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The Roles of Import Competition and Export Opportunities for Technical Change

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Abstract
A variety of empirical and theoretical trade papers have suggested and documented a positive impact of trade on the productivity of firms. However, there is less consensus about the underlying mechanism at work. While trade papers focus on access to export markets, other papers stress the importance of import competition. Since imports and exports (and even tariffs affecting either) are usually highly correlated, it is unclear which mechanism the existing empirical papers uncover. This paper conducts a "horse race" between export opportunities and import competition. Using Spanish firm level data, instrumenting for exports and imports with tariff changes and controlling for selection, I find robust evidence that access to export markets leads to productivity increases, but only for firms that were already highly productive before. The evidence on import competition is weaker. If anything, initially low-tech firms manage to increase their productivity in response to increased competition from abroad. The latter finding is at odds with most trade models, so I propose a model incorporating non-profit maximizing managers to reconcile theory with the evidence. Empirically, I find that all productivity upgrades are driven by increased R&D, patenting, and product innovation. Access to export markets also leads to the adaptation of foreign technologies. There is no evidence that either mechanism leads to increased full time employment, instead full time workers seem to be replaced by part-time or temporary workers.

Keywords: Import competition, technical change, productivity, exporting
JEL codes: F12; F13; F14; L25

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1 Introduction

A variety of papers have empirically established the positive impact of trade on the productivity of firms. However, there is less consensus about the underlying mechanism at work: While the trade literature has typically focused on access to export markets as reason for productivity upgrades (e.g. Lileeva and Trefler 2010; De Loecker 2007; Bustos 2011; Pavcnik 2002), some papers, especially in the industrial organizations literature, have stressed increased competition from foreign entrants (e.g. Aghion et al. 2009; Blundell et al. 1995; Bloom et al. 2011; Tybout 2004; also Aghion et al. 2014 in a lab experiment).

Unfortunate for empirical investigations of causal effects is that increased export opportunities usually coincide with increased competition from abroad, as most trade liberalization episodes are bilateral and increase trade in both directions (even within narrowly defined industries). Regressions focusing on either the import or the export side omit an important variable and might pick up the productivity effect caused by it. Note that using tariff changes as instruments for imports or exports does not solve the problem either, as for the same reason own tariff changes are usually highly correlated with tariff changes abroad.

This paper disentangles whether import competition and/or access to export markets drive productivity gains from trade.[1] This is important, because each mechanism might have different implications: Larger export markets give firms the opportunity to expand and increase employment, while increasing competition might force firms to contract and reduce their workforce.

In theory both export opportunities and import competition could lead to productivity upgrades of firms. Several trade theory papers show that firms can be induced by export opportunities to upgrade their productivity (e.g. Melitz and Costantini 2007; Bustos 2011; Atkeson and Burstein 2010). In standard trade models with CES preferences markups are constant and unaffected by import competition. With variable markups as in Melitz and Ottaviano (2008), import competition decreases the incentive to innovate as profits fall. However, there are a variety of (not necessarily trade) models that predict an increase in innovation resulting from competition, for example relying on trapped factors (Bloom et al. 2013), non-profit maximizing managers and X-inefficiency (Aghion et al. 1999; Horn et al. 1995), a differential impact of competition on post- and pre-innovation rents (Aghion et al. 2005), or imitation based on a search model (Waugh et al. 2014).

It is plausible to think that import competition and access to export markets affect different types of firms. For example, the market access mechanism is only relevant for firms that are eventually able to export, or at least think they might have the capacity to do so. It is widely known in the trade literature that these are typically only the most productive firms in an industry. Bustos (2011) and Lileeva and Trefler (2010) show that mostly large firms increase productivity as response to export access. There is less consensus about which firms might be induced by import competition to upgrade their productivity. On one hand, import competition could be more relevant for firms with low profits, which are close to the border of bankruptcy and want to avoid exit. On the other hand, import competition could discourage already unproductive firms from trying harder, whereas already productive firms might be induced

[1] Only a few papers focus on the response of productivity to both increased imports and exports. Pavcnik (2002) finds productivity increases among incumbents in import-competing industries but not in exporting industries, but does not allow for both forces to affect different firms within the same industry. In contrast, Trefler (2004) incorporates both import and export tariffs of the US and Canada and finds in firm level regressions that only the export effect is a significant driver of productivity increases, but he is not able to control for a selection effect as he has no information on firm exits, in contrast to this paper.

to innovate in order to escape competition. For example, Aghion et al. (2005) provide evidence that competition discourages firms with initially lower productivity from innovating but encourages already productive firms to innovate more in order to escape competition. In contrast, Waugh et al. (2014) show in a theory model that firms at the lower end of the productivity distribution are more incentivized by import competition to update productivity because they can gain more, but they do not provide empirical evidence for this mechanism. This paper allows for heterogeneous responses to both the export access and import competition mechanism.

Summarizing, this paper attempts to answer the following questions: Do import competition and/or access to export opportunities induce firms to increase their productivity? Is there a heterogeneity in the productivity response? And finally, how do firms achieve productivity increases?

Using Spanish firm level data, the main empirical specification in this paper is a regression of productivity on both imports and exports of an industry as measures for import competition and export opportunities to address the omitted variables bias, and interactions of those measures with a firm's initial productivity to allow for heterogeneous responses. I estimate this regression in first differences to take out firm specific, time-invariant factors, and add firm level fixed effect and year fixed effects to consider only deviations from firm specific growth rates. Both import and export changes are instrumented with changes in domestic and foreign trade tariffs to address the remaining endogeneity problem.

The Spanish data set used has a number of variables that allows me to carefully address several common pitfalls in the literature: For example, it provides firm specific input and output price changes that allow me to obtain a measure of total factor productivity that is not driven by changes in markups. Besides this, it is necessary to control for selection, as firms that are hit very hard by a negative productivity shock exit the sample, and the effect of trade on productivity might be overestimated. The Spanish data includes a measure for firm exits (as opposed to non response, which many data sets cannot distinguish from exits) and allows me to control for selection. Furthermore, I show that import competition is not picking up the effect of better access to imported inputs, and that firms which increase their productivity because they are exposed to export opportunities increase their exports at the extensive and intensive margin.

The results suggest that empirical papers focusing on import competition pick up the effect of access to export markets by omitting this variable. On average, the impact of export opportunities on productivity is large and significant, while the impact of import competition is small and insignificant. However, this masks a high degree of heterogeneity with respect to both mechanisms. Access to export markets leads to productivity increases only for firms that were *already very productive*. On the other hand, if anything, import competition induces only *initially low-tech* firms managing to upgrade their productivity.

The latter result is surprising, as standard trade models predict the opposite: Increased import competition reduces markups and profits, but more so for less productive firms, providing them with *less* incentive to innovate. I therefore provide a trade model that is consistent with the empirical findings. I add non-profit maximizing managers to a Melitz and Ottaviano (2008) model extended to an endogenous productivity choice. Managers receive a fixed salary if the firm exists, which introduces convexity in their payoff function. As a result, increased import competition induces those managers to upgrade productivity by more.

A final contribution of this paper lies in shedding light on the way how firms increase their productivity.

Most empirical papers focus on labor productivity or total factor productivity, exceptions are Bloom et al. (2011) who include patents, IT spending and R&D spending for subsets of their data, and Bustos (2011) who distinguishes between process and product innovation. The rich Spanish firm level data used in this paper includes most of these variables such as R&D investment, patenting, product innovation, but also other variables such as adaptation of foreign technologies or implementation of other technologies (e.g. computer-aided design CAD). I find that productivity upgrades are driven by increased R&D, patenting, and product innovation, and the adaptation of certain technologies like CAD. Productive firms with access to export markets also start assimilating foreign technologies, but import competition does not induce firms to do so. There is no evidence that either mechanism leads to increased full time employment, instead full time workers seem to be replaced by part-time or temporary workers.

The remainder of the paper is organized as follows: Section 2 contains a description of the used Spanish firm level data of manufacturing firms that allows for TFP estimation and the analysis of firm exits, and provides a rich set of outcome variables. Section 3 provides an overview of Spain's trade flows, which have grown strongly over the observed 15 years. Section 4 describes the empirical strategy and section 5 discusses and interprets the empirical results. In section 6 I provide a trade model with non-profit maximizing managers that is consistent with the heterogeneous effect of both import competition and export access on productivity. Section 7 concludes.

2 Description of Data

This paper uses panel data from a Spanish survey of manufacturing firms (ESEE; Encuesta Sobre Estrategias Empresariales), that is collected by the Fundación SEPI, a foundation affiliated with the Spanish Ministry of Finance and Public Administration.[2] The survey is designed to cover a representative sample of Spanish Manufacturing firms and includes around 1,800 firms per year. Participation of firms with more than 200 employees is required, while firms with more than 10 but less than 200 employees are sampled via a stratified sampling approach. SEPI makes a great effort to replace non-responding and exiting firms to ensure the continuing representativeness of the sample, leading to a total number of around 4,000 observed firms between 1993 and 2007.

The most distinctive feature of this data set is the very rich information it provides on several dimensions that are important for careful empirical investigation: Detailed capital stock and investment needed for TFP estimation; input and output price changes to distinguish TFP changes from markup changes; information on exits (distinct from non-response) and entry to deal with selection; and a wide variety of productivity related activities such as R&D, patenting, and the adaptation of certain technologies (e.g. use of robots, computer aided design, flexible manufacturing systems).

Total factor productivity. We need detailed data on capital stock, output, employment and intermediate inputs to estimate TFP at the firm level. In many firm level data sets capital stock is not available and must be reconstructed using investment data (often using only average depreciation rates). The problem of a missing initial capital stock is only negligible if data over a long period of time is available and initial capital stock is depreciated for much of the observed sample period. Fortunately, the Spanish data set provides both gross and net capital stock together with firm level depreciation and investment, which

[2]For more information see `http://www.fundacionsepi.es/esee/sp/spresentacion.asp`

allows a precise construction of the capital stock at any point in time.

Estimation of total factor productivity by OLS suffers from several problems: Employment and capital choices are endogenous, and TFP cannot easily be distinguished from markup changes (Beveren 2012). I use the well-established Levinsohn-Petrin procedure to deal with the endogeneity problem, which uses intermediate inputs to control for unobserved expected productivity changes. This is preferable to the Olley-Pakes method which uses investment as control, because investment is often reported as zero, which casts doubt on the validity of the assumed monotonicity condition requiring that investment is strictly increasing in unobserved productivity. The monotonicity condition is more likely to be satisfied for intermediate inputs, as firms usually report positive numbers.

Beveren (2012) points out that policy evaluations are usually robust to the TFP estimation method, with one exception: It is necessary to control for input and output prices (Loecker 2011). Luckily, the Spanish firm level survey provides a remedy to this omitted price bias as it also reports input and output prices. Firms are asked by how much % the sales price of its products and the purchasing price of its intermediate inputs and services has changed compared to the previous year. The price changes are a weighted average across final products and markets (for output prices), and a weighted average across intermediate inputs, energy consumption and purchased services (for input prices), which I use to deflate output and intermediate inputs at the firm level (instead of usually used industry-wide deflators).

The results in this paper are robust to using different productivity measures such as labor productivity and simple TFP fixed effects estimation.

Exits. Empirical papers focusing on import competition face another problem, as they might falsely pick up a positive effect on productivity, because firms that are hit very hard by a negative productivity shock exit the sample. Without correcting for this selection effect, the effect of trade on productivity might be overestimated. Unfortunately in many data sets it is not possible to distinguish exiting from non responding firms. The Spanish data set used however provides this information, as it follows up on non-responding firms to determine their status. Exiting firms include closed firms, firms in liquidation, and firms that are taken over by other firms. Annual exit rates in this sample are between 0.1% and 2.5%.

Other productivity related activities. In order to understand what firms do in order to increase productivity, I use a variety of productivity related activities such as R&D expenditure, number of filed patents, and product innovation. Every four years the survey contains additional questions about the use of specific technologies. These technologies are the use of robots, computer aided design (CAD) and flexible manufacturing systems. Furthermore the survey asks whether firms make an effort to assimilate foreign technologies, which is might potentially respond to trade liberalization.

Trade and tariff data. This paper exploits the variation in industry-specific imports and exports over time. I merge the firm-level data with industry level trade data from COMTRADE using the NACECLIO industry classification of firms (20 NACECLIO categories[3]). Section 3 provides an overview of Spain's imports and exports over time and by industry. I use the tariffs that the EU imposes on imports from the rest of the world ("import tariffs") and tariffs that other countries impose on imports from the EU

[3]The 20 industries are: Meat related products; Food and tobacco; Beverage; Textiles and clothing; Leather, fur and footwear; Timber; Paper; Printing and publishing; Chemicals; Plastic and rubber products; Nonmetal mineral products; Basic metal products; Fabricated metal products; Industrial and agricultural equipment; Office machinery, data processing, precision instruments and similar; Electric materials and accessories; Vehicles and accessories; Other transportation materials; Furniture; Miscellaneous.

