DISCUSSION PAPER SERIES

No. 6411

INNOVATION AND THE EXPORT-PRODUCTIVITY LINK

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INDUSTRIAL ORGANIZATION and INTERNATIONAL TRADE

Centre for Economic Policy Research

www.cepr.org

Available online at: www.cepr.org/pubs/dps/DP6411.asp

ISSN 0265-8003

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Discussion Paper No. 6411
August 2007

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CEPR Discussion Paper No. 6411

August 2007

ABSTRACT

Innovation and the Export-productivity Link*

We explore the relationship between innovation activity, productivity, and exports using a panel of Spanish manufacturing firms for 1990-1998. Our results - based on non-parametric tests - suggest that firm innovation status is important in explaining the positive export-productivity association documented in prior research. For the sample of small innovating firms, we find no significant differences in productivity levels between exporters and non-exporters. Especially product innovation seems to explain the positive association between exports and productivity for this group of firms. For small non-innovating firms with low and medium productivity levels exporting firms continue to exhibit higher productivity than non-exporting firms.

JEL Classification: D21, O31 and O32
Keywords: exports, innovation, process innovation, product innovation and productivity

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* We are grateful for the comments received from José Manuel Campa and seminar participants at the Jornadas de Economia Industrial in Barcelona and the EARIE conference in Amsterdam. We acknowledge financial support from the Anselmo Rubiralta Center for Globalization and Strategy and the Public-Privat Sector (SP-SP) Research Center at IESE Business School, the Steunpunt O&O at the Catholic University of Leuven, and the Spanish Ministry of Education and Science and Technology for the project nº SEJ2006-11833/ECON.

Submitted 24 July 2007

1. Introduction

The dynamic process of firm formation, growth, prospering, or failure generates a great amount of heterogeneity in firm performance, not only across industries, but more interestingly, also within industries (Bartelsman and Doms, 2000).

Most of the theoretical models on industry dynamics assume that firms are born with an inherent ability, their productivity. Efficient firms survive and grow in the market, while inefficient firms, with productivity below a certain threshold, decline and fail (Jovanovic 1982; Hopenhayn 1992). These models, however, assume that the productivity distribution across firms is exogenous to firms, thus relating firm survival to luck-of-draw. Firms with low productivity exit, while "lucky" firms with high productivity survive and continue growing. Little room is left for firm decisions, except for the decision on exiting, which is endogenized. The model of Pakes and Ericson (1995) improves on these models by introducing investment decisions that can potentially enhance survival chances. But endogenizing such decisions severely complicates solving these theoretical models.

While theoretically such heterogeneity and dynamics is difficult to handle, empirically it provides a wealth of interesting observations. Nevertheless, we know very little about the connection between individual firm decisions and their dynamic consequences. One of the basic empirical facts related to productivity is a strong positive association between productivity and exporting activity at the firm level. Most of the studies explain this pattern by self-selection of more efficient firms into the export market (Clerides, Lach et al. 1998; Bernard and Jensen 1999; Delgado, Fariñas et al. 2002; Fafchamps, El Hamine et al. 2007), confirming the sunk cost hypothesis that only those firms who are efficient enough to bear entry costs and intense competition of the export market will start exporting. This suggests that a closer examination of prior firm decisions might be needed to understand this important selection.

In this paper, we take a first step towards explaining the observed productivity – export link. We argue that a potential underlying mechanism for the selection of more productive firms into exporting is related to the firm's innovation decisions. Successful innovation enhances the firm's productivity, leading to the selection of the more productive firm into the export markets. Yet, anything affecting a firm's productivity could drive the firm into exports. The recent productivity literature, however, has found evidence that suggests that firm specific demand variations, rather than technical efficiency, are the dominant factor in determining firm survival and positively influence measured productivity (Foster et al. 2006). This suggests that product innovation related to positive demand shocks rather than innovation in process related to production efficiency could be responsible for the increase in measured productivity and, consequently, entry into exporting. Consistent with this argument, product innovation has been found to play an important role in explaining the export decision of the firm (Cassiman and Martinez-Ros 2007) showing that innovation active firms are significantly more likely to become exporters than non-innovators. Then, accounting for innovation may be critical in explaining the strong positive correlation between exporting and productivity in the existing research findings. We thus argue that the observed productivity-export link may be partly explained by the firm's innovation status.

We examine the relationship between productivity and exports using a panel of Spanish manufacturing firms. We investigate the export-productivity link of the firms that engage in innovation activities and compare the results to those obtained for the non-innovating firms using non-parametric tests. As our findings indicate, innovating firms show no significant difference in productivity levels for exporting and non-exporting groups, suggesting that firm innovation strategy is an important factor in explaining the export-productivity association. Our findings could have important policy implications. If innovation activity is a source of productivity growth, then policies aimed at promoting innovation, and product innovation in particular, might be more effective than direct export promotions, at least for firms “at risk” for innovating.

The paper proceeds as follows. In Section 2 we discuss the related literature. Sections 3 and 4 describe the data and methodology used in this study. Section 5 presents the results of the empirical analysis. A discussion section concludes.

2. The export-productivity link and innovation

In the empirical international trade literature, the positive association between exports and firm productivity has been well-documented. At least two explanations for the observed export-productivity link have been suggested. On the one hand, the positive association between exporting and productivity is explained through a selection mechanism. Sunk start-up costs associated with becoming an exporter lead to the self-selection of more productive firms into exporting (Roberts and Tybout 1997; Bernard and Jensen 1999, 2004; Clerides, Lach and Tybout 1998; Greenaway and Kneller 2000; Aw, Chen and Roberts 2001; Delgado, Farinas et al. 2002; Fafchamps, El Hamine et al. 2007). The hysteresis in exporting serves as evidence for the sunk entry costs in the export market. On the other hand, there is the possibility of learning-by-exporting – exporters may learn from their foreign contacts, adopting new production technologies and increasing productivity (Aw, Chung and Roberts 2000; Delgado, Farinas et al. 2002).

With both mechanisms being plausible, empirical evidence is rather unanimous in supporting the selection hypothesis behind the export-productivity link (Roberts and Tybout 1997; Clerides, Lach and Tybout 1998; Bernard and Jensen 1999; Delgado, Farinas et al. 2002; Fafchamps, El Hamine et al. 2007). The general finding is that exporting firms have higher productivity than non-exporters before taking up exports and no significant productivity advantages are observed among continuous exporters or non-exporting firms respectively over time.

Such heterogeneity in productivity raises an important question about the sources of high productivity of these exporting firms. How do firms obtain higher productivity levels that allow them to enter the export market? International trade literature, following the work on industry dynamics (Jovanovic 1982; Hopenhayn 1992), has attempted to incorporate firm heterogeneity in the international trade modeling. Recent theoretical work by Melitz (2003) and Bernard et al. (2003) formulates the theories that reflect the empirical regularities observed in the exporting behavior and productivity. In these theories, the initial productivity level of a firm is determined by a random draw from a known distribution function. The model by Melitz (2003) assumes sunk entry costs in the export market, while Bernard et al. (2003) assume Bertrand competition among producers, which only allows the most productive firms to incur trading costs associated with exports. Thus, these theories demonstrate the selection mechanism of more productive firms into the export market. The models, however, do not explain why these firms are more productive and self-select into exporting, that is, the theories are not causal theories between firm decisions and their decision to export.

One important source of productivity differences seems to be related to R&D and innovation activities (See Griliches, 1998). 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. (2004) for Chinese firms show that new product sales are positively associated with productivity. Huergo and Jaumandreu (2004) using the panel of Spanish firms find that process innovation is an important determinant of productivity growth at the firm level. Investigating the relationship between innovation and productivity in four European countries, Griffith et al. (2006) 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 of the four countries. Finally, Doraszelski and Jaumandreu (2007) revisit the knowledge capital framework within an extension of Erickson and Pakes (1995) and find important effects of R&D investments on productivity.

At the same time, R&D and innovation activities seem to play a very important role in explaining a firm's decision to export and export volumes. In particular, recent studies find that innovation is a very important driver of the export decision. Basile (2000) for a sample of Italian manufacturing firms shows that firms introducing product and/or process innovations either through R&D or through investments in new capital are more likely to export. Bernard and Jensen (2004) find that firms switching primary SIC code – which could indicate new product introductions – significantly increase the probability of entering the export markets. In a related paper, Cassiman and Martinez-Ros (2007) find a strong positive effect of product innovation on the decision of a firm to export.

Taken together, prior empirical findings suggest that innovation activity may be responsible for both the productivity enhancement and export orientation of a firm and explain the correlation between exports and productivity. A number of studies provide empirical results going in the direction of our argument. Aw and Batra (1998), on a sample of Taiwanese firms, find that for the group of large, high-technology firms, exporters do not differ from non-exporters in their efficiency levels. However, in the group of small firms with no formal investments in technology, exporters are significantly closer to the production frontier than non-exporting firms. Delgado et al. (2002) using the sample of Spanish firms, show that the export-productivity link varies depending on firm size. They observe no significant difference in productivity levels between exporters and non-exporters for large firms. But for small firms, exporters show significantly higher productivity levels than non-exporters. In a recent paper, Aw et al. (2007) find that for firms that do not invest in R&D, productivity of exporters is significantly higher than that of non-exporting firms. Moreover, firms that export and invest in R&D are found to have higher productivity than those that only export. This evidence is used to argue that not only do more efficient firms select into the export market, but exports and R&D are important and complementary sources of productivity growth, with R&D activities facilitating the assimilations of the benefits from export markets. These findings coupled with the well-documented positive link between innovation and firm size (although possibly at a decreasing rate) point to the importance of innovation as an explanatory variable driving the export – productivity link.

