product of marginal distributions (Hoeffding–Blum–Kiefer–Rosenblatt test) are also distribution free when residuals, rather than observations, are employed. Despite the fact that this result has not been extended to two-sample problems for general functions depending non-linearly on estimated parameters, in a earlier version of this paper (see Delgado et al., 1999) we have proved formally that asymptotic Kolmogorov–Smirnov's tests is also distribution free. Therefore, we can use the same tables for the test based on $\ln \lambda_{ft}$ and the infeasible $\ln \lambda^*_{ft}$.

Fourth, we provide two P-values for each of the statistics: one based on the limiting distribution and the other on the bootstrap approximation. Asymptotic and bootstrap P-values are fairly close, which illustrates the good accuracy of the asymptotic approximation. The 'naive' bootstrap for empirical processes has been justified by Giné and Zinn (1990). Bootstrap P-values are computed in our context as follows.

(a) Obtain a resample $\chi_N^* = \{z_1^*, \ldots, z_n^*, z_{n+1}^*, \ldots, z_{n+m}^*\}$ by random sampling with replacement from $\chi_N = \{z_1, \ldots, z_n, z_{n+1}, \ldots, z_{n+m}\}$.

(b) Compute bootstrap analogs of δ_N and η_N, say δ_N^* and η_N^*, based on the resample χ_N^*.

The bootstrap P-values are

$$\begin{aligned} P^*\text{-value}(\delta_N) &= \Pr\{\delta_N^* \geq \delta_N | \chi_N\} \\ P^*\text{-value}(\eta_N) &= \Pr\{\eta_N^* \geq \eta_N | \chi_N\}. \end{aligned}$$

Calculating these P-values is computationally unapproachable in practice. However, they can be approximated, as accurately as desired, by Monte Carlo. That is, we repeat steps (a) and (b) B times, B as large as desired accuracy, obtaining bootstrap statistics δ_N^{*b} and η_N^{*b}, $b = 1, \ldots, B$. The bootstrap P-values are approximated by

$$\begin{aligned} P_B^*\text{-value}(\delta_N) &= \frac{1}{B} \sum_{b=1}^{B} 1(\delta_N^{*b} \geq \delta_N) \\ P_B^*\text{-value}(\eta_N) &= \frac{1}{B} \sum_{b=1}^{B} 1(\eta_N^{*b} \geq \eta_N). \end{aligned}$$

Under H_1, the bootstrap P-values converge to zero almost surely.

To further illustrate the comparisons between different groups of firms we have graphed estimates of the distribution functions. In particular, we have computed the smooth, or perturbed, sample distribution function, rather than the sample distribution function itself, which provides nice smooth distribution estimates. The smooth sample distribution estimator was proposed by Nadaraya (1964). Since the purpose here is to produce graphical representations of the differences between two groups of firms, we represent these distributions for the whole population of firms. Consider for that purpose the distribution $F_t(.)$, which corresponds to the productivity of, say, exporting firms, and $F_t(.|\tau = \tau_0)$, $\tau_0 = \{0,1\}$, which denotes the conditional distribution function for a given size group of firms – small ($\tau = 0$) or large ($\tau = 1$). The selective sampling scheme used in our data set implies that only these conditional cumulative distribution functions, $F_t(.|\tau = \tau_0)$, can be estimated directly. However, the cumulative distribution function for the whole population of exporters can be obtained by the following expression:

$$F_t(.) = P_t(\tau = 0) \times F_t(.|\tau = 0) + P_t(\tau = 1) \times F_t(.|\tau = 1) \tag{1}$$

where $P_t(.)$ represents the probability of being either a small or a large firm in the considered group of exporting firms. This expression indicates that the cumulative distribution function for the whole population of firms can be estimated as a weighted average of the two conditional cumulative distribution functions. Marginal probabilities can be calculated from the information provided by the ESEE[3]. For example, following this procedure, in Fig. 1 we report estimators of distribution functions for the whole population of firms, which permits visual comparisons between any pair of distribution functions.

A different but related graphical tool is the relative distribution function, *R*. This distribution permits us to compare a target distribution, for example the distribution *G*, to a reference distribution *F*. This tool is an alternative that can be used to depict the two compared distributions directly as in Fig. 1. The relative