("export tariffs") as instrumental variable for trade flows. All trade and tariff data used in the analysis is from COMTRADE (provided by UNSD) and TRAINS (provided by UNCTAD); all data sets are accessed via the WITS software provided by the World Bank.[4]

3 Trade growth in Spain

This paper uses import and export growth in Spain between 1993 and 2007 as source of variation in access to export markets and import competition. Trade has grown substantially over this time period. Figure 1 shows that Spain's world exports in 2007 (171 bn EUR) were almost four times larger than in 1993 (45 bn EUR). Spain's world imports grew even stronger, from 60 bn EUR in 1993 to 265 bn EUR in 2007. The trade growth was not entirely linear (neither in levels nor in logs): It increased strongly in the 90's, slowed down in the early 2000's, and picked up again around 2003 (especially imports). Spain incurred a trade deficit from goods trade in every single year over the observed time period. The trade deficit increased from around 2% of GDP to a staggering 10% of GDP at the end of the sample period.

Most of Spain's trade is with the European Union: In 2007, 73% of Spain's exports went to EU25 countries, compared to 60% of imports. Figure 2 graphs Spain's trade with its most important trading partners over time. A large share of exports are destined for Spain's neighboring countries in Europe: France, Germany, Italy, Portugal and Great Britain. Among those, exports to France have increased the most over the sample period. Most of Spain's imports are also coming from EU countries: Germany has the largest import share, followed by France and Italy. However, imports from China have been skyrocketing: China's share in Spain's imports has increased from 2% in 1993 to 6% in 2007.

Table 1 shows that the rise of China is most prevalent in certain industries like leather/fur/footwear, textiles/clothing, and nonmetal mineral products. Table 2 lists the top 3 export destinations by industry. Portugal has become a prominent destination for computer products and electronics; printing and publishing; leather, fur and footwear; and nonmetal mineral products. But also United Kingdom and the United States have increasingly become the destination for Spain's exports.

Overall, the distribution of trade across industries has remained fairly stable over time. Figure 3 shows that the most important export and import industry is vehicles and accessories, covering a quarter of exports and one fifth of imports. Second is the chemicals sector, followed by industrial and agricultural equipment. The food industry ranks fourth among Spanish exports. The dominant industries have only become more dominant over time.

Researchers have attributed the increased trade with EU countries to increased European integration that came with the introduction of the euro, the European Single Market, and the European Monetary Union (e.g. Berger and Nitsch 2008; Bergin and Lin 2012; Brouwer et al. 2008). Another important trade liberalization episode that occurred during the sample period was China's accession to the WTO in 2001, which was accompanied by a fall of tariff and non-tariff barriers between China and the European Union, among others, and led to increased trade with China (e.g. Bloom et al. 2011).

[4] `http://wits.worldbank.org/wits/`

4 Empirical strategy

Import competition versus export opportunities. How do access to export markets ("export opportunities") and competition from foreign firms ("import competition") affect firm productivity? In order to test this, I estimate the following firm-level equation that relates a firm's productivity (*TFP*) to measures of export access (*EXP*) and import competition (*IMP*):

$$TFP_{ist} = \beta_0 + \beta_1 IMP_{st} + \beta_3 EXP_{st} + \text{yearFE} + \text{firmFE} + \varepsilon_{ist} \tag{4.1}$$

where i indicates the firm, s indicates one of 20 industries (NACECLIO classification), and t is year (between 1993 and 2007). The main empirical measure for TFP_{ist} is obtained via Levinsohn-Petrin estimation (using material inputs to control for unobserved productivity) with an extra adjustment for changes in input and output prices, as described above.

Spain's world imports at the industry level are used as proxy for competition from foreign firms to domestic firms IMP_{st} (instead of a firm's actual imports, because firm imports are inputs and not outputs, but I want to measure import competition at the level of a firm's end product). Similarly, access to export markets EXP_{st} is proxied by Spain's world exports in industry s and year t (instead of actual firm level exports, to proxy for *potential* export opportunities to the firm). Year fixed effects control for unobserved common time trends, and firm level fixed effects control for unobserved, time-invariant heterogeneity at the firm level. All variables are in logs.

I proceed by estimating this equation in first differences, which controls for unobserved firm heterogeneity, as the firm level fixed effects cancel out. However, industries might have both higher productivity growth and higher trade growth for reasons other than export access or import competition. I add industry fixed effects to avoid using the cross-sectional variation and exploit the time-variation in trade within industries instead. In the main specifications I also add firm level fixed effects (which absorb the industry fixed effects) to control for firm characteristics that affect the productivity growth rate:

$$\Delta TFP_{ist} = \beta_1 \Delta IMP_{st} + \beta_3 \Delta EXP_{st} + \text{yearFE} + \text{firmFE} + \nu_{ist} \tag{4.2}$$

All standard errors are clustered at the industry level, in the spirit of Bertrand et al. (2004).

Heterogeneous effects. Since Melitz (2003) the trade literature has focused on firm level heterogeneity. In models with heterogeneous firms we do not expect all firms to be affected in the same way by import competition and export opportunities. For example, import competition might affect firms with initially lower productivity by more, because the threat of bankruptcy is stronger for them. On the other hand, firms with already low productivity might be discouraged by import competition, and only firms with a high enough productivity level to start with might even try to push the productivity frontier further out to become productivity leader. Similarly, we should expect a heterogeneous response to a better access to export markets. For example, the trade literature finds that usually only the most productive firms export.

In order to test for a heterogeneous response of firms depending on their initial productivity level I interact changes in import competition and export access with *TFP* in the first year of the analysis (in 1993, denoted as $TFP93_i$):

$$
\begin{aligned}
\Delta TFP_{ist} &= \beta_1 \Delta IMP_{st} + \beta_2 \left(TFP93_i \cdot \Delta IMP_{st}\right) \\
&\quad + \beta_3 \Delta EXP_{st} + \beta_4 \left(TFP93_i \cdot \Delta EXP_{st}\right) + \text{yearFE} + \text{firmFE} + \eta_{it}
\end{aligned} \tag{4.3}
$$

As robustness check I add industry*year specific fixed effects, which are collinear with the main effects of import competition and export access, but still allow me to estimate the sign on the interaction terms, β_2 and β_4.

Endogenous trade flows. A potential threat to identification is the endogeneity of industry level imports and exports to the productivity of a firm (even though trade is measured at a more aggregated, the industry, level). For example, there might be reverse causality: If firm productivity in a sector is high, this might lead to fewer imports (e.g. due to Ricardian comparative advantage of Spain) and more exports in that industry. Industry (or firm) level fixed effects in regression 4.1 avoid such cross-sectional comparisons across industries with different productivity levels and focus on within industry comparisons. However, even within industries reverse causality might hold over time: Imports are higher and exports lower when sectoral TFP is lower. Regression 4.2 addresses some of this endogeneity concern by using year fixed effects to absorb common time trends and industry (or firm) level fixed effects to look only at deviations from the industry (firm) specific TFP growth rate.

If these sets of fixed effects cannot address the endogeneity problem fully, this would likely lead us to underestimate the effect of import competition and overestimate the effect of access to export markets. Many empirical trade papers use exogenous trade liberalization events and/or tariff reductions to instrument for trade. Very often trade liberalization episodes lead to a bilateral reduction of tariffs, therefore own tariff changes are usually highly correlated with tariff changes abroad. I will use the word "import tariff" to refer to Spain's tariffs, and "export tariff" to refer to import tariffs that foreign countries impose on imports from Spain. The high correlation between import and export tariffs means that using tariff changes as instruments will not solve the omitted variable bias problem in papers studying the effect of only import competition or export access, as import tariff changes are not uncorrelated with changes in exports and vice versa.

Any study focusing on the effects of export or imports on firms needs two instruments, one for exports and one for imports. Futhermore, they cannot be too highly correlated. Econometrically, with multiple endogenous regressors it is not sufficient for identification to have a significant first stage for each endogenous regressor, because each first stage might use the same level of exogenous variation. Instead, the matrix of first stages needs to be of full rank to ensure identification. The Kleibergen-Paap statistics (Kleibergen and Paap 2006, implementation in Stata provided by Baum et al. 2010) provides a rank test to check this.

I use the tariffs that the EU imposes on imports from the rest of the world and the tariffs that other countries impose on imports from the EU as instruments for trade. More specifically, I use the maximum tariff[5] for each product category (ISIC Rev. 3; 244 product categories) and aggregate them to NACECLIO industries using the import shares of each product within an industry and across countries. Empirically, some tariff changes are more relevant for trade patterns than others, i.e. some are "binding" and inhibit

[5] Changes in the maximum tariff were empirically the changes with the most relevant impact on trade.

trade, whereas other tariff changes do not seem to be as relevant for trade. In order to use only binding tariff changes which have an impact on trade flows (and therefore a strong first stage), I multiply the weighted tariffs with an "importance weight" if tariff changes led to trade changes in the previous period. The lagged importance weights are given by $w = -\Delta\text{tariff} * \Delta\ln(\text{trade})$ if $w > 0$, and 0 otherwise.

It is not always clear whether tariff changes can be interpreted as exogenous to firms and industries, as large companies often try to influence policy makers to negotiate favorable tariffs. However, in the case of Spain tariffs are negotiated at the European level, and it is less likely that Spanish firms are able to influence European decision making. Furthermore, many tariff changes are a part of a larger political process, for example, EU enlargement, or China's WTO accession, and therefore likely out of control for specific Spanish firms.

Selection. There is a potential selection bias in the estimation above because some firms went bankrupt during the sample period. It is plausible to assume that these firms exit because they have been hit hard by a negative productivity shock. Omitting these firms from the sample and carrying out the estimation on the surviving firms which experienced relatively more positive productivity shocks would lead to an overestimation of the effect on productivity. This problem might be most severe for the productivity estimation of the firms that have a very low productivity to begin with, because negative productivity shocks are even more likely to cause bankruptcy for them.

The Spanish data set provides information about firm exits. It turns out that the number of exiting firms is very small (between 0.1% and 2.5% per year), so it is unlikely that exits affect the estimates too much in our case.[6] In order to account for selection I assign exiting firms the lowest observed productivity change in the exit year. The results are robust to this specification. I have also conducted a simple alternative fix to this problem: using quantile instead of mean regressions. This is possible because quantile regressions provide consistent estimates in the case of a censored dependent variable (assuming that exiting firms have been hit by a very negative productivity effect), as long as exit rates are lower than the estimated quantile (Angrist and Pischke 2009). It turns out that including or excluding exiting firms in quantile regressions for various percentiles does not matter for the results, showing that selection is not a concern in this paper.[7]

Robustness checks and other outcomes. In the remaining part of the paper I perform a variety of robustness checks. For example, I show that the results are not sensitive to the way of measuring

[6] Note that while the data set allows me to distinguish between non responding and exiting firms, exiting firms include closed firms, firms in liquidation, but also firms that are taken over by other firms. The last category of firms might not necessarily have been hit by a negative productivity shock, if firms like to take over only targets that are very productive ("cherry picking"). However, there is also evidence that take over targets are very unproductive ("lemon grabbing"), because they have a potential of high returns after a successful turnaround (Weche Gelübcke 2013). In the cherry picking case, I might be underestimating the true effect on productivity. In any case, note that the number of exiting firms is very small, and take overs are even rarer, so this should not affect the results very much.

[7] The quantile estimation results are available upon request from the author. I pursued a censored quantile regression approach as in Powell (1986) by assigning exiting firms the lowest observed productivity change in the exit year. The specific quantile is identified if censoring is only on one side of the conditional percentile. Buchinsky (1994) proposes a estimation algorithm to ensure this condition. The proposed estimation algorithm (which amounts to checking that the predicted values for productivity changes for exiting firms are above the censored values) converges already in the first round in all of my estimations. As in the mean regressions I would like to allow for firm and year fixed effects in the quantile regressions. However, estimating quantile regressions with large number of fixed effects is tricky. For example, it is not valid to transform variables to deviations from means, as the conditional quantile function is not linear. Estimating a large number of fixed effects is computationally very intensive. Furthermore, a large number of fixed effects increase the variability of other estimates. In order to solve this problem, I follow an approach suggested by Koenker (2004) using penalized quantile regression and sparse linear algebra.

productivity. I also provide evidence that the import competition mechanism is not capturing an increased access to imported inputs, and that increased export opportunities indeed lead to larger exports and a higher propensity to exports at the firm level, without affecting output prices.

Furthermore, I show what type of activities Spanish firms undertake in order to increase productivity, by looking at a large number of other variables such as R&D investment, patenting, product innovation, adaptation of foreign technologies or implementation of other technologies. Finally, I use employment as a dependent variable to check whether import competition and export opportunities have any or differing effects on firm employment.

