Trade Liberalization, Domestic competition and Total Factor Productivity: Evidence from manufacturing sector

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It is widely argued according to heterogeneous firms trade models that trade openness will lead to the exit of the least efficient firms from the market, as they cannot afford the competition by foreign firms. Thus, trade will lead to an increase in the average productivity in the sectors that are exposed to foreign competition. Hence, using the UNIDO sectoral-level data, we use Levinshon and Petrin (2003) methodology to estimate the Total Factor Productivity (TFP) to test how trade liberalization will affect the TFP across countries. The results show that tougher import competition increases the total factor productivity in the manufacturing sector and lower tariffs restrictions leads to higher TFP. Moreover, when we disentangled this trade openness effect by the size of the sector, we found that sector size does not matter. Finally, when we differentiate the results by the development level of the country, we find that developed countries benefit more than developing countries from higher international competition. This reflects that there exist many obstacles in developing countries that prevent gains in productivity increase after trade openness. These results provide us with new evidence regards the hypothesis that international competition positively affects total factor productivity and the extent at which increasing international competition is beneficial for developing countries in the manufacturing sectors.

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A preliminary version

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1. Introduction

One of the main assumptions of the industrial economics theory is that competition matters for productivity levels. Moreover, according to heterogeneous firms trade models. it is widely argued that trade openness and increased international competition will lead to the exit of the least efficient firms from the market as they cannot afford the competition by the foreign firms. Thus, trade will lead to an increase in the average productivity in the sectors that are exposed to foreign competition.

The first empirical studies to examine the impact of international competition on domestic producers focused on the effect of imports on profitability and prices (Domowitz et al. (1986); DeRosa and Goldstein (1981)). Later, research focuses more directly on the effect of exposure to international competition on productivity. Baumol (1986), Bernard and Jones (1996), Bernard and Jones (1996b), Edwards (1998), they all concluded that import share positively affects a country's total factor productivity growth. Other empirical studies focused on the micro level. They have explored the impact of international competition on determining the levels of productivity growth among firms and industries. Bernard and Jensen (1999), Nickell (1996) and McDonald (1994), found different results on the effect of international competition on productivity differences across firms and industries.

This paper tries to analyze whether the extent at which increasing international competition is beneficial for TFP in the manufacturing sector is the same for developing and developed countries.

In other words, this paper aims to study how trade openness and tougher import competition affect the total factor productivity in the manufacturing sector. We disentangle this effect of trade liberalization and international competition by the country development level and by the sector size. Our objective is to test whether the impact of trade liberalization on sector productivity is different in developed vs. developing countries. Hence, using the UNIDO sectoral-level data, we use Levinshon and Petrin (2003) methodology to estimate the Total Factor Productivity (TFP) to test how trade liberalization will affect the TFP in the manufacturing sector across countries. To do so, we merge the UNIDO Industrial Statistics Database with the UNIDO Industrial Demand-Supply Balance Database to be able to draw conclusions on how fiercer competition due to trade openness will affect the productivity per sector. This would enable us to discuss the policy implications of trade on the manufacturing sectors of different countries.

The contribution of this paper is twofold. First, we will expand upon the previous literature by developing, in a first step, a model from which we will estimate the Total

Factor Productivity (TFP) using Levinshon and Petrin (2003) and then, in a second step, we will use the estimated TFP to test the effect of international competition and openness to trade on total factor productivity in the manufacturing sector. Second, we extend the analysis to measure the differential effect between developed and developing countries, and also between various sectors sizes.

The remaining of the paper will be organized as follows. Section 2 presents the theoretical background on mechanics of TFP and openness and the literature review. Section 3 shows the econometrical methodology, data and variables definition. Section 4 presents some stylized facts. In Section 5, the results of the model are depicted and discussed. Finally, we conclude in Section 6.

2. Literature Review

In this section, we will examine the theoretical background of the relationship between Trade openness and firm productivity. Then, we will explore the main empirical works that tested for this relationship.

2.1. Theoretical background on the Mechanics of TFP Growth and Openness

The seminal model of Melitz (2003) showed that trade openness leads to the exit of the least productive firms as they could not afford the competition faced from foreign firms (Bernard & Jensen, 1999). Thus, trade liberalization increases the average productivity available in the market. Due to the existence of fixed and sunk costs of exporting, only the most productive firms could afford these costs and start to export.

Melitz & Ottaviano (2008) showed in their model of monopolistic competition with heterogeneous firms and endogenous markups that free trade leads to higher productivity, lower markups and greater products variety. Their model combines all possible sources of welfare gain following trade in the same set-up.