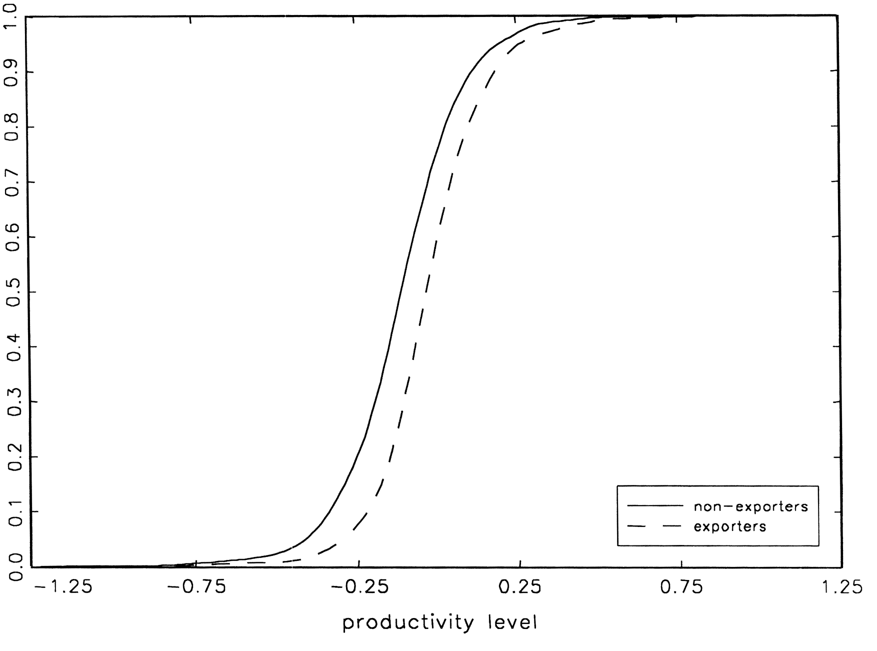

Fig. 1. Productivity differences of exporters versus non-exporters (smooth sample distribution function).

[3]The estimation of marginal probabilities for the population of firms takes into account the sampling proportions of the data set. As Section 3.1 indicates, the sampling proportion is 0.05 for small firms and 0.7 for large firms. Therefore, for any group of firms, say exporters, the number of large and small firms can be estimated multiplying the number of firms in the sample by the inverse of the sampling proportion. This procedure permits the calculation of relative frequencies and therefore the estimation of marginal probabilities of being either a small or a large firm. In particular, for the group of non-exporting firms, the estimated probability of being small is $\hat{P}_t(\tau = 0) = 0.993$ and the probability of being large is $\hat{P}_t(\tau = 1) = 0.007$. For the group of exporting firms, these probabilities are $\hat{P}_t(\tau = 0) = 0.924$ and $\hat{P}_t(\tau = 1) = 0.076$.

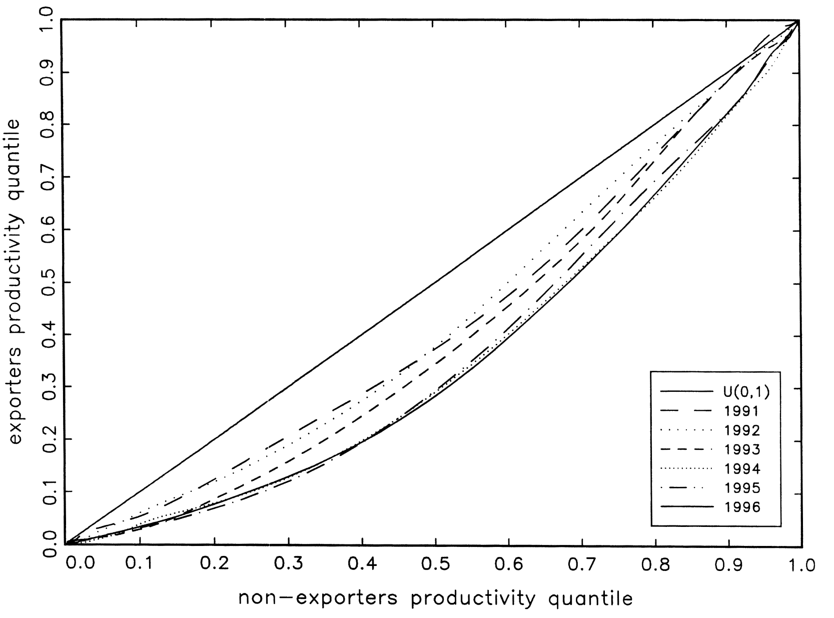

Fig. 2. Relative distribution functions of exporters' productivity to non-exporters' productivity: 1991–96.

distribution is defined as $R(r) = G(F^{-1}(r))$, where $0 \leq r \leq 1$. Notice that if both distributions are identical, then the relative distribution, i.e. $F(F^{-1}(r))$, is the uniform distribution on [0,1]. Fig. 2 provides an example of the comparison between two distributions over several years. The diagonal represents the uniform distribution, i.e. the relative distribution if both distributions were identical. The position of the relative distribution below the diagonal suggests that the distribution represented in the vertical axis stochastically dominates the distribution in the horizontal axis.

The next section presents the results based on formal tests of the differences between various groups of firms. Systematic visual representations of the compared distributions are also included.

