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Domestic Regulation, Import Penetration and Firm-Level Productivity Growth

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Abstract

This paper shows that the impact of import penetration on firms' productivity growth depends on firms' distance to the efficiency frontier and on product market regulation. Using firm-level data for a substantial number of OECD countries from the late 1990s to late 2000s, the analysis reveals non-linear effects of both sectoral import penetration and *de jure* product market regulation measures, depending on firms' positions along the global distribution of productivity levels. Close to the technology frontier, import penetration has a strongly positive effect on firm-level productivity growth, with less stringent domestic regulation enhancing this effect substantially. However, far from the frontier, the effect of import penetration on firm-level productivity growth is much smaller and often unsignificant. Its interaction with domestic regulation has mostly no statistically significant effect either. The heterogeneous effects of import penetration and domestic product market regulation on firm-level productivity growth are consistent with a neo-Schumpeterian view of trade and regulation.

Keywords: Firm productivity growth, behind-the-border regulatory barriers, product market regulation, import competition, international trade.

JEL Classification Numbers: F1, K2, L2, L5, O1

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1 Introduction

Globalization has dramatically reduced "explicit" barriers to international trade in OECD as well as non-OECD countries over recent decades. These tariff-type barriers have fallen far enough in manufacturing that they likely no longer represent a major obstacle to goods exporting and importing (Bouët *et al.*, 2008). Institutional limits on protection that prevent countries from raising tariffs even in times of economic crisis have so far proven effective in preventing a bout of defensive, or retaliatory, anti-trade measures, even in the context of the panic-inducing Great Recession that we have recently experienced. Nevertheless, behind-the-border regulation still remains quite stringent in many economies (OECD, 2011), representing an important opportunity for further trade integration.

Stringent regulation of domestic product markets obstructs firm entry, operation and exit, thereby limiting competition, which can reduce firms' ability and incentives to improve their productivity. Trade openness increases competitive pressures by allowing foreign goods to enter the domestic market. How trade integration and product market regulation interact is however not clear-cut. On one hand, foreign competition is expected to have a stronger effect in environments where the initial competition level is low, as it generates incentives that were absent before. On the other hand, import competition may create incentives to improve production efficiency only for firms that are productive enough to react to the new competitive pressures. In this case, firms operating in markets protected from competition may be unable to respond, and import competition would create instead a discouragement effect.In their recent review of endogenous growth theory, Aghion and Howitt (2009) argue that the non-linear relationship between the degree of competition and productivity growth crucially depends on the firms' position with respect to the global technological frontier. Firms closer to the world frontier face stronger incentives to innovate in order to maintain a technological superiority and overcome the potential threat of new entrants. Near the frontier, stringent regulation reduces this "escape-competition" effect, harming firm innovation and productivity growth. In contrast, farther from the frontier, Schumpeterian "appropriability effects" dominate and firms are discouraged from innovating when competition increases, making productivity growth less likely. Far from the frontier, the (threat of) entry of foreign products generates a discouragement effect regardless of domestic regulation. We use this framework and investigate empirically in an open economy setting whether foreign competition has different effects on the productivity growth of heterogeneous firms operating in markets with different regulation systems.

New trade theory also incorporates firm heterogeneity in technological efficiency. One group of theoretical papers, notably Melitz's (2003), show how trade liberalization yields firms entry and exit dynamics that reallocate market shares from low-productivity firms to higher productivity firms that compete in international markets. He considers single product firms, takes firms' productivity levels as given and further investigates how sectoral productivity changes in the aftermath of trade liberalization. Bernard *et al.* (2007) show how this process can help strengthen comparative advantage through creative destruction, and endogenous productivity changes at the industry level. Melitz and Ottaviano (2008) highlight the pro-competitive effect of trade taking into account market size. They show theoretically that sectoral productivity can be enhanced through increasing toughness of import competition, implying the potential for dynamic gains from policy reform. Chen *et al.* (2009),Acharya and Keller (2008) and Cabral and Mollick (2011) investigate empirically how rising import penetration affects domestic sectoral productivity. Krammer (2010) shows that human capital and R&D efforts reinforce the productivity gains expected from trade liberalization. We use detailed firm level data for a wide set of countries and complement those papers by investigating within-firm responses to import penetration, and how both distance to the TFP frontier and domestic product market regulation shape those firm responses. Cameron *et al.* (2005) investigate whether import penetration depends on the sector distance to the TFP frontier. We show here that the interaction between import penetration and distance to the TFP frontier matters also at the firm level. The work here goes further by investigating intra-firm productivity dynamics – not just sectoral dynamics – resulting from changes in import competition.

A smaller group of papers in the new trade theory literature also investigates within-firm responses to trade liberalization. Bernard *et al.* (2006) show that a fall in sector-level trade costs is associated with positive firm productivity growth among U.S. manufacturers. Related work takes into account the specificities of multi-product firms and investigates how trade affects firm outcomes through product switching. Bernard *et al.* (2011) show that trade liberalization induces firms to change their product mix which generates within firm dynamics through the reallocation of resources within firms. They find that this mechanism increases U.S. firms' productivity. Atkeson and Burstein (2010) develop a model where trade liberalization encourages not only the entry of new firms through product creation but also process innovation that increases firms' productivity.

This paper provides a novel empirical analysis of the effect of international trade on within-firm productivity growth. It gathers the findings of trade models on the pro-competitive effect of trade along with the prediction of endogenous growth models where the effect of competition (and regulation) on firm productivity depends on firms' efficiency levels relative to the efficiency frontier. Amiti and Khandelwal (2013) also combine insights from the new new trade literature with the distance-to-the-frontier models to explore the effect of import competition on product quality. They show that foreign competition has heterogeneous effects depending on the distance of a product with respect to the world quality frontier. A fall in tariffs is associated with further quality improvements of products close to the world quality frontier. Similarly, we incorporate distance-to-the-technological-frontier in an analysis of import competition effects. In contrast to their paper, ours investigates the heterogeneous effect of import competition on productivity growth at the *firm* level, while considering the role of anti-competitive domestic regulation. In so doing, we develop new evidence in support of both sets of theories, suggesting that (*i*) trade models could be enriched by incorporating a distance-to-frontier and intra-firm productivity dimension, and (*ii*) distance-to-frontier ideas could be further enriched by examining their interactions with trade, helping to better explain the underlying mechanisms. Beyond these general insights, several important findings stand out.

First, stronger competition, in the form of higher import penetration, is associated with higher firm-level productivity growth close to the technological (measured in terms of productivity levels) frontier, an effect that remains robust even when estimated in lags, though it varies when the smallest firms are over-sampled in the dataset. The main result is consistent with the predictions of the Aghion endogenous growth model as well as the Melitz and Ottaviano framework, though the latter would not have predicted a differential firm-level effect vis-à-vis the technology frontier.

Second, close to the technology frontier, anti-competitive product market regulation substantially reduces the scope for TFP improvements spurred by import competition; far from the frontier, the interaction between regulation and foreign competition is not statistically significant. The effect of product market regulation depends on sectoral trade orientation; more precisely, stringent product market regulation is found to damage the scope for productivity growth at least in part by reducing the competition-enhancing effect of import competition on top firms.

Third, the productivity-enhancing effect of import competition and the mitigating effect of product market regulation are robust to the inclusion of a Herfindahl index that captures the market share concentration across firms, controls for the stringency of upstream regulation, as well as country-time fixed effects and industry fixed effects that capture respectively country specific policies or macroeconomic shocks and time-invariant industry-specific characteristics such as the intensity of ICT use.

In order to examine these questions, a large-scale firm database (Amadeus) is examined that covers close to half of the OECD member countries, which is then re-weighted to be representative of the actual size distribution of firms in the whole population, and matched with regulation and trade datasets. This firm data is sufficient to allow for the measurement of robust productivity measures that take account of potential simultaneity biases. Unique OECD indexes of product market regulation are used to measure *de jure* regulatory settings, at the country level and across time. International trade data are matched with production data, to generate measures of import penetration at the detailed industry level.