5 Main empirical results

Import competition versus export opportunities. Table 3 conducts a "horse race" between import competition and access to export markets by estimating equation 4.2 to see whether either one affects firm level productivity. Columns (1) and (2) regress productivity on import competition and export access separately, and both regressions show a similar sized, significant effect of trade on productivity. However, if including both measures in column (3), the coefficient on import competition falls and becomes insignificant, showing that the regression in column (1) suffered from severe omitted variable bias and captured the joint effect of both imports and exports. As imports and exports are usually highly correlated, there is a substantial omitted variable bias in empirical studies focusing only on import competition or export opportunities. A similar argument holds when comparing columns (2) and (3), but the effect of export opportunities on productivity remains significant.

Adding industry fixed effects in column (4) and firm fixed effects in column (5) makes the difference between import competition and export access even more pronounced. Access to export opportunities has a strong and significant positive effect on firm level productivity. If exports increase by 10%, average firm level productivity increases by 1.1%. On the other hand, import competition has a much smaller and insignificant average effect. A regression focusing only on import competition is actually picking up the effect of export opportunities. However, this does not necessarily mean that there is no economic role of import competition, as the average effect washes out heterogeneity in the response of firms.

Heterogeneous effects. Not all firms might react in the same way to increased import competition or increased export opportunities. It might even be that the insignificant coefficient on import competition hides a heterogeneous reaction that averages out. Table 4 therefore checks for heterogeneous effects by adding interaction terms with the firm's initial productivity level (in year 1993) as in equation 4.3. An interesting pattern emerges in column (1): While the overall average effect of import competition is positive but insignificant, the firms with the lowest initial productivity levels actually do increase their productivity. This effect fades out as firms' initial productivity increases. At the same time, while the overall average effect of export opportunities is positive and significant, it turns out that it is really only firms with an initially already high level of productivity that are driving these results. This should not come as a surprise, as the trade literature on heterogeneous firms (e.g. Melitz 2003) predicts that only firms with high productivity are exporting, and the empirical literature (e.g. Bernard et al. 2007) find that exporting firms are usually the most productive firms in an industry.

This pattern is even more pronounced in column (2) which adds firm fixed effects. Column (3) adds industry*year fixed effects that absorb imports and exports as well as any difference across industries and over time. However, the interaction effects can still be estimated and their coefficients are robust to this inclusion.

In order to interpret the coefficients in Table 4, I plot the predicted change in productivity from import competition and export opportunities by initial productivity for the observed sample of firms. Figure 4 uses my preferred specification in column (2) of Table 4 and shows that the average annual increase in import competition (11.1%) leads firms with the lowest productivity level to increase their productivity by 2.4%. The effect from export opportunities is even stronger, but only for the firms with the highest productivity levels: The average annual increase in export opportunities (10.9%) makes highly productive firms increase their productivity by 3.5%. Scaled up to the overall observed increase in trade over the 15 years in the sample, import competition could have been responsible for a 35% productivity increase for low-TFP firms, and export opportunities could have been responsible for a 53% productivity increase for high-TFP firms (Table 5).

Endogenous trade flows. If trade flows depend on the productivity growth in an industry, our estimates might be biased. Therefore I use weighted import and export tariff changes (constructed as described in section 4) as instruments for import competition and export opportunities in Table 6, and the interaction of tariff changes with initial TFP as instruments for the interaction terms. Column (1) repeats my preferred OLS specification in column (2) in Table 4, including both firm and year fixed effects. Column (2) in Table 6 shows the instrumented version of that regression. The Kleibergen-Paap statistics reported in the last row is 22.10, confirming a strong joint first stage. Table 7 reports the four first stages associated with column (2). Import tariffs have a negative impact on imports, and the same is true for exports, as expected. This relationship also holds for the interaction terms.

The magnitudes of the IV estimates is larger compared to the OLS results, pointing to measurement error in imports and exports in the OLS regression.[8] The effect of import competition is no longer significant, but the effect of access to export markets remains significant. According to the IV estimates in column (2), the average annual increase in export opportunities increased the productivity of high-TFP firms by 9.8% (compared to 3.5% in the OLS estimation). Columns (3) and (4) add industry*year fixed effects, omitting the main effects, but the findings in terms of the interaction terms are very similar.

Measurement of productivity. The results on access to export markets are not sensitive to the way of measuring productivity. For example, in Table 8 I use labor productivity or TFP estimates obtained via simple fixed effects regression (of sales on employment and capital including firm and year fixed effects) as dependent variable, and the results are very similar. The results on import competition are not significant across all specifications, but if anything it points again to firms with the lowest initial productivity being affected the most.

Selection. As previously explained, we might still be overestimating the effect of trade on productivity because there is a selection effect coming from the exits of unproductive firms. In order to include exiting firms, I assign them the lowest observed productivity change tin a given industry and year, and include these firms in the OLS and IV regressions in columns (5) and (6) of Table 6. As there are not very many exiting firms, the sample increases by less than 2%. Figure 5 shows that exiting firms tend to have a

[8]It is not that surprising to find measurement error in export and imports. Other studies have found that trade flows reported by the importing and exporting country often differ, and attribute this to misreporting.

lower initial productivity as continuing firms, but there is still quite a wide dispersion, so assigning them the lowest observed productivity change might be conservative. However, compared to the regressions without exiting firms, the estimates remain largely unchanged. In the IV regressions, the import competition effect becomes significant when including exiting firms.

Quantile regressions are robust to the precise value that is assigned to exiting firms, as long as the share of exiting firms is smaller than the estimated quantile. Therefore I conducted a set of quantile regressions with and without exiting firms.[9] As there is little change in the estimated effects, selection does not seem to be a major explanation for observed effects on productivity.

Overall, the regressions conducted so far have shown a very robust effect of access to export markets on the productivity of firms, but only for firms that initially already had a high productivity. The effect of import competition on productivity is weaker and not significant in all specifications. If anything, only initially low productive firms increase their TFP because of import competition.[10]

Robustness checks. Are those firms who are induced by export opportunities to update their productivity also the ones who actually increase their exports or start to export? Otherwise I might be not be capturing the right mechanism. To check this, column (1) in Table 9 uses firm level exports as dependent variable in the IV regressions from before (IV specification as in column (2) of Table 6). It is reassuring to see that the result is consistent with the export access mechanism and not picking up any spurious correlation, as firm level exports increase in response to increased export opportunities (driven by tariff changes), but only for the most productive firms. Column (2) uses the change in exporter status as a dependent variable, and the pattern is similar. Access to export markets increase exports at both the extensive and intensive margin. Column (3) checks whether the increase in exports is related to prices or quantities by using the change in output prices as a dependent variable.[11] However, there is no significant change in output prices related to access to export markets. Note that the combined first stage is again strong enough in all three regressions, as indicated by the large Kleibergen-Paap statistics.

Another concern is that increased imports might not be only a measure of import competition, but also provide firms with the opportunity to use (potentially cheaper) imported goods as intermediate goods which might be reflected in TFP. The used instrumental variable captures tariff changes at the output level of an industry and should therefore not pick up variation in imports driven by inputs. However, tariff changes for inputs and outputs of an industry might be correlated, and therefore the regression might still pick up a change in imported inputs. Table 10 uses firm level imports as dependent variable in the IV regressions to check this. Column (1) shows no significant change in firm level imports as response to import competition. Column (2) uses the change in the probability to import as dependent variable, and these results go into the opposite direction as the productivity results. Column (3) uses the change in intermediate input prices as dependent variable.[12] Again, the results go into the opposite direction as the productivity results. Interestingly, these changes are also observed for firms who get access to export

[9] I conducted quantile regressions for the 0.1, 0.25, 0.5, 0.75 and 0.9 percentile; with and without interaction terms, and all results were insensitive to the inclusion of exiting firms (because their number is quite small). The estimation results are available upon request from the author.

[10] In earlier, unpublished work I found the same results using French firm level data. As this data set did not distinguish between non-response and firm exits, I was unable to address the selection problem. However, it is reassuring that the results seem to be general and hold across different countries and data sets.

[11] This variable refers to all products produced by a firm, not only for exported goods, which is not available in the survey.

[12] This variable refers to all inputs of a firm, not only imported goods, which is not available in the survey.

markets. The most productive firms which upgrade their productivity as response to export opportunities reduce imports and pay higher input prices which is the opposite of what we would expect to happen if our measures are picking up a better access to imported inputs.

Ways to increase productivity. What do firms actually do to increase their productivity? Table 11 checks whether firms that are exposed to increased import competition or get access to export markets engage in some activities that have the potential to increase TFP. Columns (1) and (2) show that firms upgrade their productivity by increasing R&D expenses and starting to engage in R&D. Firms also increase the number of patents and start to engage in patenting (columns (3) and (4)).[13] Column (5) shows that the firms also engage in product innovation, as they increase their number of products. For firms with access to export markets this could mean that they adapt their products to foreign tastes or standards. Firms under competition from abroad might be forced to develop new products in niches where they can still be competitive, or to adapt their products to compete with foreign firms.

Every four years the survey contains additional questions about the use of specific technologies. These technologies are the use of robots, computer aided design (CAD), and flexible manufacturing systems. As these variables are only surveyed every four years, the sample size drops significantly, and the first stage becomes too weak to use IV regressions. In column (6) I report therefore the OLS results of the adaptation of the technology that had significant coefficients in the regressions: the use of CAD. However, CAD is only used by productive firms that are exposed to export opportunities, and not by firms exposed to import competition.

Trade liberalization is often believed to allow or induce domestic firms to adapt foreign, more efficient technologies in order to stay competitive. In order to test this claim empirically, I check whether firms make an effort to assimilate foreign technologies in their production process as a result of increased trade. Column (7) finds that this is true, but only for the access to export markets channel, and only for very productive firms. Interestingly, firms faced with increased import competition do not adapt foreign technologies.

Implications for employment. There is strong evidence for the productivity enhancing effect of export opportunities, and weak and heterogeneous evidence of the productivity enhancing effect of import competition. Both channels might have different implications for employment: Import competition might lead to labor-saving productivity increases, while access to export markets might lead to employment growth. Table 12 uses employment as the dependent variable in IV regressions. Interestingly, neither import competition nor access to export opportunities lead to significant employment changes. Note that although exports and sales increase for high-TFP firms that are exposed to export opportunities, labor productivity increases as well, leading to an insignificant net change in employment. However, when taking a closer look by employment type, e.g. full-time and part-time employment as well as temporary workers (who are not included in total employment), there is some evidence that low-TFP firms induced by import competition to upgrade their productivity have increased their temporary staff (potentially replacing full time workers, but the coefficient is not significant), whereas high-TFP firms induced by export opportunities to increase their productivity increased their part time staff (again, potentially replacing full time workers, but the coefficient is not significant). In any case, there is no evidence that employment increased as a result of increased trade.

[13] The results are unchanged if I normalize the number of filed patents by employment.

6 Model

This section provides a trade model that is consistent with the empirical findings: Access to export markets induces already very productive firms to upgrade their productivity, whereas import competition induces only firms with low initial productivity to increase their productivity.

While incorporating endogenous technology choice in a standard Melitz (2003) type trade model yields the prediction about export access (e.g. Bustos 2011; Melitz and Costantini 2007; Lileeva and Trefler 2010), including the "import competition" mechanism is more difficult. Standard CES preferences result in constant markups and therefore there is no role for import competition. With alternative preferences it is possible to show that trade liberalization has pro-competitive effects as it reduces markups (e.g. quasilinear preferences as in Melitz and Ottaviano 2008; translog preferences as in Feenstra 2003; CARA utility as in Behrens and Murata 2007; or decreasing relative love for variety as in Zhelobodko et al. 2011). However, in this case endogenous technology choice does not provide an incentive for the initially *least* innovative firms to upgrade, but the opposite. In order words, if low productive firms would have wanted to increase their productivity, they would have done so even before trade liberalization.

One possibility to generate the behavior observed in the data is to introduce non-profit maximizing managers, as in Aghion et al. (1999). Managers innovate in order to reduce the risk of bankruptcy following increased competition. In this paper I apply this idea as follows: Managers get a constant salary if the firm exists and therefore face a discontinuous cost when the firm goes bankrupt. I incorporate this idea into a Melitz and Ottaviano (2008) which is extended to allow for endogenous productivity upgrades.