4. Empirical results

This section is organized as follows. First, we begin by examining differences in total factor productivity between exporters and non-exporters. Second, we explore a possible source for the observed differences between exporting and non-exporting firms by examining if firm transitions between the domestic and the export market are consistent with certain patterns of productivity differences. We make two comparisons: (1) ex-ante productivity differentials between firms entering into the export market and non-exporters and (2) productivity differences between exiting exporters and continuing exporters. Finally, we examine whether or not productivity growth of firms in contact with the export market is greater than the productivity growth of non-exporters. All these comparisons are carried out through non-parametric methods described in previous sections.

4.1. Exports and productivity

We begin the analysis of the relationship between productivity and exports by examining the magnitude of productivity differentials between exporting firms and non-exporting firms. Exporters are defined as firms that export at period t, and non-exporters are firms not selling abroad at t; in both cases switchers are excluded. Very frequently, switchers are a special type of exporting firm that sells abroad intermittently, in time intervals greater than a year. For this reason, the group of firms switching their export status more than once during the given period are excluded from the comparison. However, results reported below do not change when switchers are included in accordance to their export status in year t.

Fig. 1 illustrates the differences between the productivity distributions of exporting and non-exporting firms in year 1996 within the whole population of firms. The position of the distribution for exporting firms with respect to the distribution of non-exporting firms indicates higher levels of productivity for exporters versus non-exporters. All quartiles of the productivity distributions are higher for exporting firms relative to non-exporting firms. In particular, the median productivity of the former is 7% higher than the productivity of the latter. Productivity differences are greater at the lower part of the distribution, 10% in favor of exporting firms at the lower quartile, and smaller in the upper part, 5% in favor of exporting firms at the upper quartile.

Fig. 2 shows the relative distribution of exporting firms with respect to non-exporting firms for all of the years in the period 1991–1996. The relative distribution is a graphical tool for the comparison of two distributions. As Fig. 2 illustrates, the position of the relative distribution of exporters to non-exporters is below the diagonal during the whole period; suggesting that the productivity distribution of exporters stochastically dominates the distribution of non-exporters. In 1996 around 50% of non-exporting firms' productivity is below the 30% quartile of exporting firms' productivity.

Given the assessed differences, now we formally test to see if the productivity distribution of exporting firms stochastically dominates the productivity distribution of non-exporting firms For each time period and size group τ_0, we compare

$$F_t(.|\tau = \tau_0) \quad \text{vs.} \quad G_t(.|\tau = \tau_0),\, t = 1991, \ldots, 1996 \text{ and } \tau_0 = 0{,}1$$

using the one and two-sided tests described in Section 2.2, where F_t and G_t denote

Table 1
Productivity level differences between exporters and non-exporters; hypotheses test statistics

Year	Small exporting firms vs. small non-exporting firms						Large exporting firms vs. large non-exporting firms					
	Number of observations		Equality of distributions		Differences favorable to exporters		Number of observations		Equality of distributions		Differences favorable to exporters	
	Exporters	Non-exporters	Statistic	*P*-value[a]	Statistic	*P*-value[a]	Exporters	Non-exporters	Statistic	*P*-value[a]	Statistic	*P*-value[a]
1991	361	725	2.270	0.000	0.384	0.745	598	82	0.956	0.320	0.272	0.862
				(0.000)		(0.729)				(0.304)		(0.835)
1992	373	730	2.152	0.000	0.088	0.985	541	63	0.872	0.432	0.872	0.218
				(0.000)		(0.975)				(0.373)		(0.180)
1993	395	673	2.604	0.000	0.016	0.999	457	47	0.512	0.956	0.433	0.687
				(0.000)		(0.998)				(0.926)		(0.606)
1994	428	606	3.544	0.000	0.000	1.000	510	48	0.750	0.627	0.357	0.775
				(0.000)		(1.000)				(0.577)		(0.739)
1995	441	519	3.529	0.000	0.000	1.000	470	43	0.825	0.505	0.450	0.667
				(0.000)		(1.000)				(0.454)		(0.649)
1996	477	537	3.771	0.000	0.030	0.998	447	37	0.615	0.843	0.454	0.662
				(0.000)		(0.997)				(0.777)		(0.618)

[a] *P*-values are based on the limiting distribution. *P*-values based on the bootstrap approximation (10 000 replications) are presented in parenthesis.

the productivity level (ln λ_{ft}) distribution for exporting firms and non-exporting firms in year t, respectively.

Table 1 presents the hypotheses test statistics of productivity differentials between exporters and non-exporters. Tests are applied separately both to the groups of small and large firms. First, for the group of small firms, the null hypothesis of equality between both distributions can be rejected at the 0.01 level for all years. The null hypothesis that the sign of the difference is as expected, i.e. small exporters have greater productivity than small non-exporters, cannot be rejected at any reasonable significance level. Second, for the groups of large exporters and non-exporters, the equality of both productivity distributions cannot be rejected at any reasonable significance level. Although productivity differences between exporters and non-exporters are rather modest in the group of large firms, they favor large exporters with respect to non-exporters, as suggested by test statistics reported in Table 1. P-values based both on the limiting distribution and on the bootstrap approximation lead to the same results.