While there is previous evidence on the effect of domestic regulation on productivity, these studies have in general not examined their interaction with trade at the firm level.[1] A number of empirical studies, particularly those of the OECD (2003, 2006, 2011), have found distortionary effects of indicators of product and labor market regulation on overall productivity outcomes. For instance, Arnold *et al.* (2010) look at the effect of product market regulation on firm-level productivity – through the ICT channel – and find supportive evidence of distance-to-frontier effects. At the industry level, Bourlès *et al.* look at the effect of upstream product market regulation on sector-level productivity, and they also find distance-to-frontier effects. Conway *et al.* found similar sectoral effects for broader market regulation, while Nicoletti and Scarpetta (2003) found related, yet inverted, effects with respect to the distance-to-frontier.

More aggregate empirical work has used less detailed indicators of institutional and policy settings to examine the role of institutions in mediating the role of trade in affecting overall growth and productivity outcomes. Cross-country studies include Dollar and Kraay (2003), Rodrick *et al.*

[1] An exception discussed below is Acharya and Keller (2008) who investigate how entry regulation shapes the effect of import penetration on sectoral productivity.

(2004), Alcalá and Ciccone (2004), and Freund and Bolaky (2008), who have tried to disentangle the respective roles of institutions and trade for growth at the country level. On balance, the evidence appears to suggest that institutions have a more fundamental role, as they complement trade liberalization, and strengthen the long-term effects of trade on growth, by enhancing the role of comparative advantage. However, the types of policies and reforms that may drive productivity in this context are still not clear from this literature.[2]

Turning to the effect of trade openness, there have been a series of country-specific firm-level studies that have identified substantial roles for international trade (not behind-the-border) regulation specifically in affecting firm entry/exit and reallocative margins, for Chile (Pavcnik, 2002; Bas and Ledezma, 2010), Columbia (Fernandez, 2007), France (Bas and Strauss-Kahn, 2011), India (Topalova, 2004; Goldberg *et al.*, 2010), Indonesia (Amiti and Konings, 2007) and the UK (Aghion *et al.*, 2009). Several of these studies show that reductions in import barriers can help to boost within-firm productivity (Amiti and Konings, 2007; Bas and Ledezma, 2010; Goldberg *et al.*, 2010).

A very small group of papers analyses jointly the effect of trade and market regulation. To do so, single-country studies are often not well suited to address behind-the-border regulation, which varies principally *across* countries. An exception is Topalova and Khandelwal (2011) who exploit regional variation in labour market regulation and industry-specific reforms in India. They show that lower tariffs have increased firm-level productivity and that the effect is strongest in industries not subject to excessive domestic regulation. Acharya and Keller (2008) investigate how entry regulation shapes the effect of import penetration on sectoral productivity for a sample of industrialized countries. They find that in the short run, stringent entry regulation reduces the productivity gains expected from trade liberalization. Research at the level of the firm combining countries with different regulation systems is promising to reveal the underlying mechanics of how policies may work through trade to affect productivity and growth outcomes. Firm-level analysis has revealed a substantial role for product market regulation in affecting the margins of firm exit and entry as well as the reallocation of productivity across firms (e.g., Bartelsman *et al.* (2009)). However, this work does not explicitly consider how international trade may drive and/or reinforce

[2] One promising approach from a related literature uses incomplete contract theory to examine the effect of overall institutional quality on the organization of trade. Studies following this approach include Acemoglu *et al.* (2007), who find an important role of contracting institutions leading to strengthened comparative advantage.

these margins.[3]

We thus contribute to the literature by addressing the questions raised above at the firm level for a sample of OECD countries. We estimate firm productivity growth equations where exposure to international markets and to domestic regulation both interact. We show that stringent entry regulation reduces the productivity gains expected from trade liberalization, not only at the sector level as found by other papers, but also at the firm level. We additionally show that this effect can be non-linear and depends on the characteristics of heterogeneous firms – especially their distance to the global technological frontier. Moreover, the scope for this type of behind-the-border reform appears to be vast.

The paper proceeds as follows. The second section describes the data and sampling frame, the construction of productivity, import penetration and domestic regulation measures. The third section motivates the empirical approach, and examines the effects of import penetration and domestic regulation on firm-level productivity growth. The fourth section concludes.

2 Data and measurement

In order to investigate the questions raised above, firm-level data are used to compute productivity measures, sectoral trade data are used to measure foreign competition, and restrictive regulation is measured using the OECD's economy-wide indexes of product market regulation.

2.1 Firm-level data: Amadeus

Firm level data are used based on company reports included in the Amadeus database compiled by the Bureau van Dijk. This database covers European OECD countries over the time period 1995–2005. The countries with sufficient numbers of firms for our use are Belgium, the Czech Republic, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Poland, Portugal, Spain, Sweden and the United Kingdom. The data for Greece are not used since they lack wage and materials data. While all the countries included are OECD members, the former transition economies of Central and Eastern Europe are likely to have a wider dispersion of productivity

[3] Although not focused on productivity, Crozet *et al.* (2012) take an innovative approach to address the effect of different countries' domestic regulations on services trade, using bilateral export data from French firms. The study finds strong detrimental effects of purely domestic regulations on both the extensive and intensive export margins of the firms – with domestic regulations being even more damaging for trade than explicit international trade barriers.

across firms than the other countries as a result of their one-time structural transitions.

Data are cleaned for potential outliers that we identify by several criteria. First, firms with negative values for any variable entering the production function – operating revenue or value added, wages, capital stock, material inputs – or with depreciation higher than net capital stock are eliminated from the sample. Firms that report extreme year-to-year variation in ratios between production function variables and extreme reversals in one of these variables are not retained, either. Finally, outliers have been removed by eliminating the top and bottom one percent of the productivity distribution and subsequently re-estimating productivity without these extreme observations. The productivity estimation is described in more detail below.

Firm's sectoral affiliation corresponds to its main sector of activity and is given at the 4-digit of the ISIC classification. Sectoral coverage includes all tradable goods and services, including mining, all of manufacturing (ISIC 15 to 37), electricity, utilities (ISIC 40, 51, 52), transport and communications (ISIC 60 to 64), business activities as R&D, advertising (ISIC 71 to 74) and recreational and cultural activities (ISIC 92). Consolidated accounts in the Amadeus dataset are dropped, which avoids problems of double-counting.

2.2 Sampling frame

The Amadeus data are broadly representative of the business sectors of OECD countries, since they include virtually all public companies, and as such are a fair representation of larger companies. However, smaller firms are underrepresented, since they typically do not report balance sheet information publicly. In addition, not all firms in the Amadeus data report information on all production function variables. The remaining sample used in this study includes only firms for which TFP estimates could be obtained.

In order to ensure that the sample of firms is as representative as possible of the population distribution of firms across size classes, sectors and countries, a re-sampling procedure was applied (see Schwellnus and Arnold, 2008). First, population weights for every size-sector-country strata were calculated from the OECD Structural Demographic Business Statistics (SDBS) database for the year 2000. Second, random draws with replacement from each size-sector-country strata in the TFP sample were taken until the weight of each strata corresponds to its population weight.[4]

[4]The re-sampling procedure is restricted to firms with at least 20 employees since the coverage below this threshold

This method resulted in a sample that is representative of the population distribution along the dimensions of employment size, sector and country. The sample size is then set to 139,065 firms (drawn from a set of 79,513 real firms) which results in 831,187 firm-year observations. While this method yields a more representative sample in the year 2000, it may also increase measurement error since 'successful' smaller firms are over-sampled. As a result, the resampled dataset may be less representative as the time period shifts away from the year 2000 since normally such firms have high rates of entry and exit. Thus, both the non-resampled and the resampled data are considered in the basic specifications in order to ensure robustness.

2.3 Estimation of Total Factor Productivity

Our productivity variable, total factor productivity (TFP), measures the firm-level efficiency in the use of all inputs. We calculate TFP as the residual from the estimation of a logarithmic Cobb-Douglas production function of the form:

$$\ln y_{isct} = \alpha_{sc} \ln l_{isct} + \beta_{sc} \ln k_{isct} + \epsilon_{isct} \tag{1}$$

where the subscripts stand for the firm i from country c operating in sector s at time t. The dependent variable of the production function is the firm's value-added (y). The production factors are labor (l) and capital (k). When value-added was not available, it was imputed as the residual between operating revenue and material inputs. Labor inputs are measured using the total wage bill, while net capital stocks were used to measure capital input. Nominal values are deflated using sector-specific price indexes, with the exception of capital stocks that have been deflated using deflators for gross fixed capital formation. The production function is estimated at the sector-country level sc, in order to avoid strong assumptions on the homogeneity of production technologies across sectors and OECD countries. The residuals ϵ_{isct} represent plant-specific efficiency in the year t.