Therefore, connecting innovation, productivity and exports, we argue that accounting for innovation might take us some way in explaining the positive association between exports and productivity. Furthermore, in a recent paper Foster et al. (2006) find that firm specific demand shocks rather than production efficiency shocks explain differences in measured productivity, suggesting that product innovation rather than process innovation might improve measured productivity more, and, consequently, drives the decision to export.

3. Data

The data that are used in this study come from a survey (ESEE) of Spanish manufacturing firms started in 1990 with data collected annually up to 1998. The project was conducted by the Fundación Empresa Pública with financial support of the Spanish Ministry of Science and Technology. The information collected each year is consistent with the information in the previous years. The sample includes the population of Spanish manufacturing firms with 200 or more employees. It also contains a stratified sample of small firms comprising 4% of the population of small firms with more than 10 and less than 200 employees. Small firms that exited the original sample during the sampling period were replaced by firms with similar characteristics drawn from the population.[1] Previous research has used the same data set as it is representative for the Spanish manufacturing industry over this period (Delgado et al (2002); Campa (2004); Huergo and Jaumandreu (2004); Cassiman and Martines-Ros (2007); Doraszelski and Jaumandreu (2007) among others). The original sample includes 2188 firms in 1990 and 3195 firms in 1998 from 20 distinctive industries. Due to entry, exit, and missing values, the resulting sample is an unbalanced panel with 11855 firm-year observations.

The ESEE dataset provides an appropriate setting to investigate the relationship between innovation, exports and productivity. First, it is longitudinal data, thus we are able to trace the firms and their export and innovation behavior over time. Second, exporting firms constitute a large proportion in the sample and very few firms (less than 0,3% of the sample), especially among small and medium firms, engage in foreign direct investment. In this way we are able to focus particularly on exporters. Finally, during 1990-1999 Spain has gone through an entire business cycle. In 1990 the economy was still growing, a slow down and a sharp recession in 1993 followed, turning into a recovery during the last years of the sample period (Campa 2004). Such variation can be usefully exploited to examine the productivity dynamics during 1990-1999.

Table 1 presents information on the distribution of exporting and innovating firms by year and size.[2]

Insert Table 1 about here

The proportion of exporting firms has increased significantly from 33% in 1991 to 52% in 1998 for small and medium firms, and from 84% to 95% for large firms. The percentage of firms with product and process innovations also shows an increase during the sample period in both size groups. The proportion of small firms with product innovation has grown from 14% in 1991 to almost 16% in 1998, averaging at 15% during 1991-1998. The average percentage of small firms with process innovation is 21% during the sample period, increasing from 20% in 1991 to 26% in 1998. For large firms, the average proportion of firms with product (process) innovation is 22% (40%), growing from 19 % (40%) in 1991 to 25% (41.4%) in 1998 respectively. Thus, the sample exhibits significant variation in the export and innovation behavior across firms as well as over time.

4. Empirical methodology

Our empirical strategy is as follows. We start by reproducing the positive association between productivity and export status for our sample. Next, we compare the productivity levels of innovating versus non-innovating firms in order to show that innovation activity correlates with firm productivity. Finally, we check whether the differences in productivity of exporters and non-exporters persist when firm innovation status in previous periods is taken into account.

Productivity measure

To measure productivity we construct an index of total factor productivity (TFP) for each firm, using a multilateral index developed by Caves et al. (1982) and extended by Good et al. (1997). Our method of computing the TFP index is similar to the methodology used in Aw et al. (2000; 2007) and Delgado et al. (2002). The productivity index is calculated as the logarithm of the firm's output less a cost-share weighted sum of the logarithms of the firm inputs. To make a comparison between any two firm-year observations possible, each firm's outputs and inputs are calculated as deviations from a reference firm. The reference firm is a hypothetical firm that varies across industries with input cost-based shares computed as an arithmetic mean of cost shares over all observations, and outputs and inputs computed as the geometric mean of outputs and inputs over all observations. Moreover, since the sampling proportions in our data are different for small and medium (≤ 200 employees) and large firms (> 200 employees), the reference firm also varies across size groups. Thus, each firm's output, inputs and productivity for each year are measured relative to this hypothetical firm in the same size group (small or large) and industry. For more detail on the computation of the TFP index see Appendix.

Methods

We start with the graphical description of the TFP distributions of exporting versus non-exporting, and innovating versus non-innovating firms across 1991-1998. In our analysis, we focus only on the small firms (≤ 200 employees), since the number of large firms in our sample is not sufficient for the test to be statistically conclusive.[3]

Next, we conduct a number of tests to document the expected effects formally. We begin by comparing means and variances of the TFP level distributions of exporters and non-exporters. We then compare the productivity distributions themselves across these two subsamples of firms. To test the differences in the TFP level distributions of exporters versus non-exporters, we employ a Kolmogorov-Smirnov equality-of-distributions test, used recently in Delgado et al. (2002). This non-parametric test rejects the null hypothesis of samples coming from the same populations if there is a point for which the cumulative empirical distributions of two independent samples are significantly different. The testing procedure is based on the concept of first order stochastic dominance. Let F and G be cumulative distribution functions of TFP for two subsamples to be compared (in our case, e.g. exporters versus non-exporters). First order stochastic dominance of F relative to G is defined as: $F(z)-G(z)\leq 0$ uniformly for $\forall\ z \in \Re$ with strict inequality for at least one z. In order to show that F stochastically dominates G we need to conduct the following tests:

-two-sided test : Ho: $F(z)-G(z)=0$ for all $z \in \Re$ versus Ha: $F(z)-G(z)\neq 0$ for some z;

-one-sided test: Ho: $F(z)-G(z) \leq 0$ for all $z \in \Re$ versus Ha: $F(z)-G(z)>0$ for some z.

The two-sided test checks the hypothesis on the equality of the distributions F and G. The distributions F and G are not significantly different if we cannot reject Ho for the two-sided test. The one-sided test allows determining whether one distribution dominates the other. Not being able to reject Ho for the one-sided test will mean that F is equal or to the right of the distribution G.

Thus, in order to show that F stochastically dominates G we have to demonstrate that null hypothesis Ho for *two-sided test is rejected*, while Ho for *one-sided test cannot be rejected*. This will be consistent with F being to the right of G. In our case, it will imply that the TFP level distribution of exporters stochastically dominates the distribution of TFP for non-exporters. We conduct the Kolmogorov-Smirnov test for the sample pooled over the time period and for each time period t, t=1991, …,1998, separately.

Next, we compare the productivity levels of innovators and non-innovators using the same battery of tests. We repeat the same tests for the exporting and non-exporting groups accounting for the innovation strategy of firms. Finally, we run quantile regressions of productivity levels on the export variable and several controls in order to investigate differences in TFP levels of exporters and non-exporters in more detail.

We define exporters as firms exporting in the current year. Non-exporters are those firms that did not perform exports in the current year. Innovation activity is measured in several ways. We distinguish between innovating in product and in process, using two dummies that indicate whether a firm carried out a product or a process innovation. Next, we employ a dummy variable that indicates whether a firm has performed any innovation activity (either product or process). Finally, we a use the measure for the innovation input - whether a firm invested in R&D. The appendix provides a careful description of each of the variables. We measure our innovation variables with one year lag, since innovation is unlikely to drive the productivity improvements in the same year.[4]

5. Empirical results

5.1 Descriptives

We start with the graphical representation of the cumulative distribution functions of TFP levels for the different groups of firms, looking at the productivity distributions of 1) exporters versus non-exporting firms; 2) innovating versus non-innovating firms; and 3) exporters versus non-exporters for the innovating and non-innovating groups.

Figures 1-5 present the results for these subsamples of firms. The distribution of performers (exporters or innovators) lies to the right of the distribution of non-performers, which suggests first-order stochastic dominance. The exception is the process innovation case, for which TFP level distributions of innovating and non-innovating firms seem to coincide. Figures 6-9 compare the productivity distributions of exporters and non-exporters in the groups of innovators and non-innovators. For the non-innovating firms, the TFP distribution of exporters is clearly to the right of that of non-exporters, which points towards stochastic dominance. In the group of innovating firms the TFP level distributions seem to be closer to each other, especially for the product innovation case. Overall, the visual comparison of the TFP level distributions shows that the productivity distribution of exporters dominates that of non-exporters. For innovating firms, however, the difference is less pronounced for the product innovation case, suggesting the existence of an effect of (product) innovation activity on productivity and export decision. In the following, we perform a formal comparison of TFP level distributions.

5.2. Exporters versus non-exporters

First, we formally document the existence of the positive association between export orientation and firm productivity in line with prior research.

Table 2 lists the results for tests on means and variances and Kolmogorov-Smirnov test for exporters and non-exporters.