Two conclusions can be derived from previous test statistics: (1) the productivity distribution of small exporting firms stochastically dominates the productivity distribution of small non-exporting firms; and (2) the productivity distribution of large exporting firms is not above the productivity distribution of large non-exporting firms. To obtain conclusions about productivity differences in the whole population of firms, some additional comparison across size groups is required. In particular, the difference between exporters and non-exporters, $[F_t(.) - G_t(.)]$, can be expressed as a linear combination of productivity differences in the group of small firms $[F_t(.|\tau = 0) - G_t(.|\tau = 0)]$, the group of large firms $[F_t(.|\tau = 1) - G_t(.|\tau = 1)]$, and differences between large non-exporting firms and small non-exporting firms $[G_t(.|\tau = 1) - G_t(.|\tau = 0)]$. A formal test of this latter difference leads to the conclusion that the productivity distribution of large non-exporting firms stochastically dominates the distribution of small non-exporting firms. Furthermore, the parameters weighting the linear combination are positive. Therefore, our results can also be interpreted as evidence supporting the hypothesis that in the whole population of firms, exporters stochastically dominate non-exporters.

4.2. Productivity and transitions between the domestic and the export market

We turn now to the consideration of possible sources for productivity differences between exporting and non-exporting firms. We explore whether or not the higher productivity of exporters reflects selection forces at work, i.e. export markets selecting the most efficient firms. This selection mechanism can work both on the entry side and on the exit side. On the entry side, the implication of selection is that only firms with higher productivity should enter the export market. On the exit side, if selection is at work, low productivity exporters should leave the export market.

To test for selection on the entry side of the export market, we compare two groups of firms: non-exporters and entering exporters. To define both groups we take as a reference the set of non-exporting firms in 1991. Entering exporters are defined as the group of firms entering the export market at some point between 1992 and 1996. The rest of firms defines the group of non-exporters. Switchers are excluded from the comparison. We consider a 5 year entry period that permits us to enlarge the number of observations. The test performed compares the productivity level of both groups of firms in the year 1991, before entry took place for the group of entering exporters.

For the whole population of firms, Fig. 3 reports kernel estimators of the cumulative distribution functions of productivity for non-exporters and entering exporters. Both distributions correspond to the year 1991. The distribution position for entering firms is to the right of the position of non-exporters, indicating that firms that eventually enter the export market were more efficient than non-exporters. To examine this difference more formally, we test to see if the productivity level distribution of entering firms in the export market stochastically dominates the productivity distribution of non-exporters during the period before entry took place. Consequently, we apply the one and two-sided tests to compare

$$F_t(.|\tau = \tau_0) \quad \text{vs.} \quad G_t(.|\tau = \tau_0), \quad t = 1991 \text{ and } \tau_0 = 0{,}1,$$

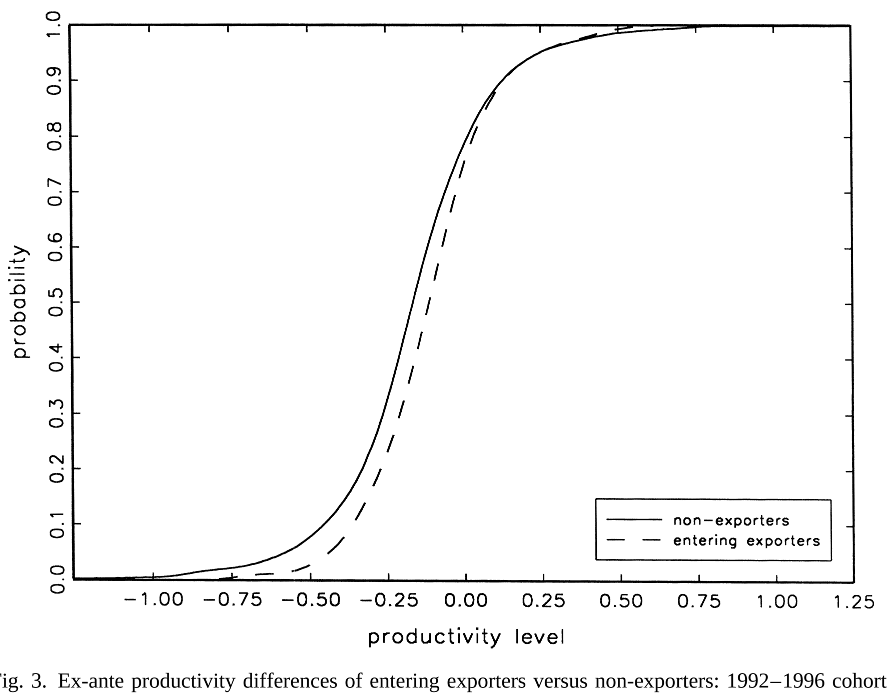

Fig. 3. Ex-ante productivity differences of entering exporters versus non-exporters: 1992–1996 cohort of entering firms (smooth sample distribution function).