The ideal measure of TFP would be in volume terms, "physical TFP". However, given the available data, we use a "revenue-based TFP". The pluses and minuses of using various measures are discussed in Foster *et al.* (2008). In most business micro data sets like Amadeus, establishment-level

is unsatisfactory. The firm size classes used for resampling (from SDBS) are: 20-49; 50-99; 100-499; 500 or more employees.

prices are unobserved. Thus, establishment output is measured as revenue divided by a common industry-level deflator. This method embodies within-industry price differences in output and productivity measures. Difficulties arise when prices reflect idiosyncratic demand shifts, demographic characteristics or market power variation rather than differences in quality or production efficiency.[5] For instance, a firm sheltered from competition because of some regulatory barriers may set high prices and according to a "revenue-based TFP" it may look more efficient than a firm in a more deregulated environment even if their efficiency levels are similar. Since we cannot implement the Foster *et al.* treatment, firm fixed effects are considered as controls for time-invariant characteristics that may determine firm-level prices.

Estimates of the main analytical results using firm-level fixed effects are shown in Table 12. These estimates use the balanced panel dataset, where there are sufficient repeated observations to carry them out, and show that the baseline results are robust to firm fixed effects. This estimate also addresses concerns about the use of a Cobb-Douglas production function, if the underlying production function departs from constant returns to scale. In addition, (insignificant) firm size dummies were used in alternative specifications, and these did not affect the results.

We now turn to the endogeneity issue. Estimation of Equation (1) by OLS can lead to biased estimates as inputs in the production function are likely to be related to the residuals. Let us decompose the residuals as follows:

$$\epsilon_{isct} = \omega_{isct} + u_{isct} \tag{2}$$

Equation (2) decomposes firm efficiency into a part that is predictable by the firm ω_{isct}, though not observable in the data, and a part due to a productivity shock that can be forecast neither by the firm nor by the econometrician.

Firms choose their input on the basis of their knowledge of their environment and own efficiency ω_{isct}. Hence, if firms that anticipate high efficiency level hire more workers and invest more, OLS estimates will be biased upward. The endogeneity of input choices is well known in the literature. Consistent productivity estimates are obtained using the semi-parametric estimation techniques of Olley and Pakes (1996) or Levinsohn and Petrin (2003). These methods correct for simultaneity

[5] Note that an important advantage of using a revenue-based TFP measures is that if we observe positive effects of competition-related measures on TFP growth, the result is not subject to concerns about markups being conflated, since markups would reduce TFP growth, thus implicitly the efficiency effects must be dominating.

biases. To carry out such estimations, we need data on investment for the former and intermediate inputs for the latter in order to proxy firm's private knowledge of its efficiency.

Our preferred TFP estimates are those from the Levinsohn and Petrin (LP) method, which uses information on materials to correct for simultaneity biases. We do not use the Olley and Pakes technique, as their method requires primary information on investment to proxy for unobserved productivity shocks, while prior information on investment is not provided in Amadeus. Although we could create an investment measure using the perpetual inventory equation, we do not follow this path because of a high probability of measurement errors in capital depreciation.

Hence, we compute firm-level TFP by using intermediate inputs m to capture variation in firms' prediction of their efficiency ω:

$$\omega_{isct} = f(m_{isct}, k_{isct})$$

Introducing this function into Equation (1), we now have:

$$\ln Y_{isct} = \alpha_{sc} \ln l_{isct} + \beta_{sc} \ln k_{isct} + f(m_{isct}, k_{isct}) + u_{isct} \tag{3}$$

The variation in inputs is now not related with the error term u_{isct} so that we have consistent estimates of the parameters. We compute each firm's TFP as the residual from an estimate of Equation (3). At this stage, firms' TFP values are not yet comparable across sectors and countries.

Following Pavcnik (2002) and Fernandez (2007), we construct a TFP index to deal with the comparability issue. The TFP index is based on the LP estimates and is constructed in two steps. First, for each 4-digit sector s and country c, we construct a reference hypothetical plant that has mean output and input levels calculated over the whole period. We compute the TFP of this reference plant as:

$$\ln A_{sc}^{ref} = \ln \overline{Y}_{sc} - \widehat{\alpha}_{sc} \ln \overline{L}_{sc} - \widehat{\beta}_{sc} \ln \overline{K}_{sc} \tag{4}$$

where $\widehat{\alpha}_{sc}$ and $\widehat{\beta}_{sc}$ are the estimates obtained from the regression estimate of Equation (3).

Second, we obtain plant i's *productivity index* at time t by subtracting the reference plant productivity A^{ref} from plant i's productivity as estimated in Equation (4):

$$\ln A_{isct} = \ln Y_{isct} - \widehat{\alpha}_{sc} \ln L_{isct} - \widehat{\beta}_{sc} \ln K_{isct} - \ln A_{sc}^{ref} \tag{5}$$

The relative TFP measure obtained ensures comparability across industries and countries.

Table 1: Summary statistics – Firm TFP growth

Country	Standard deviation	10th percentile	mean	median	90th percentile
All	2.87	-1.24	-.01	.01	1.28
BEL	4.09	-1.76	0	0	1.79
CZE	1.78	-.84	.09	.01	1.03
DEU	10.83	-1.7	.41	0	2.5
DNK	6.72	-.72	.14	.01	1.17
ESP	2.01	-1.01	.01	0	1.04
FIN	2.1	-1.3	.04	.01	1.46
FRA	1.2	-.63	.06	.03	.76
GBR	4.17	-1.64	-.05	-.02	1.53
ITA	2.3	-1.55	.01	.01	1.56
NLD	3.51	-1.83	.14	0	2.54
NOR	2.01	-1.12	.06	.04	1.35
POL	4.32	-1.75	.47	.05	3.13
PRT	2.15	-1.02	.07	.01	1.36
SWE	6.43	-4.16	-.45	-.03	3.4

Source: Authors' calculations based on Amadeus database. Not resampled dataset.

We then compute firms' TFP growth rates as the log difference: $\Delta A_{isct} = lnA_{isct} - lnA_{isct-1}$. Summary statistics for firm's TFP growth are shown in Table 1. It displays the standard variation, the mean, median, the 10th and 90th percentiles of firm's TFP growth for each country. It shows that there is a wide variation in ΔA_{isct} both within and across countries.

2.4 Trade openness

To capture the pro-competitive impact of trade we construct a proxy for foreign competition which is import penetration. Trade data come from the Comtrade database. By combining it with detailed production data from OECD Structural Demographic Business Statistics (SDBS) database, we compute different openness measures at the 4-digit sectoral level. Import penetration is constructed in the following way for each sector, country and year:

$$IP_{sct} = \frac{M_{sct}}{Q_{sct} + M_{sct} - X_{sct}}$$

where M_{sct} is total imports of good s to country c in year t. Q_{sct} is the production of good s while X_{sct} is the exports of good s from country c to its trade partners in year t.

Summary statistics for the import penetration measure across countries are shown in Table 2.

This table displays the median, the 25th and 75th percentiles of import penetration. There is considerable variation in import penetration across country and time, and these differences persist even within narrowly defined sectors. Figure A.1 in the appendix illustrates the variation of import penetration for a few four-digit sectors. We can see here that some sectors have higher import penetration than others and that within sectors some countries have higher import penetration than others.