Insert Table 2 about here

The forth and fifth columns report the difference in means and the test statistic under the null hypothesis that the mean TFP level of non-exporting firms is equal to the mean TFP level of exporting firms. The comparison of average TFP levels indicates that exporting firms have significantly higher levels of TFP than non-exporters. We observe an average export premium of 5,6%.

The significance of the results, however, varies across years. During 1991-1998 Spain underwent the entire business cycle, with a slowdown in the economy starting in 1991, a sharp recession in 1993 – beginning of 1994, and a recovery in 1995-1998. The unfavorable economic conditions in the beginning of the 90-s might be responsible for the insignificance of test statistics while comparing the TFP distributions of exporters/non-exporters and innovators/non-innovators.[5]

Column six presents the test statistic on the null hypothesis of equal variance of TFP levels for non-exporting and exporting firms. In most cases, we cannot reject the hypothesis that the variance of TFP levels of non-exporting firms is equal to that of exporters.

The next columns report the results for the Kolmogorov-Smirnov test - the statistic for the two-sided test on the equality of distributions and the one-sided test results. We can reject the null hypothesis of equality of distributions for exporters and non-exporters at a 1% significance level. In the one-sided test the null hypothesis states that the TFP distribution of exporters stochastically dominates the TFP distribution of non-exporters. As the results show, the null hypothesis for the one-sided test, i.e. that the TFP level differences are in favor of exporters, cannot be rejected.

Thereby, the results in Table 2 confirm the findings of prior studies for our sample, showing that firm export status is indeed associated with higher productivity levels. Exporting firms not only show higher levels of TFP, but the distributions of TFP for exporters and non-exporters are significantly different, with the exporters' TFP distribution stochastically dominating the non-exporters' TFP distribution.

5.3. Innovators versus non-innovators

We further explore the differences in productivity levels between innovating and non-innovating firms. Table 3A-D lists the results for product and process innovation variables, as well as for innovation and R&D dummies.

Insert Table 3 about here

On average, innovation active firms exhibit significantly higher productivity levels than non-innovating ones. Average TFP is about 4,4% higher for firms with product innovation than for firms with no innovation. Contrary to other findings in the literature, process innovation does not seem to have a similar effect on productivity. The test shows no significant difference in productivity for process innovators. Variability of TFP levels for innovating and non-innovating groups does not reveal any recognizable pattern, especially in case of process innovation. The results for the Kolmogorov-

Smirnov two-sided and one-sided tests show that the null hypothesis of equal distributions can be rejected for product innovators. Moreover, lower productivity levels are observed in the group of non-innovators. Process innovation does not seem to have a differential effect on productivity levels of innovators relative to non-innovators.

We present the results for the innovation and R&D variables in Table 3C-D. . Again, on average, innovating firms show significantly higher TFP levels compared to firms in the non-innovating group. The average premium in TFP is 2,4% for firms with innovation and about 3,4% for firms with R&D activities. Kolmogorov -Smirnov one-sided and two-sided tests show that the null hypothesis of equal distributions can be rejected and lower productivity levels are observed in the group of firms with no innovation and R&D.

5.4. Exporters versus non-exporters conditional on innovation

Finally, we conduct the tests for the sub samples of exporters and non-exporters accounting for firm innovation status. The results of the tests are listed in Table 4A-E.

Insert Table 4 about here

In line with our hypothesis, we find that for product innovation the association between exporting and productivity significantly weakens. Although exporters still exhibit higher TFP levels than non-exporters (average TFP premium for exporters is about 3,9%), two-sided Kolmogorov-Smirnov test statistics are only marginally significant for the pooled case.

For the non-innovating group, the results are drastically different. We observe a significant difference in TFP levels for exporters and non-exporters. The tests indicate that exporting firms outperform non-exporters with respect to TFP showing significantly higher levels of productivity. The average export premium is 5,1% for the pooled case, varying from 0,2% in 1991 to 7,8% in 1997. Moreover, the two-sided Kolmogorov-Smirnov test statistic strictly rejects the hypothesis of equality of distributions.

Further, the presence of process innovation or R&D activities does not seem to explain the export-productivity association. For process innovation, innovation, and R&D activities, we still find significant differences in TFP for exporters and non-exporters. Average TFP levels are about 5% higher for exporters innovating in process than for non-exporters with process innovation, 4% higher for innovators, and 4,2% higher for R&D. The results of Kolmogorov-Smirnov test report the significant differences in the distributions of exporters and non-exporters.

5.5. Quantile regression results

To get a more complete picture of the connection between productivity and exports across the distribution of firm productivity levels we use quantile regressions. More specifically, we regress the TFP variable on the export dummy and control variables that include foreign capital ownership, high-tech sector and year dummies.[6] We also test the association between the TFP level and innovation activity, regressing TFP on innovation variables.

The association between the export/innovation status and productivity may vary at different points of the conditional distribution of productivity levels, and a quantile regression provides the information on this variation. For each quantile we show whether the association between exports/innovation and productivity is positive, negative or insignificant, and how strong it is compared to other quantiles.

Table 5A-C presents the regression estimates of the export/innovation variables for an OLS regression and five different quantiles of the TFP level distribution for 1991-1998. We report the export and innovation coefficients only.

Insert Table 5 about here

We find that the significance and the magnitude of the export coefficient varies considerably as we move from the lower quantile (0.05) to the upper quantile (0.95) of the conditional productivity distribution. The association between productivity and exporting seems to be more pronounced in the lower tail and the upper tail of the distribution, but weakens towards the center of the distribution, suggesting that among the firms with average productivity, exporters and non-exporters tend to vary less in their productivity levels. With respect to the innovation variables, the results support our previous finding that product innovation is associated with the higher productivity, while process innovation comes out insignificant.[7]

Accounting for the firms' innovation status, we find positive and significant association between exports and the productivity level in the group of non-innovators. The positive correlation between the export variable and productivity remains significant for the firms engaged in process innovation. But for the firms performing product innovation the export coefficient is insignificant along the entire productivity distribution, suggesting the importance of the effect of product innovation in explaining the export-productivity association. Our results, therefore, show that it is mainly product innovation that accounts for differences in the productivity levels and consequently leads firms to export.

6. Conclusions

In this paper, we examine the relationship between exports, productivity, and innovation at the firm level. Our findings highlight that the innovation strategy of a firm partially accounts for the positive link between exports and productivity. Once we control for the innovation strategy of a firm, this firm's productivity turns out to dependent less on whether or not a firm participates in the export market. In particular, we observe a weak difference in productivity levels between exporters and non-exporters among firms that carry out product innovation.

Interestingly, the positive link between exports and productivity observed in prior research does continue to exist for non-innovating firms, consistent with the learning-by-exporting effect emphasized by recent studies. The observed superior productivity among exporting firms in the low and middle-productivity range may be related to their ability to get new technological information in the export markets and to the higher competition abroad. For the most productive non-innovating firms, however, positive association between exports and productivity is found to be weaker, suggesting that for these firms the learning-by-exporting effect might not be strong enough to affect their initial productivity levels.

Overall, our results imply that innovation, more specifically innovation in product, allows firms to enter the export market. Successful product innovation enhances the firm's productivity, leading to the selection of the more productive firm into the export markets. This finding appears to be especially relevant from a public policy perspective. If innovation activity is a source of productivity growth, then policies aimed at promoting innovation, and product innovation in particular, might be more effective than direct export promotions, at least for firms "at risk" of innovating.

There remain several issues to address. More specifically, we would like to look at the evolution of the firms over time comparing different groups of firms, such as "always" exporting firms, non-exporting firms, firms entering in and exiting from export markets. In follow-on work we are also focusing on the subsample of non-innovating firms, thus sorting out the effect of innovation, while testing for the selection versus the learning hypothesis in the productivity-export link.