Table 2
Ex-ante productivity level differences between entering-exporters and non-exporters; hypotheses test statistics

	Number of observations		Equality of distributions		Differences favorable to entering exporters	
	Entering exporters	Non-exporters	Statistic	*P*-value[a]	Statistic	*P*-value[a]
Small entering exporters vs. Small non-exporters	111	587	1.269	0.080 (0.065)	0.132	0.966 (0.959)
Large entering exporters vs. Large non-exporters	31	47	0.816	0.519 (0.421)	0.543	0.555 (0.480)

[a] *P*-values are based on the limiting distribution. *P*-values based on the bootstrap approximation (10 000 replications) are included in parentheses.

where F denotes the productivity level distribution of firms entering the export market and G the distribution of non-exporters.

Table 2 reports test statistics on the comparison of both productivity distributions. First, in the group of small firms we are able to reject the null hypothesis of equality of distributions at the 0.10 significance level in the year before entry. The null hypothesis that the difference favors to small entering exporters cannot be rejected at any reasonable significance level. Second, for the group of large firms we are not able to reject the equality of productivity distributions between entering exporters and non-exporters at standard significance levels. As in the case of exporting and non-exporting firms, it can be proved that both results, together with the fact that large entering exporters dominate to small entering exporters, support the hypothesis of stochastic dominance of entering exporters versus to non-exporters for the whole population of large and small firms.

Now we test for selection on the exit side. Fig. 4 reports estimators of the cumulative distribution functions of productivity for the 1995–96 cohort of exiting exporters and continuing exporters. The position of both distributions indicates that exiting exporters have lower productivity than exporters that remain in the market. To test for selection on the exit side of the export market, we compare the ex-ante productivity distribution of exiting exporters and exporters that remain active. Since only small exiting firms are observed, we restrict the comparison to small firms. For the cohort $t/t+1$, F denotes the productivity distribution in period t of firms exiting the export market in period $t+1$ and G the productivity distribution in period t of continuing exporters, i.e. firms exporting at t and $t+1$. In period t, we test to determine whether or not the ex-ante productivity distribution of continuing exporters stochastically dominates the productivity

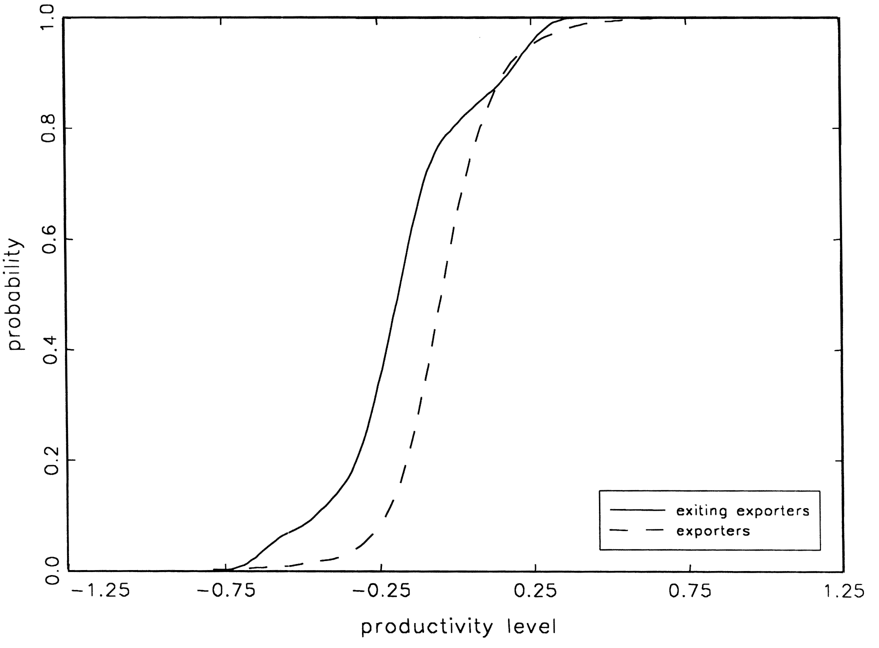

Fig. 4. Ex-ante productivity differences of exiting exporters versus continuing exporters: 1995–96 cohort of exiting firms (smooth sample distribution function).

distribution of exiting exporters. Therefore, the one and two-sided tests are applied to compare

$$F_t(.|\tau = \tau_0) \quad \text{vs.} \quad G_t(.|\tau = \tau_0), \quad t = 1991, \ldots, 1995 \text{ and } \tau_0 = 0,1,$$

Table 3 presents test statistics of productivity differences between both distributions. For the 1995–96 cohort we are able to reject the null hypothesis of equality of both distributions at the 0.01 level. The null hypothesis that the sign of the differential is as expected cannot be rejected at any reasonable significance level. Similar conclusions are obtained for the 1992–1993 and 1994–95 cohorts of exiting and continuing exporters. For the cohorts of exiting exporters in years 1992 and 1994, we are not able to reject the hypothesis of equality of their ex-ante productivity distribution with respect to continuing exporters.