Table 2: Summary statistics – Import penetration

	1996			2005		
Country	25th percentile	median	75th percentile	25th percentile	median	75th percentile
All	.17	.43	.75	.23	.55	.87
BEL	.36	.7	1.26	.42	.88	1.57
CZE	.05	.35	.61	.25	.61	1.02
DEU	.02	.2	.64	.2	.41	.87
DNK	.32	.59	.86	.4	.76	1.22
ESP	.13	.29	.55	.17	.46	.68
FIN	.16	.47	.67	.18	.49	.82
FRA	.17	.37	.54	.23	.48	.7
GBR	.17	.4	.61	.24	.54	.78
GRC	.06	.26	.63	.3	.58	.82
ITA	.12	.22	.37	.14	.31	.5
NLD	.42	.96	1.41	.4	.84	1.73
NOR	.36	.62	.82	.3	.62	.91
POL	.02	.25	.44	.16	.55	.75
PRT	.15	.41	.72	.23	.49	.76
SWE	.21	.51	.84	.27	.55	.93

Source: Authors' calculations based on Comtrade and OECD SDBS databases.

2.5 Regulation and market structure measures

The primary measure of regulation is the OECD product market regulation indicators of *de jure* anti-competitive regulations, focusing on the vintages which coincide with the coverage of the Amadeus data. These include the 1998 and 2003 data updates, the settings for which are assumed to be unchanged for the immediately following years, preceeding the most recent 2008 data update. These indicators include both domestic as well as international barriers; only the domestic barriers are used here, specifically the grouping 'barriers to entrepreneurship', which covers sub-indicators for administrative burdens on startups, regulatory and administrative opacity and sectoral barriers to competition. Each of the low-level indicators are based on a scoring of regulatory data on a 0 to 6 scale reflecting the extent to which the regulations inhibit competition (see Wölfl *et al.*, 2009).

A Herfindahl index of firm concentration at the four-digit level using the Amadeus firm database is used to control for the extent of *de facto* competition from domestic firms. It is calculated in the standard way, based on the sum of the square revenue market shares of each firm in an industry, so that it ranges between $1/n$ and 1 where n is the number of firms. The OECD 'Regimpact' measure, which assesses the industry-specific knock-on effects of anti-competitive regulation in seven network sectors is also used in robustness checks to control for the extent of upstream regulation.[6]

Table 3 displays some summary statistics for the main measures of domestic competition. Though there has been convergence in these measures over time, a wide variation is still observed across countries.

Table 3: Summary statistics – Market structure and domestic regulation

		'Barriers to entrepreneurship' Index			
Country	Standard deviation	10th percentile	mean	median	90th percentile
All	.6	1.45	2.23	2.39	3.05
BEL	.22	1.88	2.16	2.33	2.33
CZE	.08	2.09	2.13	2.09	2.27
DEU	.24	1.83	2.05	1.83	2.31
DNK	.17	1.42	1.52	1.42	1.82
ESP	.35	1.63	2.17	2.39	2.39
FIN	.49	1.42	2.01	2.41	2.41
FRA	.62	1.79	2.55	3.05	3.05
GBR	.23	.95	1.29	1.45	1.45
ITA	.54	1.58	2.38	2.74	2.74
NLD	.13	1.78	1.93	2.05	2.05
NOR	.21	1.33	1.45	1.33	1.83
POL	.28	3.15	3.42	3.15	3.72
PRT	.25	1.57	2.02	2.16	2.16
SWE	.48	1.15	1.69	2.11	2.11

		Herfindahl Index			
Country	Standard deviation	10th percentile	mean	median	90th percentile
All	.08	0	.05	.02	.12
BEL	.12	.01	.09	.04	.23
CZE	.11	.01	.09	.06	.22
DEU	.2	.04	.22	.16	.45
DNK	.11	.02	.11	.08	.21
ESP	.07	0	.03	.01	.07
FIN	.13	.02	.11	.06	.25
FRA	.07	0	.04	.02	.1
GBR	.09	.01	.08	.04	.18
ITA	.06	0	.03	.01	.08
NLD	.21	.05	.23	.15	.53
NOR	.09	0	.05	.03	.09
POL	.13	.02	.1	.05	.25
PRT	.21	.06	.22	.15	.51
SWE	.09	.01	.07	.03	.17

Source: 'Barriers to entrepreneurship' is sourced from the OECD Regulatory database. The Herfindahl Index is based on author's calculations using the Amadeus database.

[6]These indicators are calculated using a bottom-up approach in which regulatory data are quantified and aggregated to into summary indicators by sector using weights from I/O tables.

3 Empirical analysis of firm-level productivity

3.1 The effect of competition

Competition may stem from both foreign as well as domestic sources, which we take into account by differentiating the two. Our methodology assumes that increased import shares are equivalent to an increase in competition within a narrowly defined industry and that this increase is exogenous to the productivity growth of an individual firm. Several studies document that increased imports amount to tougher competition: for instance, Katics and Petersen (1994) find that it is associated with reduced price-cost margins using industry-level data for the United States. Recent empirical studies, including Aghion *et al.* (2009), Bas and Strauss-Kahn (2011), Fernandez (2007) and Pavcnik (2002), use import shares as measures of competition from trade, while Kletzer (2002) discusses assumptions necessary for this approach to be valid. Using a more structural approach, Chen *et al.* (2009) find that import penetration has a boosting effect on industry average productivity, supporting the pro-competitive effect of trade predicted by the theoretical model of Melitz and Ottaviano (2008).

To capture domestic competition, different measures have been proposed in the literature, such as price-cost margins and concentration indexes. Both measures have substantial flaws. First, they do not allow the effect of foreign competition to be distinguished from the effect of domestic competition. Secondly, while both sources of competition are supposed to put a downward pressure on price-cost margins, it is not clear that higher concentration indexes indicate lower competitive forces. Indeed, pressures from abroad may lead to exit of domestic firms, resulting in a small number of national firms operating, and a more concentrated domestic sector. While we control for concentration, we believe that the two sub-indexes of product market regulation that we use, namely barriers to entrepreneurship and burdens on startups, capture more accurately domestic competitive pressures, as they are direct measures of barriers to market entry.

Aghion *et al.* (2009) exploit several policy reforms that influenced the competitive environment in Europe, namely the European Single Market Program and industry specific reforms imposed by the Monopolies and Mergers Commission. They claim that those experiments enable them to identify the causal impact of competition on innovation. The perspective of this paper is similar; it makes the most of a country-specific product market regulation (PMR) index that captures various product market reforms that took place in OECD countries between 1998 and 2008. The product market regulation index captures various policies with different treatment intensity across countries and time.

Our empirical analysis highlights that the effect of foreign competition varies with the local stringency of product market regulation. Theoretical predictions on the interaction between trade and product market regulation are ambiguous though. On one hand, PMR and openness can go in the same direction and have a positive additive effect by demanding further productivity improvements. While foreign exposure reduces rents and demand stronger competitiveness to survive, this pro-competitive effect can be higher in countries with stringent regulation protecting incumbents as it creates new incentives to upgrade the production technology. On the other hand, rigidities can impede reallocation, innovation and firm adjustments, reducing the ability to react quickly to new competitive pressures.

3.2 Empirical specification

We relate firm-level TFP growth to domestic and foreign competition as well as domestic regulation in the following way:

$$\Delta A_{isct} = \beta_0 + \beta_1 IP_{sct} + \beta_2 IP_{sct} \times PMR_{ct} + \beta_3 X_{isct} + \beta_4 X_{sct} + \gamma_s + D_{ct} + \epsilon_{isct} \quad (6)$$

where ΔA_{isct} is the productivity growth of firm i that belongs to sector s and country c, IP_{sct} is the level of import penetration in sector s for country c in year t, PMR_{ct} is the level of product market regulation in country c and year t. One issue is that productivity growth can vary across firms because of sectoral features that have nothing to do with competitive pressures. To avoid any spurious correlation due to industry characteristics, sector fixed effects γ_s are included. They capture time-invariant characteristics that, for example, shape the potential for technological upgrading. It is also very likely that TFP growth is influenced by other institutional determinants or policies that do not affect competition. Country-time fixed effects D_{ct} are added to deal with this type of correlation. The country-time fixed effects also address country macroeconomic shock common to all sectors. X_{isct} is a set of control variables that vary across firms and time such as the size of the firm. X_{sct} includes control variables that vary across sectors s, country c and time t such as the level of concentration or the impact of regulation in services sectors on the manufacturing sector under study.