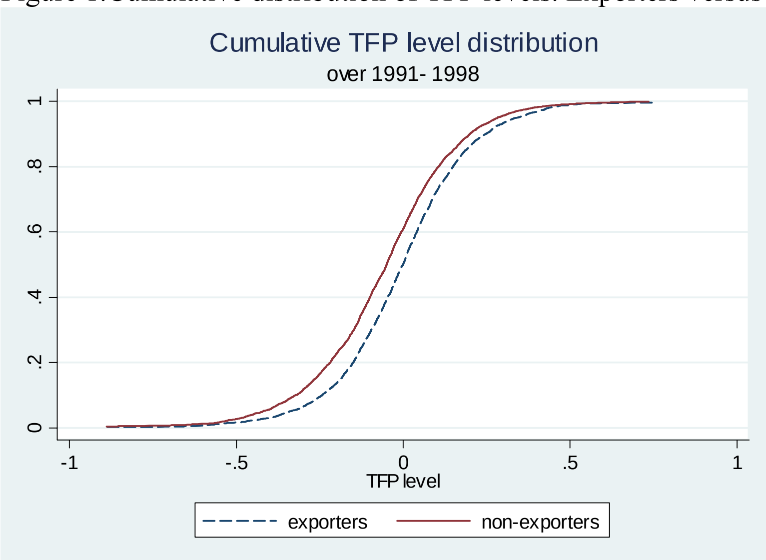
Tables and figures

Table 1. Distribution of firms by size and year, 1991-1998

		1991	1992	1993	1994	1995	1996	1997	1998	Total
Small firms	Number of observations	886	1007	981	1025	953	1015	1201	1101	8169
	% of exporting firms	33.2 (47.1)	37.5 (48.4)	38.4 (48.6)	42.8 (49.5)	47.1 (49.9)	47.5 (49.9)	51.2 (50.0)	52.0 (49.9)	44.1 (49.6)
	% of firms with product innovation	14.1 (34.8)	16.0 (36.7)	14.6 (35.3)	13.6 (34.3)	15.4 (36.1)	14.6 (35.3)	15.0 (35.8)	15.6 (36.3)	14.9 (35.6)
	% of firms with process innovation	19.9 (40.0)	19.4 (39.6)	22.3 (41.7)	20.7 (40.6)	19.8 (39.9)	19.1 (39.3)	23.2 (42.2)	26.4 (44.1)	21.5 (41.1)
	% of firms with no innovation	62.4 (48.4)	61.9 (48.5)	60.7 (48.8)	62.4 (48.4)	62.7 (48.3)	63.9 (48.0)	60.0 (49.0)	58.1 (49.3)	61.4 (48.6)
Large firms	Number of observations	514	521	424	486	451	417	445	429	3687
	% of exporting firms	84.8 (35.9)	87.3 (33.2)	89.3 (30.8)	88.8 (31.4)	89.1 (31.1)	89.9 (30.1)	94.1 (23.4)	95.3 (21.1)	89.6 (30.4)
	% of firms with product innovation	18.8 (39.2)	21.5 (41.2)	18.4 (38.8)	24.1 (42.8)	19.2 (39.5)	24.2 (42.9)	25.2 (43.5)	25.0 (43.4)	22.0 (41.4)
	% of firms with process innovation	39.8 (49.0)	38.8 (48.8)	35.8 (48.0)	37.5 (48.5)	39.7 (49.0)	39.7 (49.0)	38.1 (48.6)	41.4 (49.3)	38.8 (48.7)
	% of firms with no innovation	36.7 (48.2)	38.3 (48.6)	39.6 (48.9)	36.2 (48.1)	39.0 (48.8)	34.5 (47.6)	35.2 (47.8)	33.5 (47.2)	36.7 (48.2)

Exporting versus non-exporting firms

Figure 1.Cumulative distribution of TFP levels. Exporters versus non-exporters, 1991-1998.



Innovating versus non-innovating firms

Figure 2.Cumulative distribution of TFP levels. Firms with product innovation versus firms with no innovation, 1991-1998.

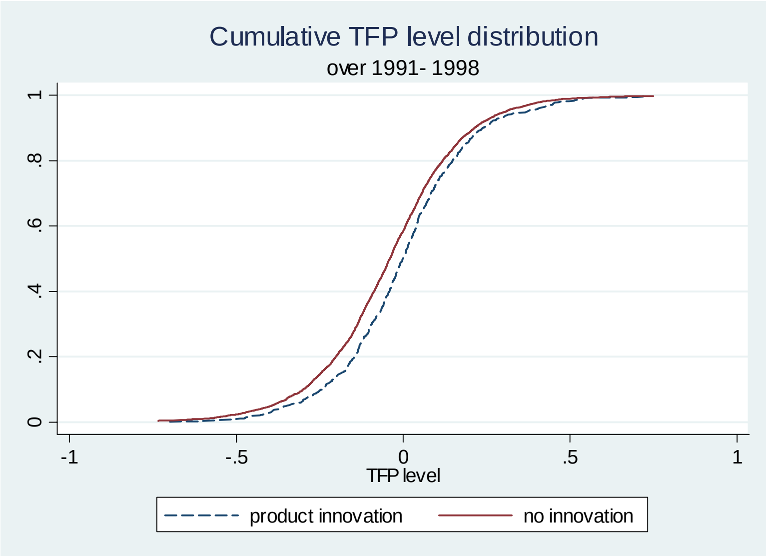


Figure 3.Cumulative distribution of TFP levels. Firms with process innovation versus firms with no innovation, 1991-1998.

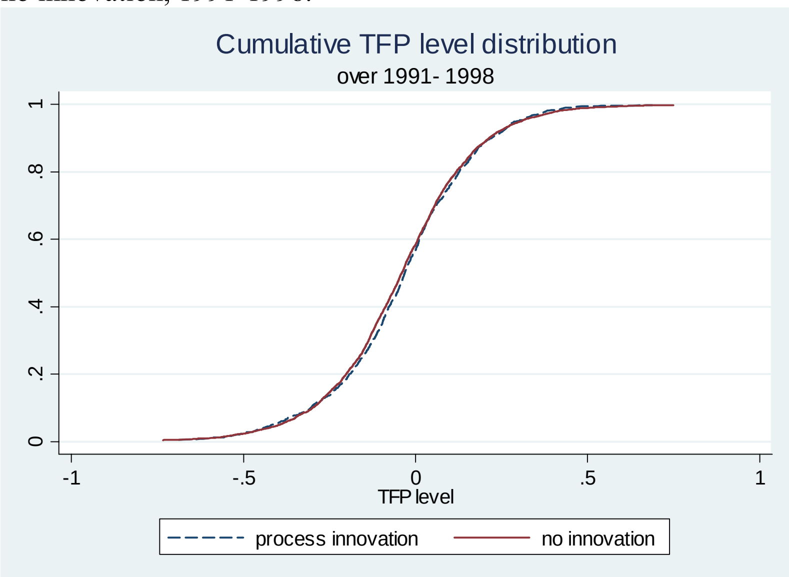


Figure 4. Cumulative distribution of TFP levels. Firms with innovation versus firms with no innovation, 1991-1998.

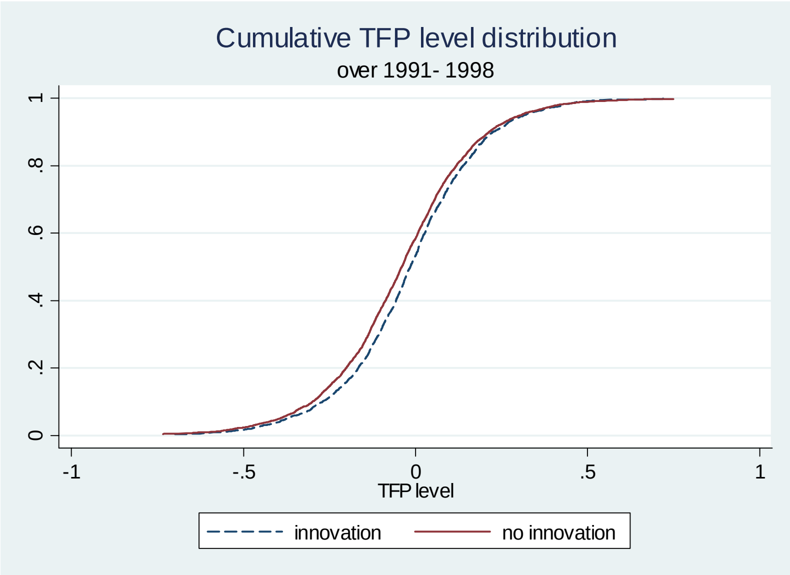
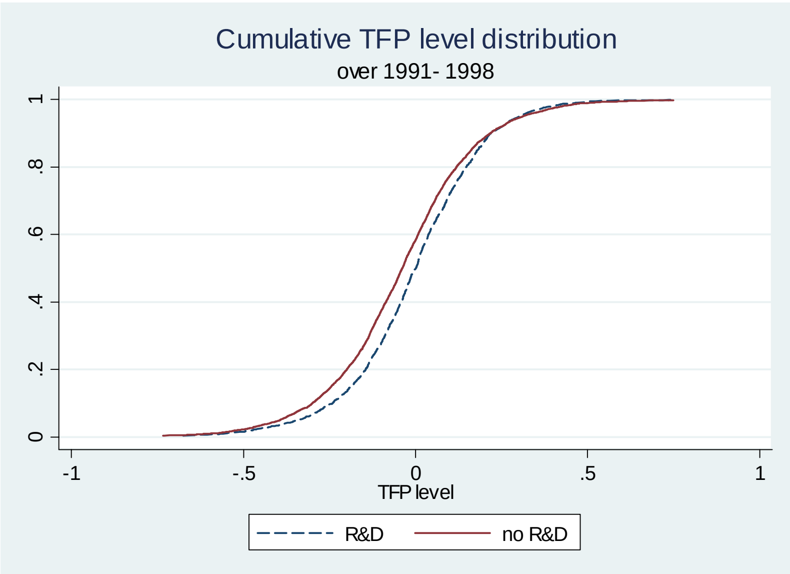


Figure 5. Cumulative distribution of TFP levels. Firms with R&D versus firms without R&D. 1991-1998



Exporting versus non-exporting firms conditional on innovation status

Figure 6.Cumulative distribution of TFP levels. Exporters versus non-exporters, for firms with product innovation and without innovation. 1991-1998