4.3. Export markets and productivity growth

A different perspective has been put forward to explain the positive relationship between exports and productivity. This view implies that entry in the export market provides the firm benefits that result in higher productivity. Consequently,

Table 3
Ex-ante productivity level differences between exiting exporters and continuing exporters; hypotheses test statistics

Year	Small exiting exporters vs. small continuing exporters					
	Number of observations		Equality of distributions		Differences favorable to continuing exporters	
	Exiting exporters	Continuing exporters	Statistic	*P*-value[a]	Statistic	*P*-value[a]
1991–1992	19	329	0.917	0.369 (0.309)	0.917	0.187 (0.157)
1992–1993	21	345	1.490	0.024 (0.017)	0.000	1.000 (1.000)
1993–1994	10	386	0.532	0.940 (0.890)	0.404	0.721 (0.662)
1994–1995	12	417	1.177	0.125 (0.094)	0.000	1.000 (1.000)
1995–1996	14	434	1.765	0.004 (0.002)	0.229	0.900 (0.862)

[a] *P*-values are based on the limiting distribution. *P*-values based on the bootstrap approximation (10 000 replications) are included in parentheses.

the productivity gap between firms that enter and those that do not enter the export market should increase after entry. This behavior may be associated to learning (for example, the knowledge that exporters acquire in international markets), although the exact channels that generate differences in productivity growth are difficult to establish.

To test this view we examine whether or not productivity growth for firms in contact with the export market is greater than productivity growth for non-exporters. Again, let F denote the distribution that corresponds to exporting firms during the period 1991–96 and G the distribution of firms that never exported during the same period of time. We compare the distributions of productivity growth between both groups of firms during the period 1991–1996,

$$F_t(.|\tau = \tau_0) \quad \text{vs.} \quad G_t(.|\tau = \tau_0), \quad t = 1996 \text{ and } \tau_0 = 0,1,$$

where firm-level productivity growth between years $t-k$ and t is given by $\ln \lambda_{ft} - \ln \lambda_{ft-k}$.

Table 4 reports test statistics that indicate that we cannot reject the equality of both productivity growth distributions for the groups of small and large firms. The sign of the differential favors to exporters only in the group of small firms. Overall, we cannot reject the equality of both distributions at the standard significance level, and therefore the evidence in favor of learning is not conclusive.

The structure of the data set permits us to design alternative ways of testing the learning-by-exporting hypothesis. In particular, for firms accumulating experience

Table 4
Productivity growth differences between exporters and non-exporters: all firms; hypotheses test statistics

	Number of observations		Equality of distributions		Differences favorable to entering exporters	
	Exporters	Non-exporters	Statistic	*P*-value[a]	Statistic	*P*-value[a]
Small exporters vs. Small non-exporters	491	341	0.997	0.274 (0.250)	0.097	0.981 (0.970)
Large exporters vs. Large non-exporters	437	16	0.925	0.359 (0.302)	0.925	0.181 (0.155)

[a] *P*-values are based on the limiting distribution. *P*-values based on the bootstrap approximation (10 000 replications) are included in parentheses.

in the export market, if learning occurs, we will observe a divergence in productivity levels between entering exporters and non-exporting firms. Similarly, yet in the opposite direction, we will also observe a convergence between the productivity levels of entering exporters and exporting firms. The hypothesis of divergence between the productivity level distributions of new exporters and non-exporting firms can be examined by testing for stochastic dominance of the productivity growth distribution of entering exporters with respect to non-exporters. Similar comparisons can be made to examine convergence between entering exporters and continuing exporters.

To test for divergence between new exporters and non-exporters, we examine whether or not productivity growth for firms entering the export market is greater than productivity growth for non-exporters. Let F_t denote the productivity growth distribution that corresponds to the cohort of firms entering the export market in year t, and G_t the distribution of non-exporters. Two cohorts of firms are considered: that of entering exporters in the year 1991 and that of entering exporters in 1992. For both groups of firms and for non-exporters, productivity growth refers to periods 1991–1996 and 1992–1996, respectively. Therefore, we compare

$$F_t(.|\tau = \tau_0) \quad \text{vs.} \quad G_t(.|\tau = \tau_0), \quad t = 1991, 1992 \text{ and } \tau_0 = 0,1.$$

In the upper panel of Table 5 we report test statistics corresponding to the comparison of the productivity growth of entering exporters and non-exporters. For both small and large firms, results indicate that we cannot reject the equality of both distributions, and therefore there is no evidence of divergence between the two groups of firms.