Equation (6) enables us to understand first how firm-level TFP growth depends on foreign competition (β_1), and second, how the effect of foreign competition varies with the regulation of the product market (β_2). Since we control for industry and country-time fixed effects, this specification identifies the effect of foreign competition through differential evolution of the import penetration across industries (industry-time variation).

An additional specification includes firm fixed effects, in order to control for firm specific elements that contribute to productivity growth but are not influenced by competitive pressures (e.g. managerial efficiency, agglomeration economies of the location, product specialization within the 4-digit sector):

$$\Delta A_{isct} = \beta_0 + \beta_1 IP_{sct} + \beta_2 IP_{sct} \times PMR_{ct} + \beta_3 X_{isct} + \beta_4 X_{sct} + \gamma_s + D_{ct} + \theta_i + \epsilon_{isct} \quad (7)$$

Models of endogenous growth, considering the existence of technological flows between firms across all countries, dwell on the role played by the pool of highly innovative firms in driving productivity growth of incumbent firms. Productivity growth of followers depends on the productivity growth of the global technological frontier. Adding productivity growth of the frontier firms (top 1 percent in levels), we estimate:

$$\Delta A_{isct} = \beta_0 + \alpha \Delta A_{st}^{front} + \beta_1 IP_{sct} + \beta_2 IP_{sct} \times PMR_{ct} + \beta_3 X_{isct} + \beta_4 X_{sct} + \gamma_s + D_{ct} + \epsilon_{isct} \quad (8)$$

where ΔA_{st}^{front} is the frontier's productivity growth. We compute the productivity level of the industry-year specific frontier A_{st}^{front} by taking the average productivity level of the top 1 percent of firms across all countries: it is thus a global frontier which is consistent with our cross-country empirical strategy.[7]

[7] As a robustness check, we also compute the productivity frontier using the average of the top 5% of firms.

3.3 The importance of the firm's distance to the frontier

We allow for a non-monotonic effect of competition according to the heterogeneity of firms. The position on the firm in the productivity distribution is determined specific to its industry, with the right tail of the distribution representing the technological or productivity frontier. Is the positive escape-competition effect conditional on the distance of the firm to its industry frontier? The rationale behind this question is the following: the closer firms are to the frontier, the stronger the escape-competition effect on TFP growth tends to be. In other words, the pro-competitive effect of trade displays a boosting effect for firms with relatively high level of productivity. On the other hand, for laggard firms, an increase of competition due to the entry of foreign products on their market has a depressing effect because they are too far from the frontier to cope with it.

To capture the size of the technology gap among firms in an open-economy setting, we compare each firm's productivity to the median productivity of the the same sector and year. We then divide firms into two groups: a group of firms that are above the median level of TFP – those closer to the global TFP frontier – and a group of firms that have a TFP level below the median of their industry – who have a larger technological gap. To evaluate the differential impact of foreign competition and product market regulation according to firm heterogeneity in the technological gap, we estimate Equations (6) and (8) separately for the two sub-samples.

3.4 The issue of reverse causality

Foreign competition is proxied by import penetration; thus it is possible that a bias exists because of reverse causality between firm productivity and trade orientation of the firm's sector. Foreign firms are able to enter a market more intensively if domestic firms are not efficient, leaving the competitive advantage to trade partners. This implies a negative correlation between average domestic firms' productivity and import shares. However, the reverse causality problem should not be an major issue in our specification, as we regress individual firm level productivity on sectoral import shares. The reverse causality issue is even less of an issue since we use TFP growth, as compared to productivity levels. Finally, in this case, reverse causality would create a downward bias on the import share coefficient and we would therefore *underestimate* the pro-competitive effect of international trade. In spite of this, our results indicate a positive relationship between

Table 4: Impact of import penetration and PMR on firms' TFP growth
Not resampled data set

PMR variable	Barriers to entrepreneurship					
	(1)	(2)	(3)	(4)	(5)	(6)
	All firms	Close to the frontier	Far from the frontier	All firms	Close to the frontier	Far from the frontier
IP	0.173**	0.542**	0.019	0.175**	0.445**	0.011
	(0.084)	(0.215)	(0.031)	(0.076)	(0.201)	(0.028)
IP×PMR	-0.094**	-0.292**	-0.008	-0.128***	-0.303***	0.032
	(0.043)	(0.114)	(0.016)	(0.046)	(0.102)	(0.029)
Herf				0.021	0.132	0.317***
				(0.221)	(0.377)	(0.098)
IP×Herf				0.134**	0.275*	-0.130**
				(0.066)	(0.165)	(0.060)
Constant	0.373	1.004	-0.381***	0.384	0.988	-0.454***
	(0.758)	(1.012)	(0.060)	(0.752)	(0.996)	(0.068)
Observations	455,491	234,361	221,130	455,491	234,361	221,130
R-squared	0.024	0.033	0.033	0.024	0.033	0.033
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses, clustered standard errors by country and sector.
*** p<0.01, ** p<0.05, * p<0.1

productivity growth of the top firms and import penetration, which strengthens our confidence in the findings. Our estimates can thus be considered a lower bound of the productivity-enhancing effect of import competition.

3.5 Interpretation of results

The first set of results from the estimation of Equation (6) are shown in Tables 4 and 5, while Tables 6 to table 9 provide robustness checks of the same equation. These results are based on the regression of firm-level productivity growth on import penetration (IP) and the interaction between import penetration and domestic regulation ($IP \times PMR$). Import penetration at the sectoral level (IP) is used to proxy foreign competition pressures, while the 'barriers to entrepreneurship' index is used to measure the stringency of domestic regulation (PMR). The same equations are also estimated with the control variables. The first set of results, Tables 4 through 7, use the 'barriers to entrepreneurship' index (PMR) contemporaneously and with lags, both with the default dataset (Tables 4 and 5) and the resampled dataset (Tables 6 and 7). Table 12 displays the results of the estimation of Equation (7) with firm fixed-effects.

Table 5: Lagged impact of import penetration and PMR on firms' TFP growth
Not resampled data set

PMR variable	Barriers to entrepreneurship					
	(1)	(2)	(3)	(4)	(5)	(6)
	All firms	Close to the frontier	Far from the frontier	All firms	Close to the frontier	Far from the frontier
IP_{t-1}	0.166*	0.518**	-0.039	0.135	0.419*	-0.012
	(0.100)	(0.222)	(0.071)	(0.096)	(0.249)	(0.071)
$IP \times PMR_{t-1}$	-0.088*	-0.281**	0.025	-0.108**	-0.268**	0.036
	(0.051)	(0.118)	(0.034)	(0.052)	(0.120)	(0.037)
$Herf_{t-1}$				-0.046	0.042	0.314***
				(0.230)	(0.408)	(0.088)
$IP \times Herf_{t-1}$				0.142**	0.168	-0.089
				(0.057)	(0.142)	(0.068)
Constant	0.380	0.908	-0.428***	0.408	0.907	-0.489***
	(0.731)	(0.942)	(0.088)	(0.731)	(0.940)	(0.093)
Observations	454,375	233,529	220,846	454,375	233,529	220,846
R-squared	0.022	0.030	0.033	0.022	0.030	0.033
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses, clustered standard errors by country and sector.
*** p<0.01, ** p<0.05, * p<0.1

Overall, the results, which split the sample by distance to frontier, are highly consistent with our hypotheses, and are robust across specifications, including those that account for potential reverse causality (using lagged values of IP) and potential sampling bias (on the resampled dataset).

Changes in firm productivity are impacted by both the domestic institutional environment and the extent of openness to foreign markets. However, firms' responses to foreign competition are heterogeneous, even within narrowly defined sectors. The evolution of firm TFP growth depends remarkably on its position in the distribution of firm efficiency. Firms that are technologically advanced benefit from competitive pressure of foreign firms' entry into their domestic markets. This "escape competition effect" is strong for the most competitive firms, with foreign competition generally having no significant impact on firms that are at the bottom of the efficiency distribution. In some specifications, import penetration affects also positively firms far away from the technology frontier but in those cases, the "escape competition effect" is much smaller than for the firms closer to the frontier.