Product innovation=1 No innovation case

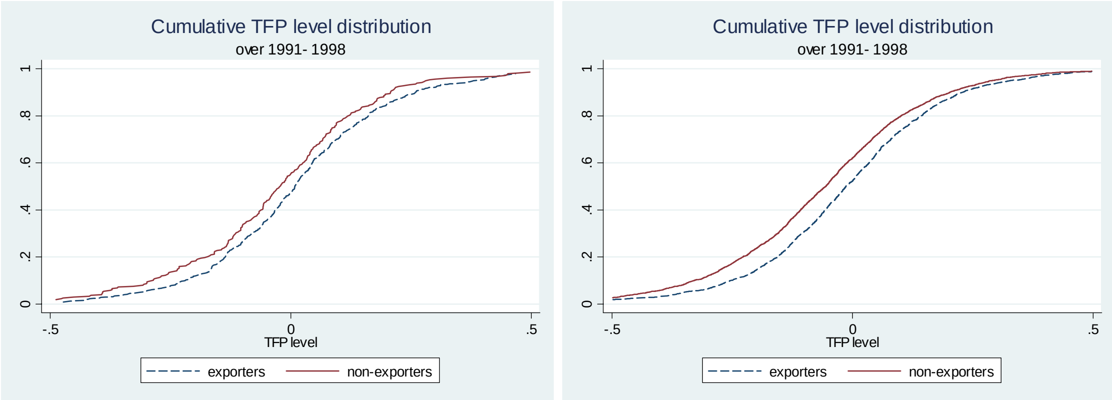


Figure 7.Cumulative distribution of TFP levels. Exporters versus non-exporters, for firms with process innovation and without innovation. 1991-1998

Process innovation =1 No-innovation case

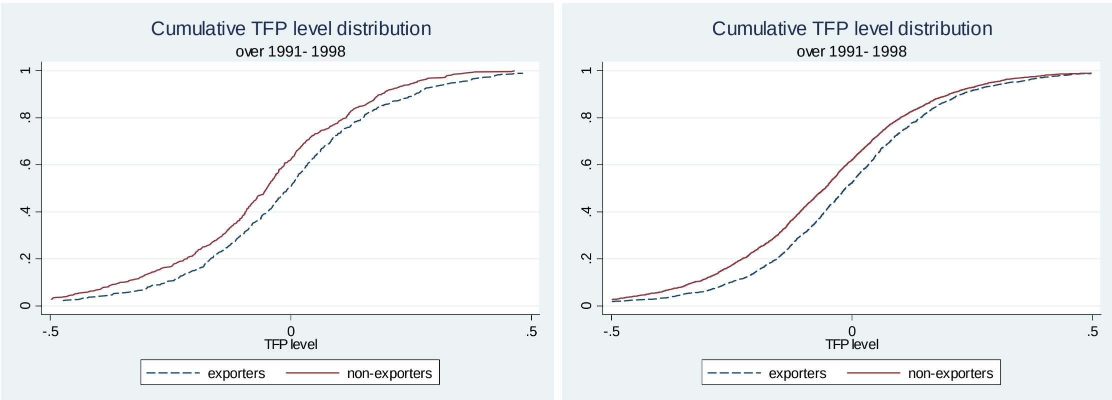


Figure 8. Cumulative distribution of TFP levels. Exporters versus non-exporters, for firms with innovation and without innovation. 1991-1998

Innovation =1 No-innovation case

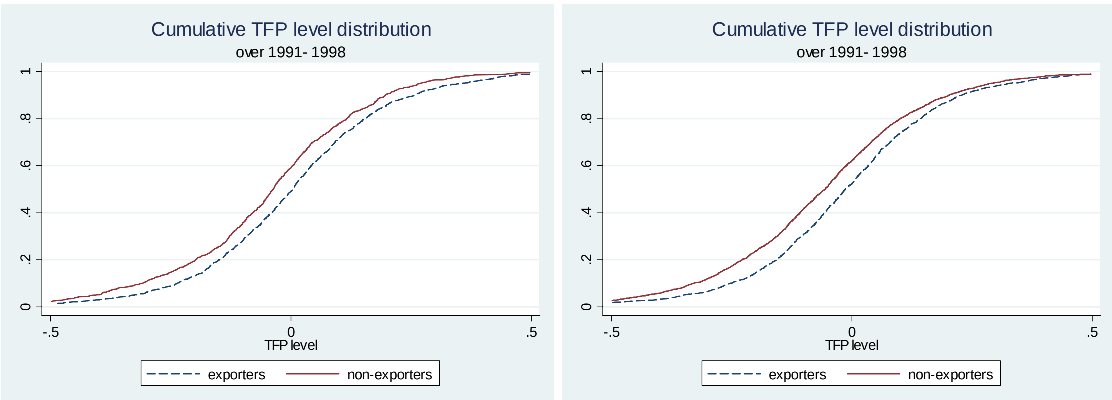
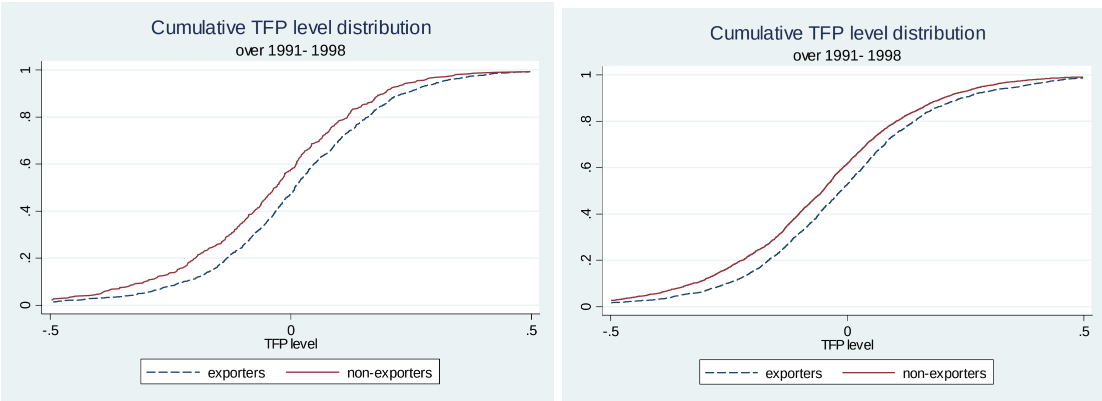


Figure 9.Cumulative distribution of TFP levels. Exporters versus non-exporters, for firms with R&D and without R&D. 1991-1998

R&D=1 R&D=0



Test results

<u>Exporting versus non-exporting firms</u>

Table 2. Difference in TFP level distributions between exporters and non-exporters[8]

	Number of firms		**Diffe-rence in means**	**Mean (non-exporters)> mean (exporters)**		**Variance (non-exporters)> variance (exporters)**		**K-S test for equality of distributions**		**Difference in favor of exporters**	
	exp=1	exp=0		t-statistic	P-value	F-statistic	P-value	D	P-value	D	P-value
Pooled	3610	4559	-0.056	-11.637	**0.000**	1.159	1.000	0.115	**0.000**	-0.000	**1.000**
1991	295	591	-0.005	-0.335	**0.368**	1.315	0.996	0.053	**0.585**	-0.030	**0.695**
1992	378	629	-0.027	-1.904	**0.028**	1.231	0.987	0.077	**0.106**	-0.021	**0.806**
1993	377	604	-0.050	-3.774	**0.000**	1.352	0.999	0.107	**0.008**	-0.003	**0.996**
1994	439	586	-0.045	-3.484	**0.000**	0.953	0.293	0.130	**0.001**	-0.013	**0.917**
1995	449	504	-0.061	-4.370	**0.000**	0.993	0.470	0.125	**0.001**	-0.000	**1.000**
1996	483	532	-0.066	-4.830	**0.000**	1.080	0.808	0.174	**0.000**	-0.003	**0.995**
1997	616	585	-0.079	-6.180	**0.000**	1.168	0.971	0.181	**0.000**	-0.000	**1.000**
1998	573	528	-0.071	-5.398	**0.000**	1.422	1.000	0.143	**0.000**	-0.000	**1.000**

Innovating versus non-innovating firms

Table 3A. Difference in TFP level distributions between firms with product innovation and firms with no innovation

	Number of firms		**Diffe-rence in means**	**Mean (no innovation)> mean (prod. innovation)**		**Variance (no innovation)> variance (prod. innovation)**		**K-S test for equality of distributions**		**Difference in favor of firms with prod. innovation**	
	Prod. inno-vation	No inno-vation		t-statistic	P-value	F-statistic	P-value	D	P-value	D	P-value
Pooled	790	4838	-0.044	-5.257	**0.000**	1.149	0.994	0.103	**0.000**	-0.001	**0.997**
1991	60	689	-0.018	-0.643	**0.260**	1.148	0.742	0.103	**0.535**	-0.074	**0.545**
1992	90	588	-0.006	-0.242	**0.404**	1.345	0.958	0.079	**0.657**	-0.055	**0.621**
1993	98	558	-0.005	-0.249	**0.401**	1.264	0.923	0.082	**0.566**	-0.050	**0.653**
1994	109	593	-0.045	-2.060	**0.019**	1.211	0.890	0.143	**0.034**	-0.019	**0.930**
1995	100	587	-0.066	-2.853	**0.002**	1.038	0.582	0.158	**0.020**	-0.017	**0.952**
1996	109	558	-0.069	-2.933	**0.001**	1.118	0.761	0.171	**0.007**	-0.001	**0.999**
1997	103	605	-0.062	-2.585	**0.005**	1.130	0.776	0.188	**0.003**	-0.007	**0.990**
1998	121	657	-0.047	-2.220	**0.013**	1.167	0.852	0.152	**0.013**	-0.009	**0.981**