As shown by Edwards (1998), there are two sources of TFP growth. A domestic source and an international source. The domestic one is associated with innovation. However, the international one is related to the rate at which the country is able to imitate technological progress. The rate of imitation depends on the “Catch-up”. However, the rate of domestic innovation depends on the level of human capital. According to many new models of growth, countries with a more open economy will have a higher steady state stock of knowledge and, with other things given, higher GDP. Thus, those models suggest that *TFP growth will be positively affected by the level of human capital and openness, and negatively affected by the initial stock of knowledge (Edwards, 1998).*

2.2. Empirical investigations on the effect of international competition on TFP

By the 1990s, empirical research began to focus on the effect of international competition on productivity (Amato and Amato, 2001). Indeed, it has been empirically proven that after periods of trade openness there was an increase in the firm-level productivity (see, e.g.; Pavcnik, 2002; MacDonald, 1994; Lawrence, 2000). The growth in the plant-level productivity may have two main reasons: first, fiercer competition induces plants to improve their productivity efficiency. Second, the firm may change its product mix by dropping the worst products and skewing its production towards its best performing varieties.

After the massive trade liberalization undergoing in Chile that significantly exposed its plants to competition during the late 1970s and 1980s, Pavcnik (2002) was motivated to empirically investigate the effects of liberalized trade on plant productivity in the case of Chile. This paper drew a census of Chilean manufacturing plants employing ten or more workers from 1979 to 1986. He first estimated a production function to obtain a measure of plant productivity. Then, by using the OLS, fixed effects, and semiparametric estimation, he identified the impact of trade on plants' productivity in a regression framework allowing variation in productivity over time and across traded and nontraded-goods sectors. He found evidence of within plant productivity improvements that can be attributed to a liberalized trade for the plants in the import-competing sector. He concluded that in many cases, aggregate productivity improvements stem from the reshuffling of resources and output from less to more efficient producers.

Trefler (2004) examined the impact of tariff reductions on labor productivity of Canadian plants after the Canada-U.S. free trade agreement. He used a sample of 4-digit Canadian SIC data (213 industries) over two peridos pre-FTA period (1980-1986) and FTA period (1988-1996). By running an OLS and an IV regresions, he reached many conclusions. First, the FTA was associated with substantial employment losses: 12 percent for import-competing group of industries and 5 percent for manufacturing as a whole. These effects appear in both the industry- and plant-level analyses. Second, the FTA led to large labor productivity gains. For the most impacted, export-oriented group of industries, labor productivity rose by 14 percent at the plant level. For the most impacted, import competing group of industries, labor productivity rose by 15 percent with at least half of this coming from the exit and/or contraction of low productivity plants. For manufacturing as a whole, labor productivity rose by about 6 percent which is remarkable given that much of manufacturing was duty-free before implementation of the FTA. Third, the FTA created more trade than it diverted and possibly lowered import prices. Thus, the FTA likely raised aggregate welfare.

De Loecker (2011) analysed whether removing barriers to trade as a proxy of trade liberalization induces efficiency gains for producers. More specifically, he measured the productivity effects of reduced quota protection using detailed production and product-level data for Belgian textile producers. The data used covered Belgian textile producers in the European Union (EU-15) market during 1994 to 2002. He found that abolishing all quota protections increased firm-level productivity by only 2 percent as opposed to 8 percent when relying on standard measures of productivity.

Jang, Cho and Kim (2015) empirically examined the impact of Korea's FTAs on firm productivity at home. They focused on the expansion of exports as a channel through which trade liberalization can affect firm productivity. They use firm-level data from 2001 to 2009. By using the fixed effect model and the difference-in-difference models they found that Korea's FTAs had positive impacts on domestic firm's TFP via the export channel. They also concluded that the impact of FTA depends on the firm size; the positive effects of FTAs on firm's TFP are more prominent in the SMEs in the short-term but in large-sized firms in the long-term.

At the industry sectoral level data, Edwards (1998) analyzed the robustness of the relationship between openness and total factor productivity growth for 93 countries at the industry level. Nine indexes of trade policy were used to investigate whether the evidence supports the view that total factor productivity growth is faster in more open economies. The results are robust to the use of different openness indicators and suggest that more open countries experienced faster productivity growth. He argued also but the size of the parameter estimates suggests that convergence is a lengthy process.

Amato and Amato (2001) used an instrumental variables approach to investigate the relationship between growth in total factor productivity and growth in imports and exports in U.S. manufacturing at the four-digit SIC industry level at roughly five-year intervals covering the period 1977–1992. The most important finding is that export growth positively affects growth in total factor productivity for the pooled model and for every year of the sample. Growth in imports has a positive impact on TFP for the pooled model and in two of four sample years.

In what follows, we will estimate the Total factor productivity in the manufacturing sectors for a group of developed and developing countries and we will disentangle the effect of trade liberalization and international competition on TFP by development level and sector size.

3. Econometrical Model

3.1. Theoretical background

Economic researchers worried about the potential correlation between input levels and the unobserved firm-specific productivity shocks in the estimation of production functions (Levinsohn and Petrin, 2003). The intuition behind this correlation is that firms that face a large positive productivity shock will respond by using more inputs. Thus, ordinary least squares (OLS) estimates will yield biased estimates of productivity.