Demand. There are L consumers with quasilinear preferences over a continuum of differentiated varieties q_i^C, $i \in \Omega$, and a homogeneous good q_0^C:

$$U = q_0^C + \alpha \int_{i \in \Omega} q_i^C \, \mathrm{d}i - \frac{1}{2}\gamma \int_{i \in \Omega} \left(q_i^C\right)^2 \, \mathrm{d}i - \frac{1}{2}\eta \left(\int_{i \in \Omega} q_i^C \, \mathrm{d}i\right)^2$$

The inverse demand curve for each variety i is then

$$q_i\left(p_i\right) = \frac{L}{\gamma}\left(\alpha - \eta Q - p_i\right) \quad \text{with} \quad Q = \int_{i \in \Omega} q_i^C \, \mathrm{d}i$$

Demand is positive as long as prices are not too high, i.e. $p_i < \alpha - \eta Q$.

Q reflects the degree of competition, as it is an increasing function of the number of firms N and a decreasing function of average prices of products that have positive demand (subset $\Omega^* \subset \Omega$):

$$Q = \frac{N\left(\alpha - \bar{p}\right)}{\gamma + \eta N} \quad \text{with} \quad \bar{p} = \frac{1}{N} \int_{i \in \Omega *} p_i \, \mathrm{d}i$$

Technology. After paying a sunk entry cost f_e, firms draw their initial productivity (marginal cost c_i) from a Pareto distribution $G(c) = \left(\frac{c}{c_M}\right)^k$. Firms are run by managers who can spend effort in order to decrease the initial marginal cost, i.e. increase the firm's productivity. The cost of effort to the manager depends on the achieved change in cost ψ and is given by the increasing, convex function $f(\psi) = \frac{1}{2}\psi^2$. A numeraire good is produced under perfect competition with a unit labor input requirement which pins down wages to equal 1. The gross profits of the firm are given by revenue net of production cost (subscript i omitted for simplicity):

$$\pi(c, \psi) = pq(p) - (c - \psi)q(p)$$

Managers. Managers receive a fixed salary s plus a share β of gross profits unless the firm is bankrupt. A firm goes bankrupt if its net profit, i.e. the profit after paying the bonus and salary to the manager, becomes negative.The utility of managers is given by

$$U^M = \begin{cases} s + \beta\pi(\psi) - f(\psi) & \text{if } (1-\beta)\,\pi(\psi) - s \geqslant 0 \\ 0 & \text{if } (1-\beta)\,\pi(\psi) - s < 0 \end{cases}$$

Managers have to decide how much effort to spend in order to upgrade productivity.

Closed economy equilibrium. Firms face monopolistic competition and therefore prices are set at[14]

$$p(c, \psi) = \frac{1}{2}(\alpha - \eta Q + c - \psi)$$

Gross profits are therefore

$$\pi(c, \psi) = \frac{L}{4\gamma}(\alpha - \eta Q - c + \psi)^2$$

In the appendix I show that if $2\gamma - \beta L > 0$, optimal effort as a function of the initial cost draw is given by the following function:[15]

$$\psi(c) = \begin{cases} \psi_L(c) := \frac{\beta L}{2\gamma - \beta L}(\alpha - \eta Q - c) & \text{if } c < c_L \\ \psi_U(c) := \sqrt{\frac{4\gamma s}{(1-\beta)L}} - \alpha + \eta Q + c & \text{if } c_L < c < c_U \\ 0 & \text{if } c > c_U \end{cases}$$

with

$$c_L := \alpha - \eta Q - \frac{(2\gamma - \beta L)\sqrt{s}}{\sqrt{\gamma(1-\beta)L}}$$

$$c_U := \alpha - \eta Q - \sqrt{\frac{s}{(1-\beta)L}}\left(\sqrt{\gamma} - \sqrt{\frac{L}{2}}\right)$$

The optimal effort function is illustrated in Figure 6. If a firm's initial cost draw is below c_L, a manager spends effort in order to equalize the marginal benefit of an increase in profits to the marginal cost of exerting effort. Since profits are convex in the initial cost draw, the lower the initial cost draw, the higher the benefits from reducing it even further. Therefore managers' effort is higher at a low cost draw compared to a higher cost draw, i.e. the effort function $\psi_L(c)$ is decreasing in the cost draw.[16]

[14] Note that managers will get a share of profits, therefore the incentives of the firm and the manager are aligned for price setting.

[15] Note that if $2\gamma - \beta L < 0$, quantities are not positive at any cost draw.

[16] Since firm's cost cannot become negative, there is a limit to the cost reduction that can be achieved by a manager. This means for firms with a very low cost draw, the managers effort will actually fall again. However, as this is only relevant for very small initial cost draws, this case is excluded from the analysis.

Once the initial cost draw is too high for the firm to be profitable, $c > c_L$, a manager increases his effort to reduce cost in order to make sure that the firm does not go bankrupt, because the manager wants to receive her salary. The higher the initial cost draw, the more effort managers need to spend in order to ensure survival: $\psi_U(c)$ is increasing. Managers exert effort until the initial cost draw is too high and the salary cannot compensate the manager anymore for the extra effort required to reduce cost. At this point, if $c > c_U$, managers' utility would be negative and the manager lets the firm exit. Note that the distribution of firms with respect to final productivity, i.e. productivity after endogenous upgrading, has a bunching point at the lowest cost cutoff c_L.

Perfect trade integration. For simplicity consider first the case in which there are no trade cost and countries are perfectly integrated. Comparing the open economy to the closed economy then amounts to analyzing an increase in market size L. In Melitz and Ottaviano (2008) trade liberalization has two effects: A market size effect, which results in an increase in profits for the most productive firms. At the same time, the increase in profits induces more firms to enter, which lowers markups and average prices. As a result the zero cost cutoff falls and firms exit, which is the import competition effect.

Here I distinguish between the two effects and consider the impact of either a reduction in the cost cutoff c_L (import competition effect, holding market access constant[17]) or an increase in L (export access effect, holding the cost cutoff constant) on the optimal effort function for the least and most productive firms.

Consider first the import competition effect: If the cost cutoff falls, managers at the old cost cutoff and below will spend more effort in order to keep the firm from bankruptcy and secure their salary (unless this is too costly for them which results in increased exits of the least productive firms). The market access effect results in an increase in profits which induces managers to spend more effort. The lower the initial cost draw, the more productive is the firm, and the larger the increase in profits and therefore the incentive for managers to upgrade productivity.

Figure 7 illustrates the change in the effort function of managers. In the appendix I show analytically how the effort function changes.

Trade liberalization with positive trade cost. Assume that there are two symmetric countries. Firms can export goods to the foreign country after paying a variable transport cost $\tau > 1$. Firms export if profits from exporting are positive:

$$\pi_X = pq(p) - \tau(c - \psi)q(p) = \frac{L}{4\gamma}\left(\alpha - \eta Q - \tau\left(c - \psi\right)\right)^2 > 0$$

Firm gross profits comprise of profits from domestic sales and profits from exporting:

$$\pi(c, \psi) = \frac{L}{4\gamma}\left(\alpha - \eta Q - c + \psi\right)^2 + \frac{L}{4\gamma}\left(\alpha - \eta Q - \tau\left(c - \psi\right)\right)^2 1_X$$

where 1_X denotes whether the firm exports or not.

Managers choose their effort in order to maximize utility

[17]Note that in contrast to Melitz and Ottaviano (2008), trade liberalization does not necessarily result in a reduction of the cost cutoff, the effect is ambiguous. While larger markets increase profits inducing a larger number of entrants and therefore reducing the cost cutoff, larger profits also makes it possible for less efficient firms to cover the fixed salary of a manager, thus increasing the cost cutoff. In this model I define the import competition effect as a reduction of the cost cutoff.

$$\max_{\psi} s + \frac{\beta L}{4\gamma}(\alpha - \eta Q - c + \psi)^2 + \frac{\beta L}{4\gamma}(\alpha - \eta Q - \tau(c - \psi))^2 1_X - \frac{1}{2}\psi^2$$

such that firms' net profits are positive:

$$(1 - \beta)\pi - s \geqslant 0$$

Denote the initial cost draw below which firms export as c_X. If the initial cost draw is higher, only domestic sales are relevant, and optimal effort functions are as before (note though that Q is different, as it reflects the number of firms and average price levels). In the appendix I derive the optimal effort function when the firm exports. Overall, the optimal effort function is given by

$$\psi(c) = \begin{cases} \psi_X(c) := \frac{\beta L}{2\gamma - \beta L(1+\tau)}(2(\alpha - \eta Q) - c(1+\tau)) & \text{if } c < c_X \\ \psi_L(c) := \frac{\beta L}{2\gamma - \beta L}(\alpha - \eta Q - c) & \text{if } c_X < c < c_L \\ \psi_U(c) := \sqrt{\frac{4\gamma s}{(1-\beta)L}} - \alpha + \eta Q + c & \text{if } c_L < c < c_U \\ 0 & \text{if } c > c_U \end{cases}$$

with

$$c_X := \frac{2\gamma - \beta L + \tau\beta L}{2\gamma\tau}(\alpha - \eta Q)$$

$$c_L := \alpha - \eta Q - \frac{(2\gamma - \beta L)\sqrt{s}}{\sqrt{\gamma(1-\beta)L}}$$

$$c_U := \alpha - \eta Q - \sqrt{\frac{s}{(1-\beta)L}}\left(\sqrt{\gamma} - \sqrt{\frac{L}{2}}\right)$$

Figure 8 illustrates the change in the effort function. Trade liberalization has again two effects: Productive firms have the opportunity to generate additional profits by exporting. The marginal benefit from exerting effort is larger for firm with lower cost draws, as profits from exporting are larger. Managers with a low initial cost draw will therefore spend more effort, this is the "access to export market" channel. Due to increased import competition, the cost cutoff point c_L above which a firm has zero profits falls. Because of the convexity in the payoff function of managers due to the fixed salary, some managers with high cost draws will now find it optimal to increase effort to ensure survival of the firm. TIn the appendix I show formally how both channels affect firms differentially.

7 Conclusions

Trade liberalization affects firms in several ways: One the one hand, firms get access to new export markets, providing them with an opportunity for growth. On the other hand, foreign firms enter the home market and create more competition for domestic firms. Both of these two "faces" of globalization might induce firms to upgrade their productivity. Increased export opportunities can make it worthwhile for firms to invest in new technology, while increased competitive pressure from foreign companies might force firms to engage in innovation in order to avoid bankruptcy or retain monopoly rents.

Existing papers have mostly focused on the productivity inducing effect of either export access or import competition. However, usually imports and exports are highly correlated (even within narrowly defined industries), and it is not clear whether empirical papers are picking up the right mechanism, or whether they suffer from omitted variable bias.

This paper disentangles the the two channels. The results suggest that empirical papers focusing on import competition pick up the effect of access to export markets by omitting this variable. On average, the impact of export opportunities on productivity is large and significant, while the impact of import competition is small and insignificant. This highlights that papers studying the effects of import competition or access to export markets need to control for the other channel in order to eliminate omitted variable bias. Furthermore, in order to deal with the endogeneity of imports and exports, it is necessary to find two instrumental variables, one for each trade direction. Trade liberalization episodes usually affect tariffs of both the importing and exporting country, making them highly correlated. It is therefore not sufficient to instrument for only exports or imports. The two instruments need to be sufficiently uncorrelated such that the matrix of first stages is full rank, so papers need to report the Kleibergen-Paap statistics on top of checking the F-statistics on each first stage separately.

Furthermore, there is a large heterogeneity in both the effects of export access and import competition, depending on the initial productivity of firms: Only already very productive firms update their productivity when subject to new export opportunities. The evidence on import competition is weaker, with possibly initially low-tech firms managing to increase their productivity in response to increased competition from abroad. The latter result is surprising, as standard trade models predict the opposite. I therefore provide a trade model that is consistent with the empirical findings, by adding non-profit maximizing managers to a Melitz and Ottaviano (2008) model extended to an endogenous productivity choice. Managers receive a fixed salary if the firm exists, which introduces convexity in their payoff function. As a result, increased import competition induces those managers to upgrade productivity by more.

Productivity upgrades are driven by increased R&D, patenting, and product innovation. Access to export markets induces the adaptation of foreign technologies for the most productive firms. There is no evidence that either mechanism leads to increased full time employment, instead full time workers seem to be replaced by part-time or temporary workers, which is probably disappointing for policy makers. Growth in firm size seems to be offset by increase in (labor saving) productivity, leveling out the effect on employment.