The positive pro-competitive effect of trade on advanced firms has a different magnitude according to the extent of product market regulation in the country. The negative coefficient on the

Table 6: Impact of import penetration and PMR on firms' TFP growth
Resampled data set

PMR variable	Barriers to entrepreneurship					
	(1) All firms	(2) Close to the frontier	(3) Far from the frontier	(4) All firms	(5) Close to the frontier	(6) Far from the frontier
IP	-0.020	0.427**	-0.023	-0.005	0.409*	-0.002
	(0.204)	(0.213)	(0.075)	(0.207)	(0.213)	(0.080)
IP×PMR	0.007	-0.232**	0.008	0.002	-0.234**	0.009
	(0.105)	(0.114)	(0.037)	(0.105)	(0.115)	(0.039)
Herf				0.371	0.303	0.117
				(0.252)	(0.304)	(0.097)
IP×Herf				-0.010	0.036	-0.049
				(0.043)	(0.079)	(0.046)
Constant	-0.179*	-5.055***	0.073**	-0.295**	-5.174***	0.042
	(0.100)	(0.960)	(0.029)	(0.150)	(0.991)	(0.039)
Observations	348,007	162,479	164,429	348,007	162,479	164,429
R-squared	0.037	0.043	0.025	0.037	0.043	0.025
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses, clustered standard errors by country and sector.
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Lagged impact of import penetration and PMR on firms' TFP growth
Resampled data set

PMR variable	Barriers to entrepreneurship					
	(1) All firms	(2) Close to the frontier	(3) Far from the frontier	(4) All firms	(5) Close to the frontier	(6) Far from the frontier
IP_{t-1}	0.422**	0.718**	0.273*	0.400*	0.645**	0.339**
	(0.209)	(0.282)	(0.160)	(0.228)	(0.305)	(0.159)
$IP \times PMR_{t-1}$	-0.193*	-0.357***	-0.128*	-0.193*	-0.348**	-0.127*
	(0.099)	(0.134)	(0.076)	(0.099)	(0.135)	(0.076)
$Herf_{t-1}$				-0.024	-0.249	0.067
				(0.288)	(0.351)	(0.110)
$IP \times Herf_{t-1}$				0.051	0.302	-0.160
				(0.208)	(0.304)	(0.105)
Constant	-0.250***	-5.269***	-0.089***	-0.241**	-5.189***	-0.117***
	(0.062)	(0.832)	(0.018)	(0.115)	(0.854)	(0.035)
Observations	338,137	158,549	159,645	338,137	158,549	159,645
R-squared	0.039	0.043	0.028	0.039	0.043	0.028
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses, clustered standard errors by country and sector.
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Impact of import penetration and PMR on firms' TFP growth
Not resampled data set

PMR variable	**Burdens on startups**					
	(1)	(2)	(3)	(4)	(5)	(6)
	All firms	Close to the frontier	Far from the frontier	All firms	Close to the frontier	Far from the frontier
IP	0.075	0.189***	-0.039*	0.181**	0.122	0.071
	(0.050)	(0.073)	(0.023)	(0.072)	(0.113)	(0.070)
IP×PMR	-0.055*	-0.117***	0.032*	-0.079***	-0.113**	0.012
	(0.029)	(0.044)	(0.019)	(0.029)	(0.044)	(0.025)
Herf				-0.121	-0.035	0.422***
				(0.260)	(0.277)	(0.101)
IP×Herf				-0.141	0.130	-0.145*
				(0.086)	(0.159)	(0.078)
Constant	-0.042	-0.614	-0.481***	-0.017	-0.597	-0.561***
	(0.309)	(0.470)	(0.109)	(0.323)	(0.475)	(0.104)
Observations	417,389	237,355	160,651	417,389	237,355	160,651
R-squared	0.025	0.046	0.035	0.025	0.046	0.035
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses, clustered standard errors by country and sector.
*** p<0.01, ** p<0.05, * p<0.1

Table 9: Impact of import penetration and PMR on firms' TFP growth
Not resampled data set

PMR variable	**Regulatory protection of incumbents**					
	(1)	(2)	(3)	(4)	(5)	(6)
	All firms	Close to the frontier	Far from the frontier	All firms	Close to the frontier	Far from the frontier
IP	0.262**	0.568***	-0.088	0.258**	0.471**	-0.014
	(0.107)	(0.211)	(0.088)	(0.108)	(0.217)	(0.086)
IP×PMR	-0.146**	-0.314***	0.047	-0.148**	-0.307***	0.050
	(0.058)	(0.116)	(0.047)	(0.058)	(0.114)	(0.047)
Herf				-0.142	-0.196	0.317***
				(0.259)	(0.387)	(0.096)
IP×Herf				0.017	0.194	-0.138***
				(0.050)	(0.148)	(0.052)
Constant	-0.061	0.251	-0.386***	-0.028	0.314	-0.461***
	(0.313)	(0.395)	(0.064)	(0.324)	(0.414)	(0.068)
Observations	417,139	213,970	203,169	417,139	213,970	203,169
R-squared	0.025	0.034	0.031	0.025	0.034	0.031
Sector FE	YES	YES	YES	YES	YES	YES
Country-Year FE	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses. Clustered standard errors by country and sector.
*** p<0.01, ** p<0.05, * p<0.1

interaction term indicates that trade becomes more beneficial as market regulation becomes less stringent. The 'barriers to entrepreneurship' PMR index is used in the estimates shown in Tables 4 through 7, which reflects anti-competitive measures such as entry barriers and administrative burdens that inhibit competition across sectors.

To more clearly delineate the effects of the measures, we use two sub-indicators in tables 8 and 9 . Table 8, with the 'burdens on startups' sub-indicator, focuses more clearly on administrative burdens for new firms, including sector-specific burdens. Table 9 displays the effect of the 'Regulatory protection of incumbents' sub-indicator which focuses on barriers to competition due to legal barriers to entry, antitrust exemption, including barriers in network sectors. Using these sub-indexes, the results yield coefficient estimates that are qualitatively very similar to the estimates with the broader PMR 'barriers to entrepreneurship' index shown in the previous tables. Stringent 'Regulatory protection of incumbents' reduce more strongly the incentive effect of import penetration than 'burdens on startups'

Domestic competition may also vary within a country, across sectors. This may have an effect on firms' incentives to upgrade their technology. The level of competition within a sector can be proxied by the concentration level within a sector. [8] In concentrated sectors, firms are not forced to reduce prices and can make positive profits more easily. Hence low productivity firms can survive. Our analysis suggests that the concentration level has a different impact on more advanced versus laggard firms, based on the raw dataset (Tables 4 and 5). While high concentration seems to allow less efficient firms to perform well, it is not a condition for high productivity firms whose TFP growth rates are not significantly affected by the concentration level. Such a concentration index is however an imperfect measure of competition as it does not capture the existence of entry threats. Moreover it focuses on a geographically limited definition of competition while European manufacturing sectors are open and some firms operate in international markets. Our favored measure of competition is the product market regulation index, as it can proxy unobservable entry threats as well as the existing regulatory scope that can be used to adjust to changes in market structure.

[8] We also use the *Regimpact* regulatory impact index to help control for pressures that may affect costs. Regimpact can control for the cost structure of intermediate inputs coming from upstream sectors. Robustness checks were run with all of the estimated equations, and the inclusion of *Regimpact* in the equations does not affect the interpretation of the estimates. Firms that are closer to the frontier are found to cope more easily with high regulation in upstream services sectors, and it has a damping effect on firms farther from the frontier.