Table 3B. Difference in TFP level distributions between firms with process innovation and firms with no innovation

	Number of firms		**Diffe-rence in means**	**Mean (no innovation)> mean (proc. innovation)**		**Variance (no innovation)> variance (proc. innovation)**		**K-S test for equality of distributions**		**Difference in favor of firms with proc. innovation**	
	Proc. inno-vation	No inno-vation		t-statistic	P-value	F-statistic	P-value	D	P-value	D	P-value
Pooled	1166	4838	-0.004	-0.648	**0.258**	1.017	0.643	0.035	**0.184**	-0.010	**0.808**
1991	41	689	0.040	1.176	**0.880**	1.073	0.592	0.114	**0.626**	-0.114	**0.365**
1992	165	588	0.002	0.099	**0.539**	1.118	0.806	0.050	**0.887**	-0.050	**0.528**
1993	143	558	0.007	0.388	**0.651**	1.222	0.927	0.053	**0.882**	-0.053	**0.524**
1994	159	593	0.014	0.782	**0.782**	1.117	0.799	0.088	**0.255**	-0.088	**0.146**
1995	153	587	-0.007	-0.349	**0.363**	0.840	0.081	0.126	**0.034**	-0.033	**0.765**
1996	151	558	-0.020	-0.997	**0.159**	1.142	0.836	0.102	**0.143**	-0.033	**0.775**
1997	151	605	-0.021	-1.075	**0.141**	1.354	0.987	0.094	**0.206**	-0.015	**0.948**
1998	205	657	-0.003	-0.215	**0.414**	0.742	0.003	0.063	**0.522**	-0.032	**0.730**

Table 3C. Difference in TFP level distributions between firms with innovation (either product of process) and firms with no innovation

	Number of firms		**Diffe-rence in means**	**Mean (no innovation)> mean (innovation)**		**Variance (no innovation)> variance (innovation)**		**K-S test for equality of distributions**		**Difference in favor of firms with innovation**	
	Inno-vation	No inno-vation		t-statistic	P-value	F-statistic	P-value	D	P-value	D	P-value
Pooled	2749	4836	-0.024	-4.716	**0.000**	1.099	0.997	0.066	**0.000**	-0.003	**0.966**
1991	160	689	-0.015	-0.831	**0.203**	1.251	0.958	0.082	**0.301**	-0.049	**0.534**
1992	372	588	-0.012	-0.847	**0.198**	1.223	0.983	0.068	**0.213**	-0.031	**0.638**
1993	348	558	-0.000	-0.020	**0.491**	1.184	0.958	0.041	**0.830**	-0.034	**0.610**
1994	372	594	-0.017	-1.297	**0.097**	1.123	0.890	0.054	**0.464**	-0.013	**0.917**
1995	361	588	-0.031	-2.161	**0.015**	0.991	0.460	0.105	**0.012**	-0.017	**0.871**
1996	351	558	-0.033	-2.194	**0.014**	1.112	0.863	0.113	**0.006**	-0.006	**0.983**
1997	342	604	-0.039	-2.624	**0.004**	1.221	0.980	0.120	**0.003**	-0.007	**0.976**
1998	443	657	-0.027	-2.057	**0.020**	0.943	0.251	0.089	**0.025**	-0.009	**0.954**

Table 3D. Difference in TFP level distributions between firms with R&D and firms with no R&D

	Number of firms		**Diffe-rence in means**	**Mean (R&D=0)> mean (R&D=1)**		**Variance (R&D=0)> variance (R&D=1)**		**K-S test for equality of distributions**		**Difference in favor of firms with R&D**	
	R&D =1	R&D =0		t-statistic	P-value	F-statistic	P-value	D	P-value	D	P-value
Pooled	1547	6039	-0.034	-5.557	**0.000**	1.216	1.000	0.088	**0.000**	-0.009	**0.788**
1991	144	705	-0.006	-0.315	**0.376**	0.948	0.330	0.093	**0.211**	-0.021	**0.894**
1992	198	762	-0.018	-1.013	**0.155**	1.456	0.999	0.098	**0.080**	-0.034	**0.688**
1993	185	721	-0.017	-1.035	**0.150**	1.424	0.998	0.095	**0.113**	-0.038	**0.651**
1994	206	759	-0.029	-1.788	**0.037**	0.992	0.464	0.072	**0.321**	-0.007	**0.982**
1995	204	745	-0.036	-2.158	**0.015**	1.322	0.991	0.124	**0.011**	-0.022	**0.856**
1996	181	729	-0.058	-3.198	**0.000**	1.322	0.988	0.177	**0.000**	-0.028	**0.789**
1997	197	749	-0.047	-2.668	**0.003**	1.219	0.954	0.138	**0.004**	-0.016	**0.918**
1998	232	868	-0.047	-2.938	**0.001**	1.258	0.983	0.146	**0.001**	-0.016	**0.908**

Exporters versus non-exporters conditional on firm innovation status

Table 4A. Differences in TFP level distributions between exporters and non-exporters conditional on firm innovation status. Product innovation.

Product innovation =1											
	Number of firms		**Diffe-rence in means**	**Mean (non-exporters)> mean (exporters)**		**Variance (exporters)> variance (non-exporters)**		**K-S test for equality of distributions**		**Difference in favor of exporters**	
	exp=1	exp=0		t-statistic	P-value	F-statistic	P-value	D	P-value	D	P-value
Pooled	512	278	-.039	-2.594	**0.005**	1.090	0.796	0.090	**0.091**	-0.006	**0.985**
1991	27	33	0.100	1.956	**0.972**	3.687	0.999	0.343	**0.036**	-0.343	**0.030**
1992	57	33	0.018	0.422	**0.663**	0.879	0.353	0.234	**0.143**	-0.234	**0.100**
1993	58	40	-0.020	-0.529	**0.298**	1.370	0.862	0.106	**0.923**	-0.106	**0.582**
1994	67	42	-0.026	-0.699	**0.242**	0.871	0.322	0.108	**0.884**	-0.108	**0.543**
1995	68	32	-0.059	-1.310	**0.096**	1.229	0.762	0.165	**0.501**	-0.016	**0.988**
1996	74	35	-0.083	-1.907	**0.029**	1.276	0.809	0.257	**0.056**	-0.030	**0.957**
1997	76	27	-0.009	-0.188	**0.425**	1.486	0.905	0.187	**0.395**	-0.090	**0.721**
1998	85	36	-0.121	-3.149	**0.001**	0.669	0.092	0.296	**0.014**	-0.011	**0.993**

Table 4B. Differences in TFP level distributions between exporters and non-exporters conditional on firm innovation status. Process innovation.

Process innovation=1											
	Number of firms		**Diffe-rence in means**	**Mean (non-exporters)> mean (exporters)**		**Variance (non-exporters)> variance (exporters)**		**K-S test for equality of distributions**		**Difference in favor of exporters**	
	exp=1	exp=0		t-statistic	P-value	F-statistic	P-value	D	P-value	D	P-value
Pooled	557	609	-0.057	-4.540	**0.000**	0.991	0.459	0.124	**0.001**	-0.004	**0.987**
1991	16	25	0.033	0.493	**0.687**	1.558	0.812	0.240	**0.517**	-0.240	**0.325**
1992	65	100	-0.030	-0.885	**0.188**	0.704	0.057	0.113	**0.630**	-0.026	**0.944**
1993	86	57	-0.035	-1.104	**0.135**	0.958	0.423	0.124	**0.592**	-0.036	**0.914**
1994	73	86	-0.035	-1.103	**0.135**	1.043	0.572	0.129	**0.455**	-0.027	**0.942**
1995	73	79	-0.062	-1.630	**0.052**	0.985	0.474	0.131	**0.456**	-0.017	**0.976**
1996	69	81	-0.034	-0.985	**0.163**	0.757	0.119	0.153	**0.280**	-0.043	**0.869**
1997	80	71	-0.064	-2.020	**0.022**	1.337	0.895	0.221	**0.034**	-0.014	**0.985**
1998	112	93	-0.113	-3.288	**0.000**	1.343	0.931	0.275	**0.001**	-0.009	**0.991**

Table 4C. Differences in TFP level distributions between exporters and non-exporters conditional on firm innovation status. Innovation (product and/or process)

Innovation=1											
	Number of firms		**Diffe-rence in means**	**Mean (non-exporters)> mean (exporters)**		**Variance (non-exporters)> variance (exporters)**		**K-S test for equality of distributions**		**Difference in favor of exporters**	
	exp=1	exp=0		t-statistic	P-value	F-statistic	P-value	D	P-value	D	P-value
Pooled	1581	1168	-.049	-6.169	**0.000**	1.036	0.745	0.106	**0.000**	-0.000	**1.000**
1991	77	83	0.034	1.128	**0.869**	1.883	0.997	0.133	**0.408**	-0.133	**0.242**
1992	191	181	-0.030	-1.386	**0.083**	0.880	0.194	0.086	**0.442**	-0.017	**0.944**
1993	179	169	-0.031	-1.518	**0.064**	1.176	0.857	0.083	**0.532**	-0.015	**0.962**
1994	212	160	-0.037	-1.780	**0.037**	0.945	0.356	0.092	**0.367**	-0.014	**0.964**
1995	214	147	-0.063	-2.738	**0.003**	1.124	0.783	0.115	**0.161**	0.000	**1.000**
1996	218	133	-0.050	-2.153	**0.016**	0.801	0.082	0.136	**0.074**	-0.013	**0.969**
1997	212	130	-0.035	-1.539	**0.062**	1.118	0.765	0.168	**0.015**	-0.020	**0.935**
1998	278	165	-0.100	-4.712	**0.000**	1.249	0.947	0.224	**0.000**	0.000	**1.000**

Table 4D. Differences in TFP level distributions between exporters and non-exporters conditional on firm innovation status. No innovation case.