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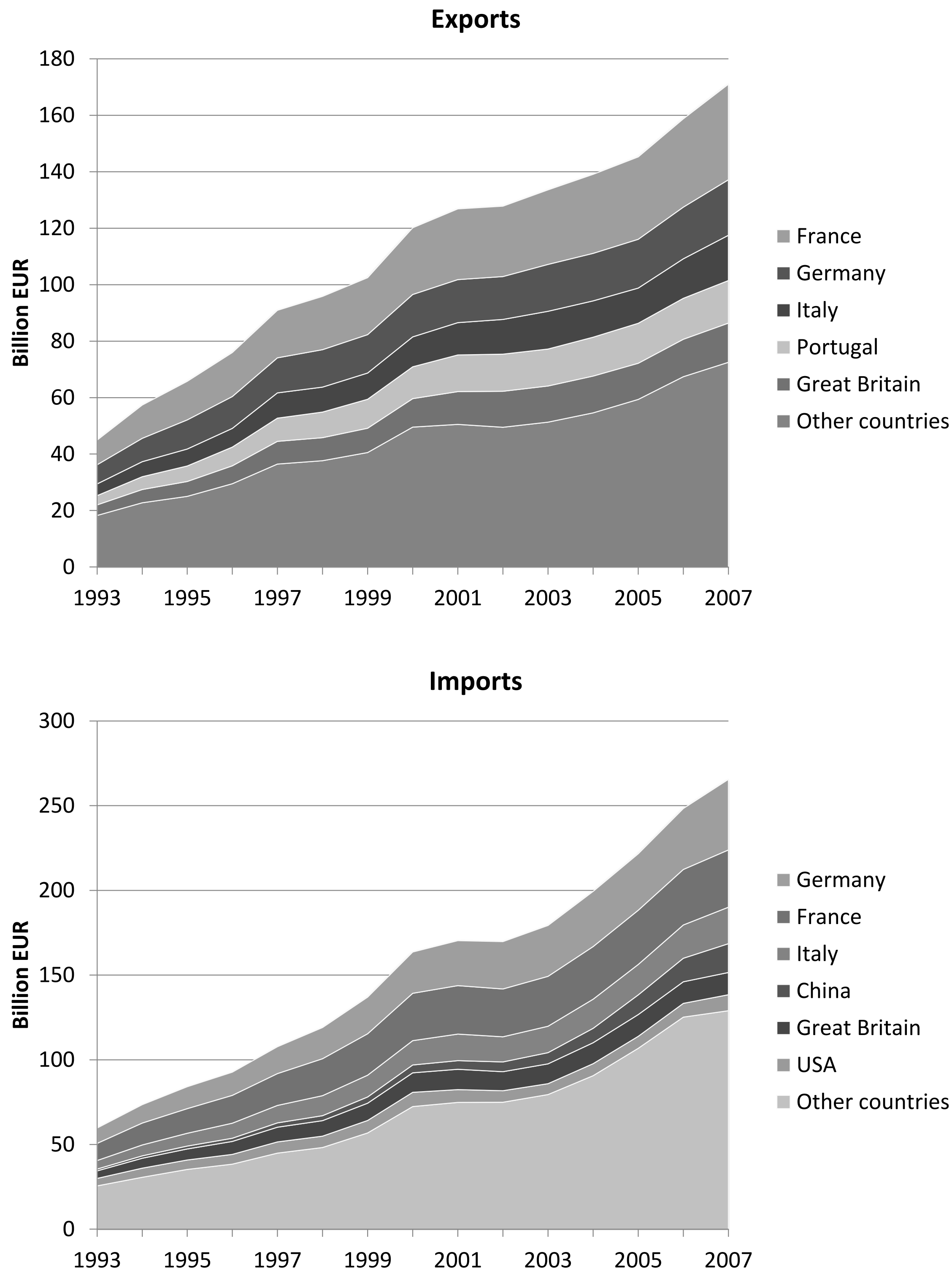
Appendix

A Figures

Figure 1: Spain's world trade over time

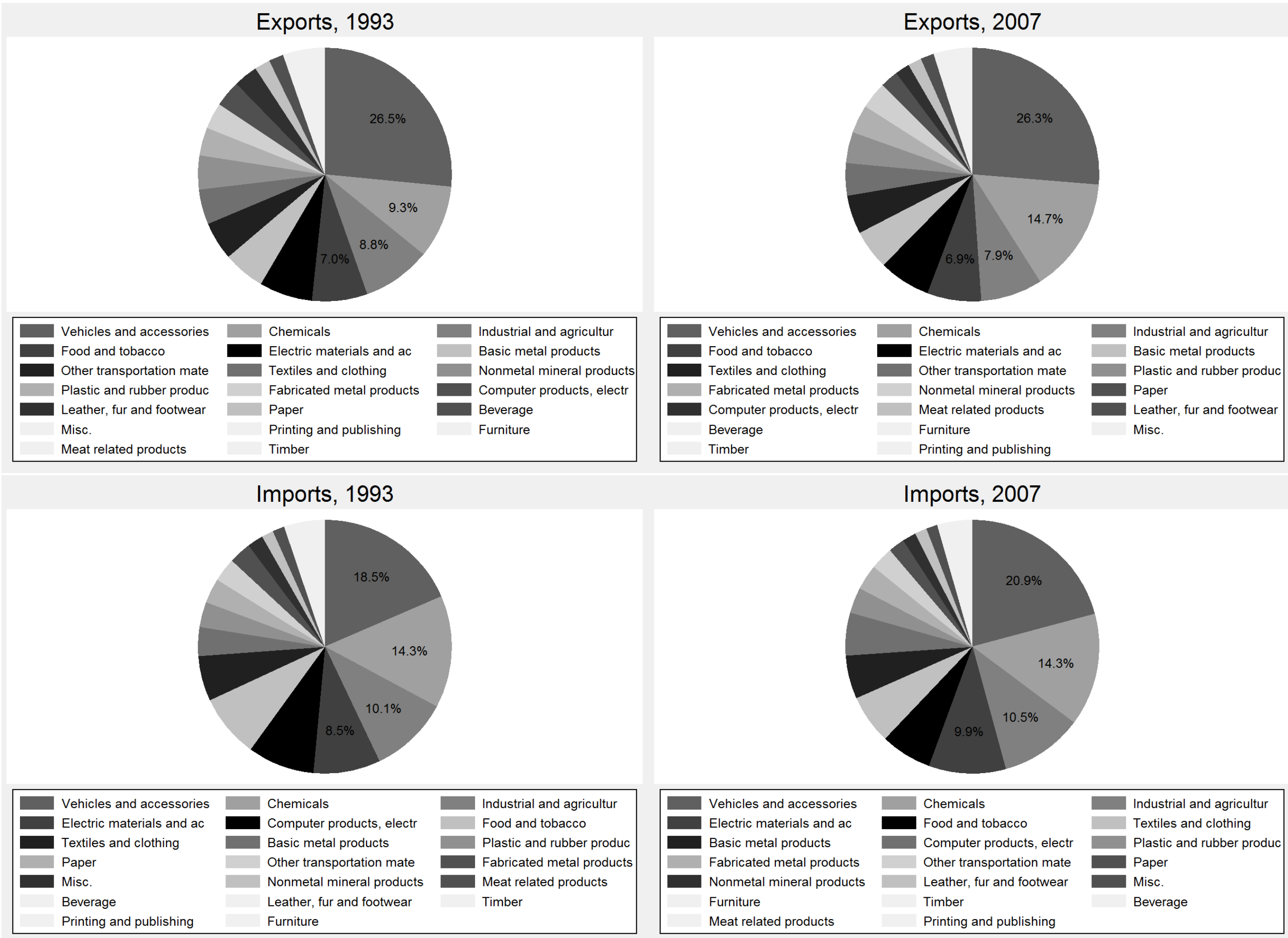
Source: United Nations COMTRADE database, accessed by World Integrated Trade Solution (WITS), `wits.worldbank.org`

Figure 2: Spain’s trade by country over time



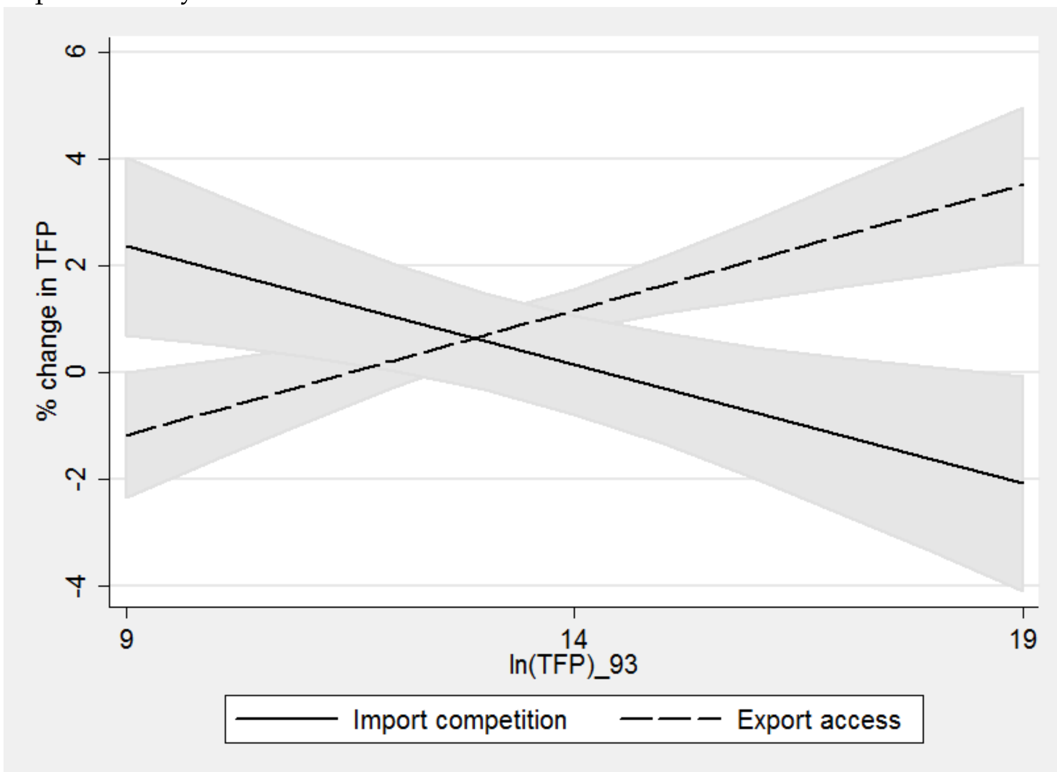
Source: United Nations COMTRADE database, accessed by World Integrated Trade Solution (WITS), `wits.worldbank.org`

Figure 3: Spain's trade by industry over time



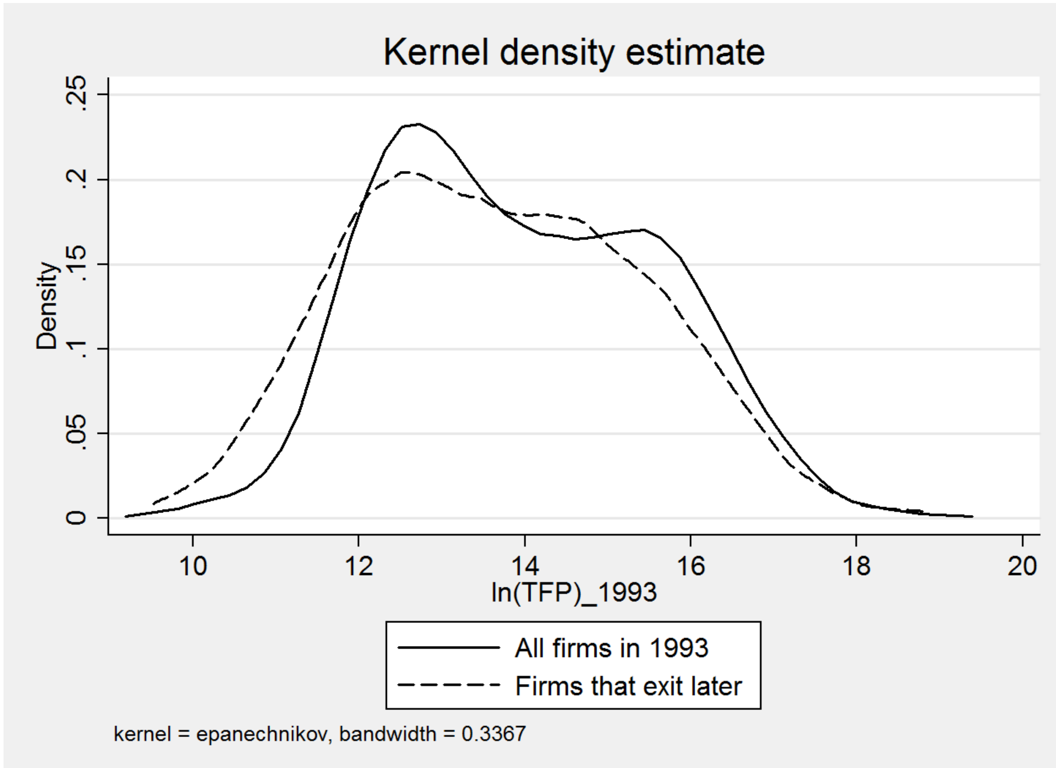
Source: United Nations COMTRADE database, accessed by World Integrated Trade Solution (WITS), `wits.worldbank.org`

Figure 4: Estimated effect of import competition and export access on productivity growth of firms, by firms' initial productivity



Notes: The average annual increase in trade is 11.1% for imports and 10.9% for exports over the observed sample period between 1993 and 2007. The shaded areas represent the 90% confidence interval of the estimates.