Table 10: The impact of IP and PMR on firms' TFP growth, with frontier TFP growth
Not resampled data set

PMR variable	Barriers to entrepreneurship					
	(1) All firms	(2) Close to the frontier	(3) Far from the frontier	(4) All firms	(5) Close to the frontier	(6) Far from the frontier
ΔA^{front}	0.003***	0.005**	0.001*	0.003***	0.005**	0.001*
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)
IP	0.172**	0.494**	-0.040	0.162*	0.382*	0.002
	(0.087)	(0.197)	(0.063)	(0.086)	(0.202)	(0.055)
IP×PMR	-0.092**	-0.265**	0.020	-0.102**	-0.252**	0.046
	(0.045)	(0.105)	(0.032)	(0.050)	(0.104)	(0.035)
Herf				0.160	0.239	0.346***
				(0.191)	(0.374)	(0.097)
IP×Herf				0.058	0.204	-0.164***
				(0.055)	(0.143)	(0.061)
Constant	-0.612***	-0.770**	-0.425***	-0.637***	-0.817**	-0.503***
	(0.191)	(0.350)	(0.092)	(0.206)	(0.393)	(0.102)
Observations	414,890	211,820	203,070	414,890	211,820	203,070
R-squared	0.032	0.042	0.031	0.032	0.043	0.031
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses, clustered standard errors by country and sector.
*** p<0.01, ** p<0.05, * p<0.1

Table 11: The impact of IP and PMR on surviving firms' TFP growth
Not resampled, balanced data set

PMR variable	Barriers to entrepreneurship					
	(1) All firms	(2) Close to the frontier	(3) Far from the frontier	(4) All firms	(5) Close to the frontier	(6) Far from the frontier
IP	0.212**	0.602***	-0.024	0.199*	0.571***	0.032
	(0.106)	(0.218)	(0.075)	(0.101)	(0.216)	(0.069)
IP×PMR	-0.114**	-0.323***	0.014	-0.119**	-0.319***	0.036
	(0.056)	(0.116)	(0.038)	(0.057)	(0.115)	(0.041)
Herf				-0.021	0.019	0.384***
				(0.268)	(0.441)	(0.120)
IP×Herf				0.048	0.056	-0.187**
				(0.065)	(0.111)	(0.077)
Constant	-0.688*	-0.945	-0.429***	-0.677*	-0.944	-0.525***
	(0.380)	(0.649)	(0.043)	(0.382)	(0.657)	(0.050)
Observations	230,267	125,647	104,620	230,267	125,647	104,620
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses, clustered standard errors by country and sector.
*** p<0.01, ** p<0.05, * p<0.1

Table 12: The impact of IP and PMR on surviving firms' TFP growth
With firm fixed effects – Not resampled, balanced data set

PMR variable	**Barriers to entrepreneurship**					
	(1)	(2)	(3)	(4)	(5)	(6)
	All firms	Close to the frontier	Far from the frontier	All firms	Close to the frontier	Far from the frontier
IP	0.310**	0.567*	0.094	0.306**	0.513*	0.100*
	(0.131)	(0.312)	(0.063)	(0.130)	(0.311)	(0.059)
IP×PMR	-0.168**	-0.307*	-0.052	-0.190**	-0.312*	-0.021
	(0.069)	(0.166)	(0.033)	(0.080)	(0.168)	(0.047)
Herf				-0.070	0.165	0.050
				(0.443)	(0.835)	(0.112)
IP×Herf				0.096	0.149	-0.121*
				(0.086)	(0.153)	(0.070)
Constant	0.102***	0.353***	-0.139***	0.120***	0.358***	-0.162***
	(0.023)	(0.046)	(0.012)	(0.036)	(0.062)	(0.019)
Observations	230,708	125,978	104,730	230,708	125,978	104,730
R-squared	0.036	0.046	0.006	0.036	0.046	0.006
Number of IDs	34,071	25,210	22,054	34,071	25,210	22,054
Firm FE	YES	YES	YES	YES	YES	YES
Country-Year FE	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses, clustered standard errors by country and sector.
*** p<0.01, ** p<0.05, * p<0.1

These results are robust to a number of alternative specifications, such as inclusion of the growth of the productivity frontier (Table 10, using Equation (8)) or the restriction of the sample to only surviving firms (Table 11).[9] While these changes in specification have a slight impact on the results, they remain the same in sign, significance and roughly the same in magnitude, in these contemporaneous results. We have also checked for the inclusion of other controls at the firm level, such as an indicator of exit during the period, the size of the firm, which has no discernible effect on the main results. We also estimated a specification that includes firm-level fixed effects and thus controls for time-invariant specificities of the firm that could affect a firm's TFP but not be related with foreign competitive pressures. The results are the same as in the main specification.

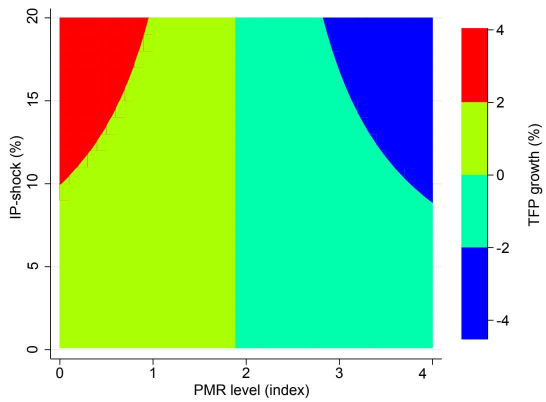
All the reported results are obtained from specifications that include country-year fixed effects which prevents us from estimating the direct impact of PMR on firm productivity growth. When we include country fixed effects and year fixed effects separately instead of their interaction, the impact of country-wide PMR is significant and negative and the results on our variables of principal

[9]Since the Amadeus dataset does not precisely identify exit and entry, what we know about these firms is that they neither exited nor shrunk substantially in size over the period.

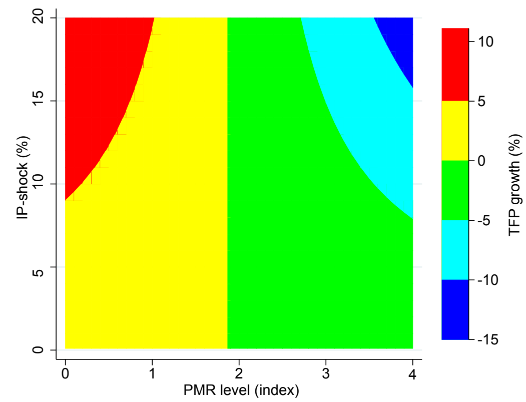
interest, import penetration and its interaction with PMR remain qualitatively similar.

3.6 Effects on productivity

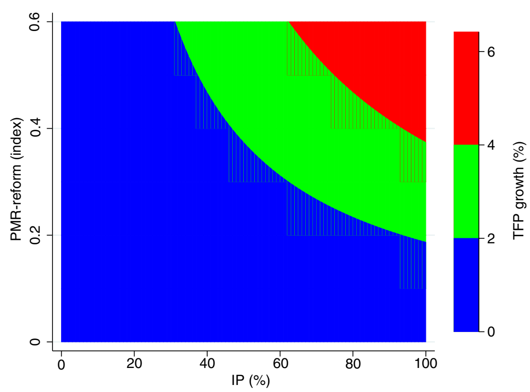
Figure 1: Estimated within-firm TFP growth effects under conditional IP and PMR shocks



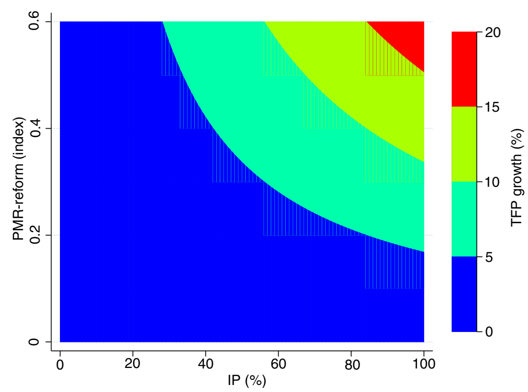
(a) Import penetration shocks: All firms



(b) IP shocks: Top firms



(c) Product market reform (PMR) shocks: All firms



(d) PMR shocks: Top firms

Source: Simulations based on equation estimates from Table 4, columns 2 and 3. Shocks to import penetration (IP) measured in percent and PMR in index units on its standard 0 to 6 scale of increasing regulatory stringency.

What is the economic significance of the results just discussed? Taking our preferred equation estimates from Table 4, the effects of changes in import penetration and product market reform can be simulated for within-firm productivity growth, among the relatively large firms in our dataset. Given our specification of the estimation equation, we therefore focus on conditional shocks. A qualitative visualization of these simulations is shown in Figure 1.