No innovation case											
	Number of firms		**Diffe-rence in means**	**Mean (non-exporters)> mean (exporters)**		**Variance (non-exporters)> variance (exporters)**		**K-S test for equality of distributions**		**Difference in favor of exporters**	
	exp=1	exp=0		t-statistic	P-value	F-statistic	P-value	D	P-value	D	P-value
Pooled	1789	3049	-0.051	-7.894	**0.000**	1.113	0.994	0.114	**0.000**	-0.000	**1.000**
1991	213	476	-0.002	-0.135	**0.446**	0.939	0.292	0.083	**0.224**	-0.020	**0.883**
1992	181	407	-0.020	-1.009	**0.156**	1.441	0.997	0.103	**0.115**	-0.065	**0.338**
1993	177	381	-0.070	-3.715	**0.000**	1.539	0.999	0.160	**0.003**	-0.004	**0.994**
1994	196	398	-0.049	-2.654	**0.004**	0.979	0.427	0.170	**0.001**	-0.012	**0.957**
1995	231	357	-0.055	-3.061	**0.001**	0.938	0.295	0.130	**0.013**	-0.006	**0.989**
1996	221	338	-0.081	-4.207	**0.000**	1.122	0.823	0.214	**0.000**	-0.003	**0.998**
1997	275	330	-0.078	-4.221	**0.000**	0.900	0.182	0.172	**0.000**	-0.003	**0.996**
1998	295	362	-0.044	-2.643	**0.004**	1.487	0.999	0.121	**0.013**	-0.019	**0.890**

Table 4E. Differences in TFP level distributions between exporters and non-exporters conditional on firm R&D status

R&D =1											
	Number of firms		**Diffe-rence in means**	**Mean (non-exporters)> mean (exporters)**		**Variance (non-exporters)> variance (exporters)**		**K-S test for equality of distributions**		**Difference in favor of exporters**	
	exp=1	exp=0		t-statistic	P-value	F-statistic	P-value	D	P-value	D	P-value
Pooled	1131	416	-0.050	-4.404	**0.000**	1.045	0.710	0.110	**0.001**	-0.003	**0.992**
1991	100	44	-0.000	-0.007	**0.496**	1.101	0.659	0.125	**0.651**	-0.040	**0.907**
1992	137	61	-0.010	-0.357	**0.360**	0.923	0.369	0.055	**0.999**	-0.044	**0.847**
1993	133	52	-0.032	-1.144	**0.127**	1.695	0.991	0.151	**0.291**	-0.068	**0.708**
1994	143	63	-0.052	-1.669	**0.048**	0.915	0.352	0.126	**0.417**	-0.014	**0.983**
1995	159	45	-0.063	-1.948	**0.026**	1.599	0.980	0.195	**0.100**	-0.054	**0.814**
1996	138	43	-0.091	-2.698	**0.003**	0.648	0.052	0.306	**0.002**	-0.014	**0.986**
1997	147	50	-0.051	-1.538	**0.062**	1.119	0.700	0.138	**0.396**	-0.020	**0.969**
1998	174	58	-0.073	-2.452	**0.007**	0.996	0.507	0.212	**0.026**	-0.005	**0.997**

R&D =0											
	Number of firms		**Diffe-rence of means**	**Mean (non-exporters)> mean (exporters)**		**Variance (non-exporters)> variance (exporters)**		**K-S test for equality of distributions**		**Difference in favor of exporters**	
	exp=1	exp=0		t-statistic	P-value	F-statistic	P-value	D	P-value	D	P-value
Pooled	2240	3799	-0.049	-8.467	**0.000**	1.062	0.946	0.095	**0.000**	-0.000	**1.000**
1991	190	515	0.007	0.400	**0.655**	1.123	0.826	0.061	**0.642**	-0.047	**0.530**
1992	235	527	-0.027	-1.519	**0.064**	1.172	0.919	0.071	**0.346**	-0.026	**0.797**
1993	223	498	-0.057	-3.458	**0.000**	1.236	0.965	0.103	**0.062**	-0.001	**1.000**
1994	265	495	-0.040	-2.532	**0.005**	1.019	0.565	0.146	**0.001**	-0.016	**0.909**
1995	286	459	-0.057	-3.455	**0.000**	0.853	0.067	0.117	**0.013**	-0.002	**0.997**
1996	302	427	-0.060	-3.574	**0.000**	1.011	0.541	0.156	**0.001**	-0.007	**0.982**
1997	340	409	-0.064	-3.895	**0.000**	0.944	0.290	0.173	**0.000**	-0.001	**0.999**
1998	399	469	-0.061	-4.088	**0.000**	1.386	0.999	0.123	**0.002**	-0.001	**0.999**

Quantile regression results, 1991-1998[9]

Table 5A. Estimation results of TFP levels for the export variable, 1991-1998.

Dependent variable: TFP level						
Reported coefficient: Export (0/1)						
	OLS	**Quantile regression**				
Export(0/1)		5%	25%	50%	75%	95%
	0.046*** (0.008)	**0.079*** (0.014)**	**0.054*** (0.006)**	**0.036*** (0.005)**	**0.028*** (0.006)**	**0.055*** (0.013)**
Number of observations: 8167						

Table 5B. Estimation results of TFP levels for the innovation variables, 1991-1998.

Dependent variable: TFP level						
Reported coefficient: Product innovation (0/1)						
	OLS	**Quantile regression**				
Product innovation (0/1)		5%	25%	50%	75%	95%
	0.034*** (0.011)	0.032 (0.020)	**0.041*** (0.010)**	**0.026*** (0.007)**	**0.018* (0.010)**	**0.051** (0.024)**
Number of observations: 5627						

Dependent variable: TFP level						
Reported coefficient: Process innovation (0/1)						
	OLS	**Quantile regression**				
Process innovation (0/1)		5%	25%	50%	75%	95%
	-0.000 (0.008)	-0.011 (0.020)	0.001 (0.009)	0.000 (0.008)	0.008 (0.009)	-0.002 (0.019)
Number of observations: 6003						

Dependent variable: TFP level						
Reported coefficient: Innovation (0/1)						
	OLS	**Quantile regression**				
Innovation (0/1)		5%	25%	50%	75%	95%
	0.018*** (0.007)	**0.025** (0.012)**	**0.024*** (0.007)**	**0.018*** (0.005)**	**0.014** (0.006)**	0.005 (0.014)
Number of observations: 7583						

Dependent variable: TFP level						
Reported coefficient: RD (0/1)						
	OLS	**Quantile regression**				
RD (0/1)		5%	25%	50%	75%	95%
	0.021** (0.009)	**0.032** (0.016)**	**0.038*** (0.007)**	**0.022*** (0.007)**	**0.016** (0.008)**	-0.016 (0.016)
Number of observations: 7584						

Table 5C. Estimation results of TFP levels for the export dummy variable conditional on firm innovation status, 1991-1998.

Product innovation=1						
Dependent variable: TFP level						
Reported coefficient: Export (0/1)						
	OLS	**Quantile regression**				
Export(0/1)		5%	25%	50%	75%	95%
	0.025 (0.018)	0.044 (0.041)	**0.026*** **(0.015)**	0.010 (0.016)	0.001 (0.018)	0.053 (0.060)
Number of observations: 790						

Have added the number of observations for each year…

Process innovation=1						
Dependent variable: TFP level						
Reported coefficient: Export (0/1)						
	OLS	**Quantile regression**				
Export(0/1)		5%	25%	50%	75%	95%
	0.050*** (0.017)	**0.097**** **(0.041)**	**0.039*** **(0.020)**	**0.040***** **(0.012)**	0.029 (0.019)	**0.087***** **(0.026)**
Number of observations: 1166						

Innovation=1						
Dependent variable: TFP level						
Reported coefficient: Export (0/1)						
	OLS	**Quantile regression**				
Export(0/1)		5%	25%	50%	75%	95%
	0.041*** (0.012)	**0.087***** **(0.024)**	**0.027***** **(0.010)**	**0.027***** **(0.009)**	**0.029***** **(0.011)**	**0.073***** **(0.019)**
Number of observations: 2748						

No innovation case						
Dependent variable: TFP level						
Reported coefficient: Export (0/1)						
	OLS	**Quantile regression**				
Export(0/1)		5%	25%	50%	75%	95%
	0.043*** (0.010)	**0.072***** **(0.017)**	**0.058***** **(0.007)**	**0.032***** **(0.006)**	**0.027***** **(0.009)**	**0.035*** **(0.018)**
Number of observations: 4837						