In the lower panel of Table 5 a similar comparison is performed for entering

Table 5

(a) Productivity growth* differences between entering-exporters and non-exporters

Cohort	Small entering exporters vs. small non-exporters						Large entering-exporters vs. large non-exporters					
	Number of observations		Equality of distributions		Differences favorable to entering-exporters		Number of observations		Equality of distributions		Differences favorable to exporters	
	Entering exporters	Non-exporters	Statistic	*P*-value[a]	Statistic	*P*-value[a]	Entering exporters	Non-exporters	Statistic	*P*-value[a]	Statistic	*P*-value[a]
1991	15	330	0.953	0.324	0.149	0.956	11	27	0.537	0.936	0.424	0.698
				(0.260)		(0.927)				(0.826)		(0.619)
1992	12	374	0.767	0.598	0.767	0.308	9	22	0.600	0.864	0.600	0.487
				(0.521)		(0.274)				(0.682)		(0.349)

(b) Productivity growth* differences between entering-exporters and continuing-exporters

Cohort	Small entering exporters vs. small continuing-exporters						Large entering-exporters vs. large continuing-exporters					
	Number of observations		Equality of distributions		Differences favorable to entering-exporters		Number of observations		Equality of distributions		Differences favorable to exporters	
	Entering exporters	Continuing exporters	Statistic	*P*-value[a]	Statistic	*P*-value[a]	Entering exporters	Continuing exporters	Statistic	*P*-value[a]	Statistic	*P*-value[a]
1991	15	203	0.862	0.448	0.228	0.901	11	409	0.636	0.814	0.636	0.446
				(0.375)		(0.845)				(0.727)		(0.376)
1992	12	223	0.985	0.287	0.985	0.144	9	379	1.038	0.232	1.038	0.116
				(0.221)		(0.108)				(0.200)		(0.103)

* Productivity growth corresponds to period 1991–96 for the cohort of 1991 and to period 1992–1996 for the cohort of 1992.

[a] *P*-values are based on the limiting distribution. *P*-values based on the bootstrap approximation (10 000 replications) are presented in parenthesis.

exporters with respect to continuing exporters. The cohorts of entering firms in the export market in 1991 and 1992 are now compared with the group of exporters. We are not able to reject the null hypothesis of equality of both distributions and as a result the evidence in favor of learning is not conclusive in this case either.

A possible explanation for not rejecting the equality of previous distributions may be that we are comparing heterogeneous firms with regard to their learning processes. In order to control this heterogeneity we repeat the testing procedure, restricting the sample to firms which are 5 or less years old at the beginning of the period 1991–1996. By doing this we are assuming that learning effects are more intensive for this group of firms. In fact, we are comparing productivity growth for two groups of firms: young entering exporters and young entering domestic firms with no contact with the export market. The age constraint we impose when defining both groups implies that we restrict our attention to the evolution of productivity in two rather homogeneous groups of firms from the point of view of their age and market life cycle. We compare the distributions of productivity growth during the period 1991–96. We only observe young non-exporters in the group of small firms, and therefore the comparison between the distribution of non-exporters and the distribution of either small and large exporters, are sufficient conditions to test for stochastic dominance in the whole population of firms. Then, we compare

$$F_t(.|\tau = \tau_0) \quad \text{vs.} \quad G_t(.|\tau = \tau_0), \quad t = 1996 \text{ and } \tau_0 = 0,1.$$

Table 6 reports the results on test statistics corresponding to both groups of firms. Now, we are able to reject the null hypothesis of equality of both distributions at the 0.05 significance level. Furthermore, we cannot reject the

Table 6
Productivity growth differences between young entering exporters and young entering domestic firms: age ≤5 years old; hypotheses test statistics

	Number of observations		Equality of distributions		Differences favorable to entering exporters	
	Exporters	Non-exporters	Statistic	*P*-value	Statistic	*P*-value
Small exporters vs. Small non-exporters	69	71	1.317	0.062 (0.045)	0.348	0.785 (0.717)
Large exporters vs. Small non-exporters	37	71	1.496	0.023 (0.017)	0.006	1.000 (0.986)

P-values are based on the limiting distribution. *P*-values based on the bootstrap approximation (10 000 approximations) are included in parentheses.