Increases in import penetration (IP) only boost firm TFP growth if PMR is sufficiently low, below a certain threshold (Figure 1, Panel A) equivalent to the median PMR setting at the end of the period studied. If PMR is higher than this threshold, an increase in IP (*i.e.* international competition) has a perverse impact on TFP, leading to negative TFP growth through discouragement. This effect arises from an even larger-magnitude effect on the firms in the upper half of the productivity distribution (Panel B). To take a particular example, for firms in the United Kingdom, the country with the lowest PMR (0.95), an increase in import penetration of 10% would raise firm TFP growth by approximately 1.0% per year on average, or 2.7% for the firms in the upper half of the productivity distribution. Yet for countries (primarily in earlier time periods) with higher PMR settings, the effect is essentially reversed, with a negative effect on TFP growth.

A similar simulation can be carried out for a range of PMR reforms taking varying levels of import penetration as given (Figure 1, Panels C and D). Product market regulatory reforms unambiguously boost productivity growth; however, their effects are magnified considerably when import penetration is higher. For instance, a PMR reform of 10% of the median setting of 2.39 would boost within-firm productivity growth by 0.5% in a sector at the 25th percentile of import penetration (20%), and by 2.3% in a sector at the 75th percentile (88%). Again, the impact is driven by firms in the upper half of the productivity distribution, where productivity growth is boosted by 1.4% and 6.3%, respectively, in low and high import penetration sectors. For firms in the lower half of the productivity distribution, the impact of PMR reform through this channel is negligible. Countries with a large share of high-productivity firms will thus benefit much more from PMR reforms.

4 Conclusion

This paper offers a new assessment of the effect of import penetration on firm-level productivity growth, taking into account heterogeneity in distance to the technological frontier and country differences in product market regulation. Our results show that firms in sectors with higher import penetration have higher TFP growth if the firms are close to their sectoral technology frontier. The most productive firms appear to enjoy a significant increase in productivity when foreign competitors' pressure is high. However, import penetration does not incentivise firms far away from the technological frontier or if so only weakly. This result illustrates that in order to understand firms' TFP growth, it is important to combine explanations based on the pro-competitive effect of trade with a "Schumpeterian" distance-to-the-frontier mechanism, an area that theoretical trade models have overlooked to date.

The pro-competitive effect of international trade depends on domestic product market regulation as measured by the OECD's Product Market Regulation (PMR) index. Our results indicate that, in the upper part of the productivity distribution, the positive effect of foreign competition is inhibited for firms operating in a country with stringent regulation such as higher barriers to entry. Domestic and foreign competitive pressures are found to be complementarity: firms' incentives or abilities to improve their productivity to cope with foreign competition are stronger in countries with lower levels of PMR. As for firms at the bottom of the productivity distribution, foreign competition does not have a significant within-firm benefit on their efficiency – irrespective of the regulatory environment – though it may faciliate their demise, whereby they relinquish their market share to more productive firms.

Future work in this area could go beyond this paper in a number of respects. First, if firm-level trade information were available in a multi-country dataset, both the extensive and intensive margins could be examined, since their impact on competition likely differs. This would also allow us to estimate the effect of material offshoring. Second, instrumentation of import penetration would make the results for the measure more robust. Third, once a longer time series of domestic regulation indicators is available, further analysis would be worthwhile.

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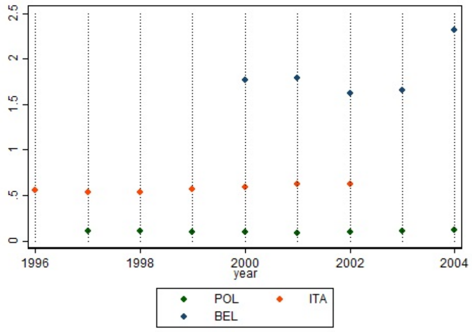
A Annex

Table A.1: Summary statistics – Number of Firm in the sample and with TFP growth

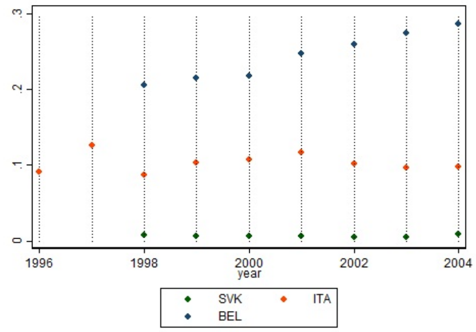
	1998			2004		
	Number of firms			Number of firms		
Country	overall	with TFP growth	average size	overall	with TFP growth	average size
AUT	12	7	634	43	17	481
BEL	1618	1,423	144	1,855	1,713	140
CZE	27	0	561	2,886	1,819	211
DEU	351	280	814	1,000	525	451
DNK				117	84	161
ESP	16,690	14,464	52	21,555	19,836	57
FIN	1,399	892	43	2,193	1,861	47
FRA	14,076	7,709	100	19,630	15,028	93
GBR	3,909	3,047	292	4,329	3,474	281
ITA	19,784	17,257	53	16,213	13,705	72
NLD	78	60	470	152	113	309
NOR				1241	1084	35
POL	289	132	419	2,044	1,445	191
PRT	619	330	120	261	125	1,321
SVK				261	166	235
SWE	2,545	7	33	4,375	4,021	51

Source: Authors' calculations based on Amadeus database with not resampled dataset. The average firm size average is number of employees. Austria and Slovakia are excluded from the estimation sample because there are too few firms in cells. We have also conducted robustness checks without Denmark.

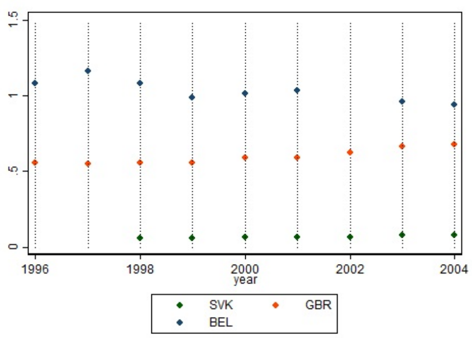
Figure A.1: Maximum, Minimum and Average Openness per 4-digit Sector and per Year



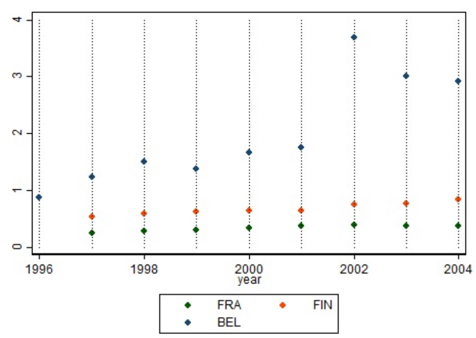
(a) Processing and preserving of fish products



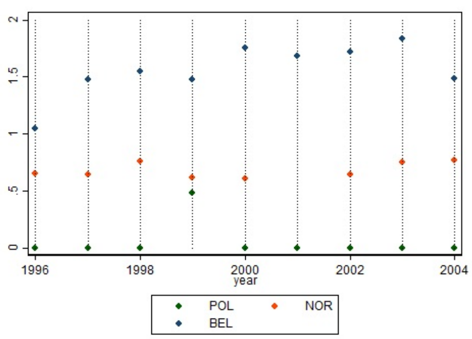
(b) Manufacture of prepared animal feeds



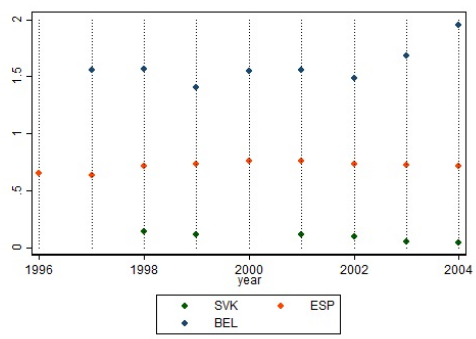
(c) Preparation and spinning of textile fibres; weaving of textiles



(d) Manufacture of pharmaceuticals, medicinal chemicals and botanical products



(e) Manufacture of instruments for measuring, testing, navigating and other purposes



(f) Manufacture of parts and accessories for motor vehicles and their engines

Source: Authors' calculations based on Comtrade data. We present here how import penetration evolves per sector x country x year, only for a few 4-digit sectors as an illustration.