Figure 5: TFP distribution of all firms and exiting firms



Notes: The graph shows the kernel density of ln(TFP) in 1993 for all firms that exist in 1993 and separately for the subset of firms that exit at some later point in time. TFP is estimated by Levinsohn-Petrin method, adjusted for changes in input and output prices.

Figure 6: Manager's compensation and incentive to increase productivity before trade liberalization.

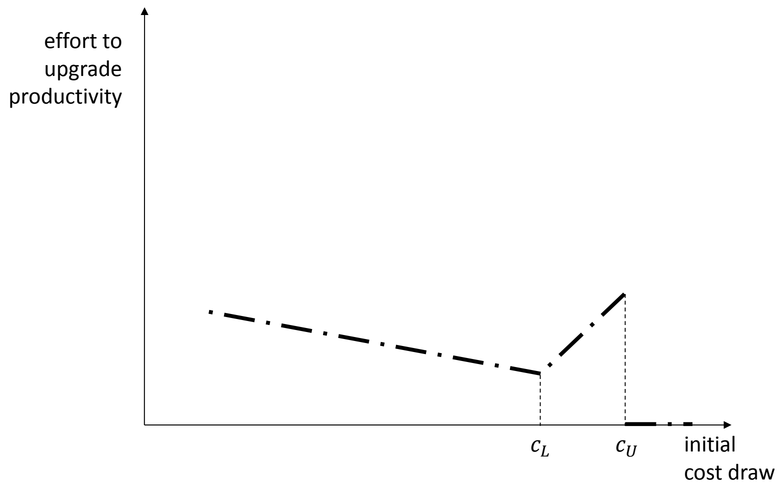


Figure 7: Effect of perfect trade integration on productivity upgrades

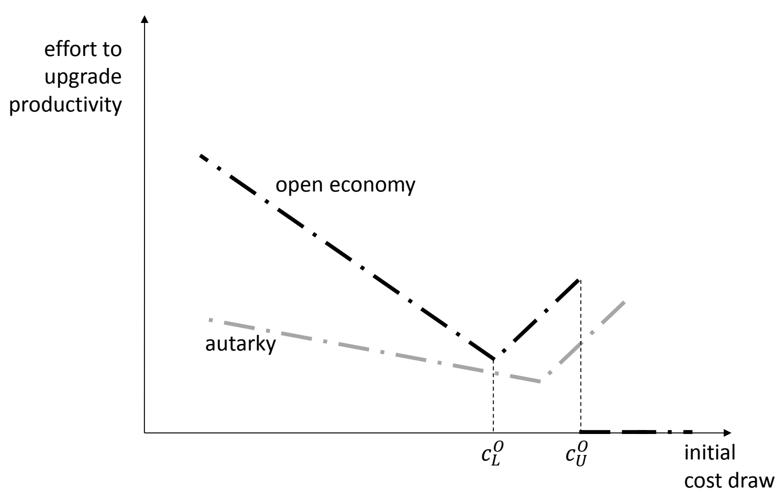
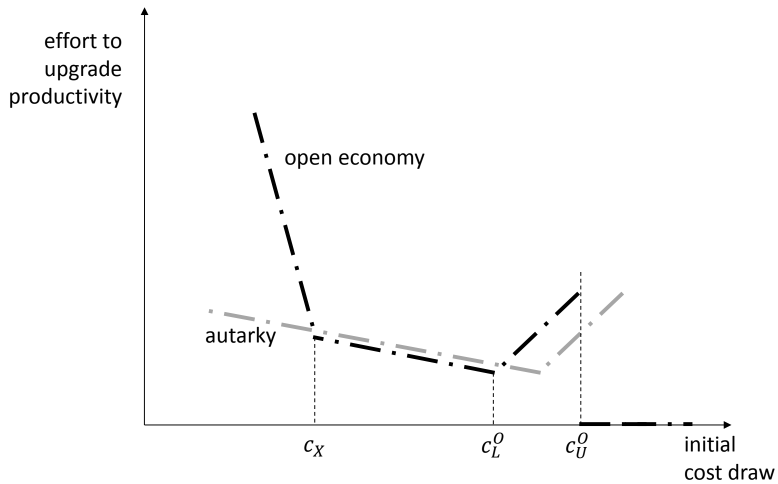


Figure 8: Effect of trade liberalization with positive trade cost on productivity upgrades



A Tables

Table 1: Top 3 import origins by industry

Industry	Country	import share 1993	Country	import share 2007	Industry	Country	import share 1993	Country	import share 2007
Total trade	France	17%	Germany	16%					
	Germany	15%	France	13%					
	Italy	8%	Italy	8%					
Meat related products	France	24%	France	21%	**Nonmetal mineral products**	France	20%	China	21%
	Netherlands	15%	Germany	15%		Germany	13%	Portugal	15%
	United Kingdom	10%	Netherlands	15%		Italy	13%	Italy	13%
Food and tobacco	France	21%	France	16%	**Basic metal products**	France	27%	France	17%
	Netherlands	9%	Germany	11%		Germany	17%	Germany	10%
	Germany	7%	Argentina	8%		United Kingdom	14%	China	9%
Beverage	United Kingdom	53%	United Kingdom	32%	**Fabricated metal products**	Germany	25%	Germany	22%
	Netherlands	11%	France	12%		Italy	20%	Italy	17%
	France	10%	Italy	8%		France	19%	France	14%
Textiles and clothing	Italy	19%	China	22%	**Industrial and agricultural equipment**	Germany	24%	Germany	22%
	France	11%	Italy	13%		Italy	21%	Italy	19%
	China	9%	Turkey	8%		France	14%	France	11%
Leather, fur and footwear	Italy	22%	China	35%	**Computer products, electronics and op**	United States	17%	Netherlands	16%
	China	15%	Italy	15%		Germany	14%	Germany	16%
	Korea, Rep.	7%	Vietnam	8%		France	13%	China	12%
Timber	United States	17%	Portugal	13%	**Electric materials and accessories**	Germany	19%	Germany	19%
	Portugal	16%	France	10%		France	14%	China	15%
	France	12%	China	10%		Japan	12%	France	9%
Paper	Finland	20%	France	20%	**Vehicles and accessories**	France	31%	Germany	34%
	France	16%	Finland	14%		Germany	30%	France	24%
	Germany	13%	Germany	14%		United Kingdom	8%	Italy	7%
Printing and publishing	United Kingdom	19%	United Kingdom	20%	**Other transportation materials**	United States	47%	France	21%
	Germany	17%	Germany	16%		Italy	10%	United States	20%
	Italy	12%	China	11%		Japan	8%	United Kingdom	12%
Chemicals	Germany	20%	Germany	17%	**Furniture**	Italy	22%	China	20%
	France	17%	France	14%		France	20%	Italy	14%
	United Kingdom	9%	United States	8%		Germany	18%	Germany	14%
Plastic and rubber products	France	27%	Germany	20%	**Games & toys, sports instr**	China	20%	China	22%
	Germany	23%	Italy	16%		Italy	14%	Germany	16%
	Italy	14%	France	16%		Japan	12%	United Kingdom	15%

Note: Countries with the largest change are shaded.

Table 2: Top 3 export destinations by industry

Industry	Country	export share 1993	Country	export share 2007	Industry	Country	export share 1993	Country	export share 2007
Total trade	France	19%	France	20%					
	Germany	15%	Germany	11%					
	Italy	9%	Italy	9%					
Meat related products	France	32%	France	29%	**Nonmetal mineral products**	France	16%	France	19%
	Portugal	19%	Portugal	20%		Germany	12%	Portugal	10%
	Germany	12%	Germany	10%		United States	11%	United Kingdom	8%
Food and tobacco	Italy	16%	France	19%	**Basic metal products**	France	12%	France	15%
	France	14%	Italy	18%		Germany	10%	Italy	15%
	Portugal	10%	Portugal	15%		China	8%	Germany	15%
Beverage	Germany	17%	United Kingdom	14%	**Fabricated metal products**	France	17%	France	21%
	United Kingdom	14%	Germany	14%		Germany	13%	Germany	13%
	France	10%	France	9%		Portugal	8%	Portugal	12%
Textiles and clothing	France	15%	Portugal	15%	**Industrial and agricultural equipment**	France	15%	France	12%
	Portugal	14%	France	13%		Germany	12%	Germany	11%
	Italy	11%	Italy	9%		Portugal	7%	Portugal	8%
Leather, fur and footwear	Germany	19%	France	20%	**Computer products, electronics and opt**	Germany	23%	Portugal	20%
	United States	17%	Portugal	10%		France	12%	France	10%
	France	15%	Italy	9%		Italy	9%	Germany	9%
Timber	France	21%	France	20%	**Electric materials and accessories**	Germany	19%	France	14%
	Portugal	15%	Portugal	20%		France	15%	Germany	13%
	United Kingdom	10%	United States	9%		Portugal	6%	Italy	9%
Paper	France	21%	France	22%	**Vehicles and accessories**	France	31%	France	32%
	Portugal	16%	Portugal	18%		Germany	21%	Germany	14%
	Germany	12%	Italy	9%		Italy	14%	United Kingdom	11%
Printing and publishing	Argentina	14%	France	23%	**Other transportation materials**	France	12%	France	14%
	Mexico	13%	Portugal	12%		Liberia	11%	United Kingdom	10%
	France	12%	Mexico	11%		Norway	11%	United States	9%
Chemicals	France	13%	Italy	13%	**Furniture**	France	26%	France	30%
	Germany	12%	France	12%		Germany	15%	Portugal	13%
	Italy	10%	Germany	11%		Portugal	11%	United Kingdom	6%
Plastic and rubber products	France	23%	France	23%	**Games & toys, sports instr**	France	20%	France	19%
	Germany	15%	Germany	13%		Germany	9%	Portugal	17%
	Portugal	9%	Portugal	11%		Portugal	9%	United States	8%

Note: Countries with the largest change are shaded.

Table 3: Import competition versus access to export markets

VARIABLES	(1) $\Delta \ln(TFP)$	(2) $\Delta \ln(TFP)$	(3) $\Delta \ln(TFP)$	(4) $\Delta \ln(TFP)$	(5) $\Delta \ln(TFP)$
$\Delta \ln(IMP)$	0.094*		0.065	0.035	0.015
	(0.049)		(0.047)	(0.052)	(0.053)
$\Delta \ln(EXP)$		0.096***	0.065**	0.085***	0.106***
		(0.034)	(0.025)	(0.024)	(0.028)
Observations	14,027	14,027	14,027	14,027	13,892
R-squared	0.001	0.001	0.002	0.002	0.002
Year fixed effects	YES	YES	YES	YES	YES
Industry fixed effects				YES	
Firm fixed effects					YES

Notes: The dependent variable $\Delta \ln(TFP)$ denotes the change in log TFP (estimated by Levinsohn-Petrin method, adjusted for changes in input and output prices). The main regressors are $\Delta \ln(IMP)$ measuring the change in log of Spain's world imports, and $\Delta \ln(EXP)$ measuring the change in log of Spain's world exports, both at the NACECLIO industry level. * p<0.05, ** p<0.01, *** p<0.001. Standard errors in parentheses are clustered by NACECLIO industries.

Table 4: Heterogeneous effects

VARIABLES	(1) $\Delta \ln(TFP)$	(2) $\Delta \ln(TFP)$	(3) $\Delta \ln(TFP)$
$\Delta \ln IMP$	0.385**	0.572**	
	(0.195)	(0.238)	
$(\Delta \ln IMP) * \ln(TFP_{93})$	-0.026	-0.040**	-0.026*
	(0.016)	(0.017)	(0.014)
$\Delta \ln EXP$	-0.521***	-0.493***	
	(0.198)	(0.188)	
$(\Delta \ln EXP) * \ln(TFP_{93})$	0.043***	0.043***	0.026*
	(0.014)	(0.014)	(0.015)
Observations	14,027	13,892	13,892
Partial R-squared	0.003	0.003	0.001
Year fixed effects	YES	YES	
Industry fixed effects	YES		
Firm fixed effects		YES	YES
Industry*year fixed effects			YES

Notes: The dependent variable $\Delta \ln(TFP)$ denotes the change in log TFP (estimated by Levinsohn-Petrin method, adjusted for changes in input and output prices). The main regressors are $\Delta \ln IMP$ measuring the change in log of Spain's world imports, and $\Delta \ln EXP$ measuring the change in log of Spain's world exports, both at the NACECLIO industry level. Both main effects are interacted with the log of a firm's initial productivity in year 1993, $\ln(TFP_{93})$. * $p<0.05$, ** $p<0.01$, *** $p<0.001$. Standard errors in parentheses are clustered by NACECLIO industries.