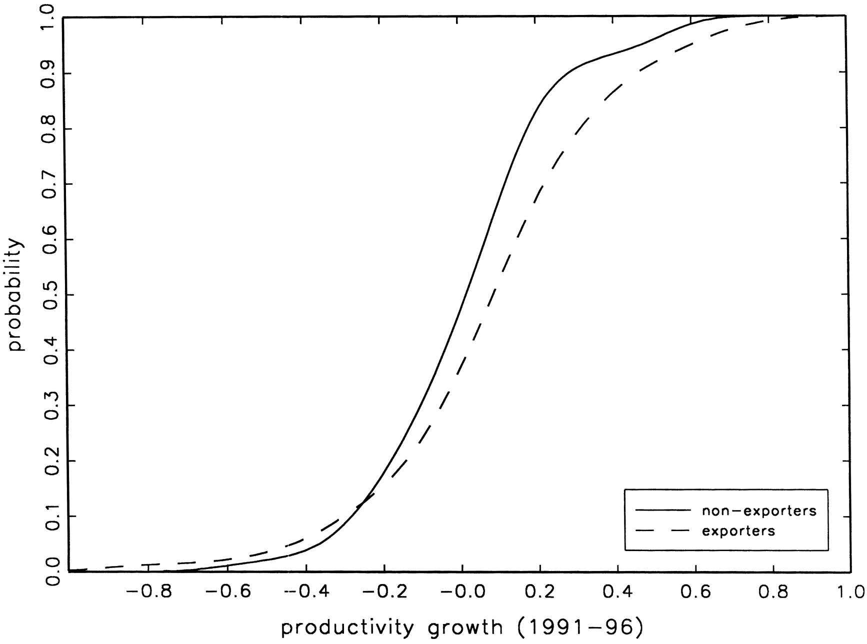

Fig. 5. Productivity growth differences of young entering exporters versus young entering domestic firms: age ≤5 years old (smooth sample distribution function).

null-hypothesis that productivity growth is greater for young entering exporters (either small or large) with respect to young non-exporters. Fig. 5 reports the cumulative distribution estimates for productivity growth of exporters and non-exporters; in both cases firms are 5 or less years old at the beginning of the period. The position of the distribution of exporters is to the right of that of non-exporters, except for the lower tail of the distribution.

5. Conclusions

This paper has examined total factor productivity differences between exporting and non-exporting firms. These differences are examined using a sample of Spanish manufacturing firms over the period 1991–1996 drawn from the ESEE. The paper also examines two complementary explanations for the greater productivity of exporting firms: (1) the market selection hypothesis, and (2) the learning hypothesis. Our empirical strategy is to compare productivity distributions of groups of firms with different transition patterns between the export and the domestic market. To organize the analysis we rely on models of firm and industry dynamics. Our results can be summarized as follows:

First, our data suggests clearly higher levels of productivity for exporting firms versus non-exporters.

Productivity differences observed in the data are consistent with the argument of self-selection of more efficient firms into the export market. First, on the entry side of the market we find evidence in favor of selection. Firms that eventually enter the export market had higher productivity than non-exporters in the period prior to their entry. Second, on the exit side of the export market we also find evidence which favors to selection. The ex-ante productivity distribution of continuing exporters stochastically dominates the productivity distribution of exiting exporters.

Finally, although the evidence we present in favor of self-selection is compelling, our results are less conclusive with respect to the learning-by-exporting hypothesis. During the period, productivity growth is similar for exporters and non-exporters and therefore evidence in favor of the learning hypothesis is not conclusive for the whole sample of firms. The comparison of entering exporters with respect to either continuing exporters or non-exporters generates similar results. We do not find significant differences between the productivity growth distribution of entering exporters and the distribution of continuing exporters, in the period after entry, and similarly for entering exporters versus non-exporters. The fact that we are not able to reject the null hypothesis of equality between these productivity growth distributions indicates that the evidence in favor of learning is not conclusive in both cases either. However, by restricting the sample of firms to the group of younger ones, for which learning effects are stronger, we find some evidence in support of this hypothesis. Post-entry productivity growth is greater for young exporters than for young domestic firms which are not active exporters. For these groups of young firms we find that initial differences in the productivity level increase after entry.

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Appendix A

The multilateral total factor productivity index for each firm is computed using a

Spanish manufacturing firms' data set drawn from the Encuesta sobre Estrategias Empresariales (ESEE). The variables needed for the index are defined as follows:

Output: measured by annual gross production of goods and services expressed in real terms using individual price indexes for each firm drawn from the ESEE.

Labor input: measured by the number of effective yearly hours of work, which is equal to normal yearly hours plus overtime yearly hours minus non-working yearly hours.

Materials: measured by the cost of intermediate inputs; which includes raw material purchases, energy and fuel costs and other services paid for by the firm. This concept is expressed in real terms using individual price indexes of intermediate inputs for each firm drawn from the ESEE.

Capital stock: is calculated following the perpetual inventory formula:

$$k_t^* = I_t + k_{t-1}^*(1 - d_t)\frac{P_t}{P_{t-1}}$$

where I_t represents investment in equipment, d_t stands for depreciation rates and P_t corresponds to price indexes for equipment published by the Instituto Nacional de Estadística.

Input cost shares: For each input, the cost share is the fraction of the cost of the input on total input costs, where the total cost is the sum of the cost of labor, the cost of intermediate inputs and the cost of capital. The cost of labor is measured by the sum of wages, social security contributions, and other labor costs paid for by the firm. The cost of capital is calculated with an estimation of the user cost of capital, which is measured by the cost of long-term external debt of the firm plus depreciation rates (d_t) minus the variation of the price index for capital goods.

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