R&D=1						
Dependent variable: TFP level						
Reported coefficient: Export (0/1)						
	OLS	**Quantile regression**				
Export(0/1)		5%	25%	50%	75%	95%
	0.043** (0.018)	**0.083** (0.039)**	**0.049*** (0.015)**	**0.028** (0.011)**	0.022 (0.015)	0.034 (0.026)
Number of observations: 1546						

R&D=0						
Dependent variable: TFP level						
Reported coefficient: Export (0/1)						
	OLS	**Quantile regression**				
Export(0/1)		5%	25%	50%	75%	95%
	0.043*** (0.010)	**0.072*** (0.014)**	**0.045*** (0.007)**	**0.031*** (0.005)**	**0.029*** (0.007)**	**0.068*** (0.016)**
Number of observations: 6038						

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Appendix

Table. Variable definitions

Variable	Description
TFP level	Firm specific index of total factor productivity constructed using a multilateral index (see below for the detailed explanation on its calculation)
Export	Export status dummy, equals to 1 if firm exports at time t and 0 if it performs no exporting activities at time t
Product innovation Process innovation Innovation R&D investment "No innovation" case	Dummy variable equals to 1 if firm carried out product innovation exclusively at time t-1; 0 – if firm performed neither product nor process innovation at time t-1 Dummy variable equals to 1 if firm carried out process innovation exclusively at time t-1; 0 – if firm performed neither product nor process innovation at time t-1 Dummy variable equals to 1 if firm carried out either product or process innovation at time t-1; 0 – if firm performed neither product nor process innovation at time t-1 Dummy variable equals to 1 if firm invested in R&D at time t-1 Firm performed neither product nor process innovation at time t-1
Foreign capital	Foreign capital dummy, equals to 1 if firm has more than 50% of foreign capital at time t
High-tech	Dummy variable, equals to 1 if firm belongs to high-tech sector. The high-tech sectors include Chemical products, Machinery and equipment, Office machinery and computing, Electronics and electronic equipment, Autos and motor vehicles industry, and Other transport equipment. High versus low technological sectors are defined according to the OECD classification of manufacturing industries based on technology (Source: OECD: ANBERD and STAN databases, 2003)
Definitions of product and process innovation in the ESEE survey:	Product innovation: - whether a firm obtained product innovation in a given year - new products, or products with new features that are different from those that a firm produced in the previous years. If the answer is yes, the type of modification is asked: - incorporates new materials - incorporates new components or intermediate products - incorporates new design or presentation - the product performs new functions Process innovation: - whether a firm introduced an important modification in the production process. If the answer s yes, the type of modification is asked: - introduction of new machinery - introduction of new methods of production organization - both

Calculation of the TFP index

The productivity index is computed as a multilateral index developed in Caves et al. (1982) and extended in Good et al. (1997). In calculating the TFP index we follow Aw et al. (2000; 2007) and Delgado et al. (2002). The TFP index measures the proportional difference in *TFP* for firm *i* from size group *s* in year *t* relative to a hypothetical reference firm in the same industry *r*. We consider two size groups, determined by the ESEE survey. A firm belongs to the group of large firms if the number of workers it employs is more than 200; and to the group of small firms if the number of employees is less or equal to 200.

The reference firm is defined as follows:

- the output is equal to the geometric mean of outputs over all observations in industry *r*;
- inputs are equal to the geometric means of inputs over all observations in industry *r*;
- cost shares are the arithmetic means of cost shares over all observations in industry *r*.

The total factor productivity index for firm *i* ($i = 1,...,N$) from size group *s* and industry *r* ($r = 1,...,R$) in year *t* ($t = 1,...,T$) is computed using the following formula:

$$\ln TFP_{itsr} = \ln Y_{itsr} - \overline{\ln Y_{sr}} - \sum_{j=1}^{J} \frac{1}{2}\left(S_{itsrj} + \overline{S_{srj}}\right)\left(\ln X_{itsrj} - \overline{\ln X_{srj}}\right) + \\ + \overline{\ln Y_{sr}} - \overline{\ln Y_{r}} - \sum_{j=1}^{J} \frac{1}{2}\left(\overline{S_{srj}} + \overline{S_{rj}}\right)\left(\overline{\ln X_{srj}} - \overline{\ln X_{rj}}\right),$$

where Y_{itsr} is the output of firm *i* in year *t*, X_{itsrj} is an input *j* ($j = \overline{1, J}$) of firm *i* in year *t*, and S_{itsrj} is a cost-based share of input *j* of firm *i* in year *t*; and

$\overline{\ln Y_{sr}} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}\ln Y_{itsr}$, $\overline{\ln Y_{r}} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}\ln Y_{itr}$, $\overline{\ln X_{sr}} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}\ln X_{itsr}$,

$\overline{\ln X_{r}} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}\ln X_{itr}$, and $\overline{S_{sr}} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}S_{itsr}$, $\overline{S_{r}} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}S_{itr}$ are the same variables for the reference firm.

The ESEE data provide information on the output and input variables needed to measure total factor productivity at the firm level. We model each firm as using three inputs in its production function: labor, capital and material input. The labor input is measured as the number of total effective working hours per year. The measure of capital input is the capital stock, calculated using the following formula: $k_t^* = I_t + k_{t-1}^*(1-d_t)\frac{P_t}{P_{t-1}}$, where I represents investment in equipment in year t, d – depreciation rates in year t, P – price indexes for equipment in year t. The material input includes raw materials, fuel and electricity costs, and other services bought by a firm. The material expenditures are deflated using the firm specific price indexes for each of the inputs provided in the ESEE survey.

Firm output is defined as total firm sales deflated by a producer price index defined at the two-digit NACE industry level.[10] Cost-based input shares are calculated as the costs of each input in total input costs. The total input cost is the sum of the labor cost, material cost and the cost of capital. Labor costs are measured as total salaries to employees deflated by the consumer price index. Capital cost is computed using an estimation of the user cost of capital for each firm. User cost of capital is calculated as the sum of the cost of long-term debt and depreciation rates less the variation of the price index for capital goods. The cost share of materials is calculated as the residual after subtracting the expenditures on labor and capital.

Large firms

For large firms we observe higher TFP levels in the case of exporters compared to non-exporters, but this difference is not significant, which is consistent with the findings of Delgado et al. (2002). But product innovators show significantly higher productivity levels compared to non-innovators.

Exporters do not differ from non-exporters for the group of firms with innovations, consistent with what we find for small firms. But, contrary to our findings for small firms, we observe no significant difference between exporters and non-exporters for the "no innovation" case, although non-innovating exporters still show higher productivity than non-innovating non-exporters. The number of observations in the group of large firms, however, is not sufficient for these tests to be statistically conclusive.

♣ We are grateful for the comments received from José Manuel Campa and seminar participants at the Jornadas de Economia Industrial in Barcelona and the EARIE conference in Amsterdam. We acknowledge financial support from the Anselmo Rubiralta Center for Globalization and Strategy and the Public-Privat Sector (SP-SP) Research Center at IESE Business School, the Steunpunt O&O at the Catholic University of Leuven, and the Spanish Ministry of Education and Science and Technology for the project nº SEJ2006-11833/ECON.

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[1] Proportion of the firms in the year t that continue in the survey in the year t+1 is approximately 90% for 1990-2001 sample period. Among the firms that exited the

sample, approximately 2.2% disappeared and approximately 7.7% stopped collaborating.

[2] Small and medium sized firms (equal or less than 200 employees) and large firms (more than 200 employees) are defined according to the ESEE survey definition.

[3] The results for large firms are in line with our findings for small and medium firms. See Appendix.

[4] As innovation does show some persistence we did experiment with various lag specifications. Our basic result is confirmed for these alternative specifications.

[5] In general, we observe the insignificant results for the beginning of the 90-s, while testing the differences in the TFP distributions for both export and innovation variables. However, we still observe lower productivity levels in the groups of non-performers.

[6]We use a foreign capital dummy to control for the potential advantage in productivity of firms with foreign capital participation over purely domestic firms. We include a dummy for a high-tech sector as an additional control for industry differences in productivity. Year dummies control for the changes in macroeconomic conditions. See Appendix for the detailed description of the variables.

[7] This result needs careful interpretation. As we are using a multilateral index of TFP for making relative comparisons, our results suggest that process innovation does not affect the relative position of firms in the TFP rankings. Nevertheless, process innovation might be necessary for maintaining ones relative rank.

[8] Here and further we report the results of the following tests:

Comparison of means:

Ho: Mean (group 1)=Mean (group 2) against Ha: Mean(group1)>Mean(group2)

Comparison of variance:

Ho: Variance (group 1)=Variance (group 2) against Ha: Variance (group 1)>Variance (group 2)

Comparison of distributions:

Ho(1): F(TFP group1)=F(TFP group2) – the test for the equality of distributions;

Ho(2): F(TFP group1)<F(TFP group2) – the test for the differences in TFP levels favorable to group1.

Here group1 and group2 are the groups of exporting and non-exporting (or innovating and non-innovating) firms respectively.

[9] Standard errors are given in parentheses. Foreign capital and high-tech industry dummy are included as covariates. Year fixed effects are included. *, **, *** are significantly different from zero at the 10%, 5% or 1% level respectively.

 The information on depreciation rates, price indexes for equipment, producer price index, and consumer price index is taken from the Instituto Nacional de Estadıstica de España (www.ine.es)