Table 5: Estimated effect of import competition and export opportunities on productivity growth of firms, by firms' initial productivity

	% increase in trade		
% change in TFP	**1%**	**11% (average annual)**	**160% (1993-2007)**
Import competition:			
Firms with lowest observed TFP	0.21%	2.36%	35.46%
Firms with highest observed TFP	-0.19%	-2.10%	-31.4%
Export opportunities:			
Firms with lowest observed TFP	-0.11%	-1.16%	-17.36%
Firms with highest observed TFP	0.32%	3.54%	53.05%

Notes: The predicted changes are calculated based on column (2) of Table 4.

Table 6: Tariff changes as instrumental variables

DEPENDENT VARIABLE: $\Delta \ln (TFP)$	(1) OLS	(2) IV	(3) OLS	(4) IV	(5) OLS	(6) IV
$\Delta \ln IMP$	0.572**	1.448			0.564**	1.634*
	(0.238)	(1.007)			(0.253)	(0.846)
$(\Delta \ln IMP) * \ln (TFP_{93})$	-0.040**	-0.106	-0.026*	-0.0947	-0.0399**	-0.130**
	(0.017)	(0.068)	(0.014)	(0.0616)	(0.0184)	(0.0602)
$\Delta \ln EXP$	-0.493***	-2.711***			-0.376	-2.973***
	(0.188)	(0.753)			(0.247)	(0.699)
$(\Delta \ln EXP) * \ln (TFP_{93})$	0.043***	0.190***	0.026*	0.179***	0.0367**	0.215***
	(0.014)	(0.049)	(0.015)	(0.0512)	(0.0176)	(0.0436)
Observations	13,892	13,892	13,892	13,892	14,178	14,178
Firm fixed effects	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES			YES	YES
Industry*year fixed effects			YES	YES		
Including exiting firms					YES	YES
First stage Kleibergen-Paap statistics		22.10		22.24		20.45

Notes: The dependent variable $\Delta \ln (TFP)$ denotes the change in log TFP (estimated by Levinsohn-Petrin method, adjusted for changes in input and output prices). The main regressors are $\Delta \ln IMP$ measuring the change in log of Spain's world imports, and $\Delta \ln EXP$ measuring the change in log of Spain's world exports, both at the NACECLIO industry level. Both main effects are interacted with the log of a firm's initial productivity in year 1993, $\ln (TFP_{93})$. Columns (2), (4) and (6) use weighted tariff changes (multiplied by importance weights) as described in the text as instrumental variables for import competition and export access, and their interactions with initial productivity as instrumental variables for the interaction terms. Columns (5) and (6) include exiting firms and assigns them the lowest observed productivity change in their exiting year in their industry. * $p<0.05$, ** $p<0.01$, *** $p<0.001$. Standard errors in parentheses are clustered by NACECLIO industries.

Table 7: First stages

VARIABLES	(1) $\Delta \ln IMP$	(2) $(\Delta \ln IMP) *$ $\ln (TFP_{93})$	(3) $\Delta \ln EXP$	(4) $(\Delta \ln EXP) *$ $\ln (TFP_{93})$
$\Delta IMPTAR$	-2.733	4.563	-1.538	18.457
	(1.693)	(32.088)	(1.188)	(24.868)
$(\Delta IMPTAR) * \ln (TFP_{93})$	0.044	-2.386	-0.010	-2.948
	(0.098)	(2.155)	(0.072)	(1.899)
$\Delta EXPTAR$	-0.000	0.013	-0.006*	0.025
	(0.003)	(0.033)	(0.003)	(0.038)
$(\Delta EXPTAR) * \ln (TFP_{93})$	-0.000	-0.003*	-0.000	-0.009***
	(0.000)	(0.002)	(0.000)	(0.002)
Observations	13,892	13,892	13,892	13,892
Firm fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES

Notes: This Table shows the four first stages of the IV regression in column (2) in Table 6. $\Delta IMPTAR$ and $\Delta EXPTAR$ are weighted tariff changes (multiplied by importance weights) as described in the text and used as instrumental variables for import competition and export access, and their interactions with initial productivity are used as instrumental variables for the interaction terms. * $p<0.05$, ** $p<0.01$, *** $p<0.001$. Standard errors in parentheses are clustered by NACECLIO industries.

Table 8: Alternative measures for productivity

	(1)	(2)	(3)	(4)	(5)	(6)
	Levinsohn-Petrin		Labor productivity		Fixed effects	
VARIABLES	OLS	IV	OLS	IV	OLS	IV
$\Delta \ln IMP$	0.572**	1.448	-0.0374	4.937**	0.283	6.683**
	(0.238)	(1.007)	(0.661)	(2.342)	(0.482)	(2.855)
$(\Delta \ln IMP) * \ln(TFP_{93})$	-0.040**	-0.106	0.00495	-0.448**	-0.0205	-0.579**
	(0.017)	(0.068)	(0.0566)	(0.210)	(0.0400)	(0.249)
$\Delta \ln EXP$	-0.493***	-2.711***	-0.781**	-3.652*	-1.006***	-6.922***
	(0.188)	(0.753)	(0.376)	(2.023)	(0.263)	(2.432)
$(\Delta \ln EXP) * \ln(TFP_{93})$	0.043***	0.190***	0.0830**	0.334*	0.0989***	0.595***
	(0.014)	(0.049)	(0.0339)	(0.172)	(0.0239)	(0.203)
Observations	13,892	13,892	15,100	15,100	14,134	14,134
Firm fixed effects	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES
First stage Kleibergen-Paap statistics		22.10		23.11		26.26

Notes: Columns (1) and (2) replicate the specifications in columns (1) and (2) in Table 6, using the change in log TFP estimated by Levinsohn-Petrin method, adjusted for changes in input and output prices as dependent variable. Columns (3) and (4) use changes in log of labor productivity as dependent variable, where labor productivity is defined as total sales divided by total employment. Columns (5) and (6) use changes in log of TFP estimated by an OLS regression of sales on employment and capital, including firm and year fixed effects.

Table 9: Firm level exports

VARIABLES	(1) Change in ln(firm level exports)	(2) Change in exporter status	(3) Change in output price
$\Delta \ln IMP$	13.76	0.815	180.2
	(12.76)	(1.440)	(163.8)
$(\Delta \ln IMP) * \ln(TFP_{93})$	-0.915	-0.0209	-9.775
	(0.778)	(0.113)	(10.93)
$\Delta \ln EXP$	-6.220	-2.864***	-30.35
	(3.790)	(0.642)	(48.71)
$(\Delta \ln EXP) * \ln(TFP_{93})$	0.463**	0.163***	1.380
	(0.216)	(0.0400)	(3.124)
Observations	7,809	12,578	23,329
Firm fixed effects	YES	YES	YES
Year fixed effects	YES	YES	YES
First stage Kleibergen-Paap statistics	12.12	34.44	19.16

Notes: The dependent variables are the change in log of firm level exports in column (1), change in exporter dummy variable in column (2) and percentage change in output prices (weighted average across all outputs) in column (3). The main regressors are $\Delta \ln IMP$ measuring the change in log of Spain's world imports, and $\Delta \ln EXP$ measuring the change in log of Spain's world exports, both at the NACECLIO industry level. Both main effects are interacted with the log of a firm's initial productivity in year 1993, $\ln(TFP_{93})$. All regressions use tariff changes (multiplied by importance weights) as described in the text as instrumental variables for import competition and export access, and their interactions with initial productivity as instrumental variables for the interaction terms. * $p<0.05$, ** $p<0.01$, *** $p<0.001$. Standard errors in parentheses are clustered by NACECLIO industries.

Table 10: Imported inputs versus import competition

VARIABLES	(1) Change in ln(firm level imports)	(2) Change in importer status	(3) Change in input price
$\Delta \ln IMP$	-31.61	-4.353**	199.6*
	(27.99)	(1.692)	(109.4)
$(\Delta \ln IMP) * \ln (TFP_{93})$	2.255	0.282**	-13.30*
	(1.936)	(0.120)	(7.236)
$\Delta \ln EXP$	34.48***	6.101***	-41.27
	(9.857)	(0.982)	(28.22)
$(\Delta \ln EXP) * \ln (TFP_{93})$	-2.349***	-0.389***	3.135*
	(0.678)	(0.0641)	(1.801)
Observations	7,646	12,502	23,291
Firm fixed effects	YES	YES	YES
Year fixed effects	YES	YES	YES
First stage Kleibergen-Paap statistics	36.38	33.17	19.01

Notes: The dependent variables are the change in log of firm level imports in column (1), change in importer dummy variable in column (2) and percentage change in input prices (weighted average across all inputs) in column (3). The main regressors are $\Delta \ln IMP$ measuring the change in log of Spain's world imports, and $\Delta \ln EXP$ measuring the change in log of Spain's world exports, both at the NACECLIO industry level. Both main effects are interacted with the log of a firm's initial productivity in year 1993, $\ln (TFP_{93})$. All regressions use tariff changes (multiplied by importance weights) as described in the text as instrumental variables for import competition and export access, and their interactions with initial productivity as instrumental variables for the interaction terms. * $p<0.05$, ** $p<0.01$, *** $p<0.001$. Standard errors in parentheses are clustered by NACECLIO industries.

Table 11: Ways to increase productivity

VARIABLES	(1) $\Delta \ln R\&D$	(2) Change in R&D dummy	(3) Δ#patents	(4) Change in patenting dummy	(5) Δ#products	(6) Change in CAD dummy	(7) Assimilate imported technology
$\Delta \ln IMP$	20.08**	3.822**	233.1*	-2.675**	5.918*	0.444	0.680
	(10.14)	(1.847)	(134.7)	(1.162)	(3.434)	(0.355)	(0.497)
$(\Delta \ln IMP) * \ln(TFP_{93})$	-1.167*	-0.207**	-17.78*	2.035***	-0.397*	-0.0298	-0.0550
	(0.685)	(0.0995)	(9.916)	(0.290)	(0.233)	(0.0250)	(0.0371)
$\Delta \ln EXP$	-9.625***	-4.812***	-347.4***	-0.127***	-7.505***	-0.880***	-0.774*
	(3.528)	(1.005)	(57.45)	(0.0210)	(1.412)	(0.338)	(0.439)
$(\Delta \ln EXP) * \ln(TFP_{93})$	0.468**	0.284***	26.06***	0.174**	0.486***	0.0635**	0.0594*
	(0.235)	(0.0631)	(4.242)	(0.0844)	(0.0909)	(0.0248)	(0.0340)
Observations	4,292	12,491	12,582	21,797	12,523	2,516	2,562
Firm fixed effects	YES	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES	YES
First stage Kleibergen-Paap statistics	17.58	33.34	34.92	21.05	33.07		

Notes: The dependent variables are the change in log of total R&D expenditures (internal and external) in column (1), change in R&D dummy variable in column (2), change in number of patents in column (3), change in patenting dummy in column (4), change in number of products in column (5), change in dummy variable indicating whether the firm used computer aided design (CAD) in column (6), and change in a dummy variable to indicate whether a firm spent effort to assimilate imported technologies in column (7). The latter two variables are only asked every 4 years in the survey. The main regressors are $\Delta \ln IMP$ measuring the change in log of Spain's world imports, and $\Delta \ln EXP$ measuring the change in log of Spain's world exports, both at the NACECLIO industry level. Both main effects are interacted with the log of a firm's initial productivity in year 1993, $\ln(TFP_{93})$. Regressions (1) to (5) use tariff changes (multiplied by importance weights) as described in the text as instrumental variables for import competition and export access, and their interactions with initial productivity as instrumental variables for the interaction terms. Columns (6) and (7) are estimated via OLS (the first stage was too weak for IV estimation because of the reduced number of observations). * $p<0.05$, ** $p<0.01$, *** $p<0.001$. Standard errors in parentheses are clustered by NACECLIO industries.

Table 12: Implications for employment

VARIABLES	(1) $\Delta \ln EMPL$	(2) $\Delta \ln FULLTIME$	(3) $\Delta \ln PARTTIME$	(4) $\Delta \ln TEMP$
$\Delta \ln IMP$	-1.789	-4.416	0.229	11.19*
	(2.514)	(2.728)	(8.186)	(6.309)
$(\Delta \ln IMP) * \ln(TFP_{93})$	0.144	0.302	0.0377	-0.678
	(0.189)	(0.194)	(0.609)	(0.458)
$\Delta \ln EXP$	-1.372	1.641	-11.09**	-13.28
	(1.070)	(1.215)	(4.619)	(10.83)
$(\Delta \ln EXP) * \ln(TFP_{93})$	0.0891	-0.106	0.768**	0.814
	(0.0755)	(0.0824)	(0.312)	(0.754)
Observations	12,635	12,555	2,548	8,931
Firm fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
First stage Kleibergen-Paap statistics	34.98	34.95	28.73	36.86

Notes: The dependent variables are the change in log of firm level employment (excluding temporary workers) in column (1), change in log of firm level full time employment (excluding temporary workers) in column (2), change in log of firm level part time employment (excluding temporary workers) in column (3), and change in log of firm level temporary workers in column (4). The main regressors are $\Delta \ln IMP$ measuring the change in log of Spain's world imports, and $\Delta \ln EXP$ measuring the change in log of Spain's world exports, both at the NACECLIO industry level. Both main effects are interacted with the log of a firm's initial productivity in year 1993, $\ln(TFP_{93})$. All regressions use tariff changes (multiplied by importance weights) as described in the text as instrumental variables for import competition and export access, and their interactions with initial productivity as instrumental variables for the interaction terms. * p<0.05, ** p<0.01, *** p<0.001. Standard errors in parentheses are clustered by NACECLIO industries.

B Proofs

B.1 Optimal effort function and cost cutoffs in closed economy

For a given cost draw c, managers choose effort in order to maximize their utility such that firm's net profits are positive.

$$\max_{\psi} s + \beta \frac{L}{4\gamma} (\alpha - \eta Q - c + \psi)^2 - \frac{1}{2}\psi^2$$

s.t.

$$(1-\beta)\pi(\psi) - s \geqslant 0$$

$$U^M \geqslant 0$$

The Lagrangian is

$$L(\psi) = s + \beta \frac{L}{4\gamma} (\alpha - \eta Q - c + \psi)^2 - \frac{1}{2}\psi^2 - \lambda \left(s - (1-\beta) \frac{L}{4\gamma} (\alpha - \eta Q - c + \psi)^2 \right)$$

The first order conditions are

$$\frac{\partial}{\partial \psi} = \frac{\beta L}{2\gamma} (\alpha - \eta Q - c + \psi) - \psi + \lambda (1-\beta) \frac{L}{2\gamma} (\alpha - \eta Q - c + \psi) = 0 \tag{B.1}$$

$$\lambda \left(s - (1-\beta) \frac{L}{4\gamma} (\alpha - \eta Q - c + \psi)^2 \right) = 0$$

$$\lambda \geqslant 0$$

$$(1-\beta) \frac{L}{4\gamma} (\alpha - \eta Q - c + \psi)^2 - s \geqslant 0$$

Case 1. The constraint is not binding, $\lambda = 0$. In this case the firm makes positive profits. Rearrange the first order condition B.1 for the optimal effort function ψ_L:

$$\psi_L(c) = \frac{\beta L}{2\gamma - \beta L} (\alpha - \eta Q - c)$$

This case holds for initial cost draws such that firm (net) profits are positive:

$$\pi^F(c) = (1-\beta)\pi(c, \psi_L) - s \geqslant 0$$

$$c \leqslant \alpha - \eta Q - \frac{(2\gamma - \beta L)\sqrt{s}}{\sqrt{\gamma (1-\beta) L}} =: c_L$$

Get an expression for quantities plugging in prices and the optimal effort function:

$$q(p) = \frac{L}{\gamma}(\alpha - \eta Q - p) = \frac{L}{2\gamma - \beta L}(\alpha - \eta Q - c)$$

Assume $2\gamma - \beta L > 0$ which ensures that there are positive quantities at some initial cost draw.

Case 2. The constraint is binding, $\lambda > 0$. In this case the manager will just put in enough effort to make the firm break even. Therefore firm's profits are zero

$$s - (1-\beta)\frac{L}{4\gamma}(\alpha - \eta Q - c + \psi)^2 = 0$$

Rearranging yields optimal effort ψ_U:

$$\psi_U(c) = \sqrt{\frac{s}{1-\beta}}\sqrt{\frac{4\gamma}{L}} - \alpha + \eta Q + c$$

The Lagrange multiplier λ can be derived from the first order condition B.1:

$$\lambda = \sqrt{\frac{\gamma}{L(1-\beta)s}}(c - \alpha + \eta Q) - \frac{\beta}{1-\beta} + \frac{2\gamma}{(1-\beta)L}$$

Since $\lambda > 0$ this gives the cutoff condition for the initial cost draw c_L.

$$c > \alpha - \eta Q - \frac{(2\gamma - \beta L)\sqrt{s}}{\sqrt{\gamma(1-\beta)L}} = c_L$$

If the initial cost draw is too high, $c > c_U$, the utility of managers becomes negative. Setting the manager's utility to zero using optimal effort ψ_U and solving for c yields the cost cutoff c_U:

$$U^M = s + \beta\frac{L}{4\gamma}(\alpha - \eta Q - c_U + \psi_U)^2 - \frac{1}{2}\psi_U^2 = 0$$

$$\alpha - \eta Q - c_U = \sqrt{\frac{s\gamma}{(1-\beta)L}} \pm \sqrt{\frac{sL}{2(1-\beta)L}}$$

Since the utility function of managers is concave, the larger of the two roots is the relevant cutoff:

$$c_U := \alpha - \eta Q - \left(\sqrt{\frac{s\gamma}{(1-\beta)L}} - \sqrt{\frac{sL}{2(1-\beta)L}}\right) = \alpha - \eta Q - \sqrt{\frac{s}{(1-\beta)L}}\left(\sqrt{\gamma} - \sqrt{\frac{L}{2}}\right)$$

Note that $\psi_L(c)$ is falling in c, while $\psi_U(c)$ is increasing in c. At the cost cutoff beyond which firms make no profits c_L (constraint is binding, case 1), the effort function has a kink:

$$\psi_L(c_L) = \psi_U(c_L) = \frac{\beta\sqrt{Ls}}{\sqrt{\gamma(1-\beta)}}$$

B.2 Impact of trade liberalization with zero trade cost

Import competition. Suppose the cost cutoff falls from c_L^A (A denotes autarky) to c_L^O (O denotes open economy). To see that a reduction in the cost cutoff results in more effort of firms with initial cost draw c_L^A

, consider that

$$\psi_U^A\left(c_L^A\right) = \frac{\beta\sqrt{sL}}{\sqrt{\gamma(1-\beta)}} < \frac{\beta\sqrt{sL}}{\sqrt{\gamma(1-\beta)}} + c_L^A - c_L^O = \psi_U^O\left(c_L^A\right)$$

because $c_L^A > c_L^O$. Plugging in the expression for c_L^O shows that the right hand side is equal to the new effort.

For $c_L^A < c < c_U^O$, effort also increases:

$$\psi_U^A(c) = \psi_U^A\left(c_L^A\right) + c - c_L^A < \psi_U^O\left(c_L^A\right) + c - c_L^A = \psi_U^O(c)$$

Firms with high cost, $c > c_U^O$, exit.

Export access. If market size L increases (holding cost cutoff c_L constant), the optimal effort for productive firms, i.e. firms with positive profits, increases:

$$\frac{\partial\psi_L}{\partial L} = \frac{\beta\sqrt{s}\frac{1}{2\sqrt{L}}}{\sqrt{\gamma(1-\beta)}} + (c_L - c)\,\frac{\beta(2\gamma-\beta L)+\beta^2 L}{(2\gamma-\beta L)^2} = \frac{\beta\sqrt{s}}{2\sqrt{\gamma L(1-\beta)}} + (c_L - c)\,\frac{2\beta\gamma}{(2\gamma-\beta L)^2} > 0$$

This increase is higher the lower the initial cost draw c:

$$\frac{\partial^2\psi_L}{\partial L\partial c} = -\frac{2\beta\gamma}{(2\gamma-\beta L)^2} < 0$$

B.3 Optimal effort function and cost cutoffs in open economy with positive trade cost

If firms are only selling in the domestic markets, managers exert the same effort as before (although Q is different, as it captures the increased number of firms and the reduced average prices). Therefore we have

$$\psi_L(c) = \frac{\beta L}{2\gamma-\beta L}(\alpha-\eta Q-c) \quad \text{if } c < c_L = \alpha-\eta Q - \frac{(2\gamma-\beta L)\sqrt{s}}{\sqrt{\gamma(1-\beta)L}}$$

$$\psi_U(c) = \sqrt{\frac{4\gamma s}{(1-\beta)L}} - \alpha + \eta Q + c \quad \text{if } c < c_U = \alpha - \eta Q - \sqrt{\frac{s}{(1-\beta)L}}\left(\sqrt{\gamma} - \sqrt{\frac{L}{2}}\right)$$

The effort at c_L is as before

$$\psi_L(c_L) = \psi_U(c_L) = \frac{\beta\sqrt{Ls}}{\sqrt{\gamma(1-\beta)}}$$

However, if cost are low enough, firms start to export. The cost threshold for exporting is therefore such that export profits become positive after exerting effort ψ_L:

$$c_X - \psi_L = \frac{\alpha-\eta Q}{\tau}$$

$$c_X = \frac{2\gamma-\beta L+\tau\beta L}{2\gamma\tau}(\alpha-\eta Q)$$

Assume that $c_X < c_L$, i.e. that there are firms selling only to the domestic market. Note that unlike in Melitz and Ottaviano 2008 this is not guaranteed by the variable trade cost $\tau > 1$, as it is not sufficient to have positive domestic profits to enter; domestic profits have to be large enough to cover the salary of managers.

The manager chooses effort in order to maximize profits from the domestic and export market:

$$\max_{\psi} s + \beta \frac{L}{4\gamma} (\alpha - \eta Q - c + \psi)^2 + \beta \frac{L}{4\gamma} (\alpha - \eta Q - \tau (c - \psi))^2 - \frac{1}{2}\psi^2$$

The first order condition with respect to effort if the firm is exporting is:

$$\frac{\beta L}{2\gamma} (\alpha - \eta Q - c + \psi) + \frac{\beta L}{2\gamma} (\alpha - \eta Q - \tau (c - \psi)) = \psi$$

and can be solved for optimal effort if exporting, ψ_X:

$$\psi_X(c) = \frac{\beta L}{2\gamma - \beta L (1 + \tau)} (2 (\alpha - \eta Q) - c (1 + \tau))$$

At c_X, the effort function has a kink, but does not jump, as $\psi_X(c_X) = \psi_L(c_X)$:

$$\begin{aligned} \psi_X(c_X) &= \frac{\beta L (\alpha - \eta Q)}{2\gamma - \beta L (1 + \tau)} \left(\frac{4\gamma\tau - (2\gamma - \beta L + \tau\beta L) (1 + \tau)}{2\gamma\tau} \right) \\ &= \frac{\beta L (\alpha - \eta Q)}{2\gamma - \beta L} \left(\frac{2\gamma\tau - (2\gamma - \beta L + \tau\beta L)}{2\gamma\tau} \right) = \psi_L(c_X) \end{aligned}$$

B.4 Impact of trade liberalization with positive variable trade cost

Again I consider the effect of a reduction in the zero profit cost cutoff c_L (import competition), and the possibility to generate profits from export markets (export access) on the optimal effort function.

Import competition. If the cost cutoff falls from c_L^A (A denotes autarky) to c_L^O (O denotes open economy), managers at the old cost cutoff c_L^A and below will spend more effort in order to keep the firm from bankruptcy and secure their salary (unless this is too costly for them which results in exits of the least productive firms).

To see that a reduction in the cost cutoff c_L results in more effort of firms with initial cost draw c_L^O (and higher, until cost are too high and they exit), consider that

$$\psi_U^A \left(c_L^A \right) = \frac{\beta \sqrt{sL}}{\sqrt{\gamma (1 - \beta)}} < \frac{\beta \sqrt{sL}}{\sqrt{\gamma (1 - \beta)}} + c_L^A - c_L^O = \psi_U^O \left(c_L^A \right)$$

For $c_L^A < c < c_U^O$, effort also increases:

$$\psi_U^A (c) = \psi_U^A \left(c_L^A \right) + c - c_L^A < \psi_U^O \left(c_L^A \right) + c - c_L^A = \psi_U^O(c)$$

Firms with high cost, $c > c_U^O$, exit.

Export access. For the most efficient firms, i.e. those with $c = 0$, effort is larger in the open economy (holding Q fixed, as this is the import competition channel):

$$\psi_X^O(0) = \frac{\beta L}{2\gamma - \beta L (1+\tau)} 2(\alpha - \eta Q) > \frac{\beta L}{2\gamma - \beta L} (\alpha - \eta Q) = \psi_L^A(0)$$

because

$$\frac{2}{2\gamma - \beta L (1+\tau)} > \frac{1}{2\gamma - \beta L}$$

As firm are less productive and have higher initial cost draw, the change in effort becomes smaller:

$$\frac{\partial (\psi_X(c) - \psi_L(c))}{\partial c} = \beta L \frac{-2\tau\gamma}{(2\gamma - \beta L (1+\tau))(2\gamma - \beta L)} < 0$$

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