Many alternatives to the OLS estimates have been proposed to correct to the potential bias using OLS method. Olley and Pakes (1996) used the investment proxy to control for correlation between input levels and the unobserved productivity shock. Levinsohn & Petrin (2003) extended their model, and used intermediate inputs instead of the investment to control for the simultaneity bias. They showed that intermediate inputs (those inputs which are typically subtracted out in a value-added production function) can also solve this simultaneity problem. The main advantage of Levinsohn & Petrin's model is data-driven: that the investment proxy is only valid for the firms that report non-zero investment. Instead, concerning the intermediate inputs, almost all plants report positive amounts of inputs like materials, electricity or fuel. There is another advantage for the intermediate inputs over the investment proxy: mainly that the use of intermediate inputs could be easily adjusted for productivity shocks than the investment, and hence the correlation between the error term and the regressors could disappear. This is done by making the intermediate input as a function of the firm's state variable, the capital and the productivity.

We follow Levinsohn and Petrin (2003) to estimate the production functions using intermediate inputs to control for unobservable productivity shocks. As mentioned by Levinsohn and Petrin (2003), Olley and Pakes(1994) highlighted the importance of not using an artificially balanced sample (and the selection issues that arise with the balanced sample). They showed that once they moved to the unbalanced panel, their selection correction does not change their results. In our case, our sample is unbalanced, and we do not focus on selection issue.

Using Levinsohn and Petrin (2003) methodology, inputs are divided into a freely variable (Labour), a state variable (capital) and intermediate inputs(materials) that is considered as the investment proxy. Writing the log of output as a function of the log of inputs and the shocks we have the following equation.

$$y_{ijt} = B_0 + B_l l_{ijt} + B_k K_{ijt} + B_m M_{ijt} + \omega_{ijt} + \eta_{ijt} \quad (1)$$

Where (l_{ijt}) is the freely variable Labor in Country i in Sector j at Year t, (K_{ijt}) is the Capital variable and (M_{ijt}) is the intermediate inputs (materials) variable. The error term is assumed to be additively separable in a transmitted component (ω_{ijt}) and an i.i.d. component (η_{ijt}).

Another methodology has been used to estimate sectoral Total Factor Productivity (TFP) by means of the augmented mean group estimator[3] to control for endogeneity, cross-section dependence and heterogeneous production technology. Thus, we explore more on this methodology in the Apppendix to ensure if our resuls are still robust.

After using in a first stage Levinshon and Petrin (2003) methodology to estimate the Total Factor Productivity (TFP), we will test in a second stage how market trade liberalization will affect the TFP across sectors by estimating the following equation by using a Fixed-effect model. So, we follow the literature and we estimate the following equation:

$$TFP_{ijt} = \beta_0 + \beta_1 Trade\ Liberalization_{ijt} + \beta_2\ GDP\ per\ Capita_{ijt} + \beta_3\ Size_{ijt} + \beta_3\ Number\ of\ establishments_{ijt} + \beta_3\ Development\ Level_{ijt} + \alpha_t + \delta_i + \eta_j + U_{ijt} \quad (2)$$

where TFP_{ijt} is the Total factor productivity in Country i in Sector j at Year t and $Trade\ Liberalization_{ijt}$ will be reflected by two main indicators as will be shown in the next subsection, α_t, δ_i and η_j are the year, country and sector fixed effects respectively.

After estimating this model by fixed effects GLS estimation, this would enable us to draw conclusions on the extent at which fiercer competition due to trade openness will affect the productivity levels in the manufacturing sectors. We will run the same regression

[3] This methodology has been used only for sectoral level data by assuming heterogenous production functions. Thus, we estimate TFP by using this methodology in the Appendix, in future versions of this paper, results of this methodology will be explored and discussed in detail.

for developed vs. developing countries to see whether the results will differ and also for different sectors sizes.

3.2. Data and variables definition

To estimate our model, we merge the UNIDO Industrial Statistics Database with the UNIDO Industrial Demand-Supply Balance Database (OADMI, 2017). Using these UNIDO sectoral-level data, our sample originally includes 130 manufacturing sectors at the 3- and 4-digit ISIC in 120 countries from 1990-2013.

UNIDO Industrial Statistics Database includes data on industrial statistics as Number of establishments, Number of employees, Wages and salaries, Output, Value added, Gross fixed capital formation and number of female employees. It contains time series data from 1990 to 2013. Data are available for country, year and ISIC at the 3- and 4-digit levels of ISIC (Revision 3), which comprises more than 150 manufacturing sectors and sub-sectors. Number of countries is 139. Coverage in terms of years, as well as data items, may vary from country to country depending on data availability.

The UNIDO Industrial Demand-Supply Balance Database contains highly disaggregated data on the manufacturing sector for the period 1990 to 2015 and includes trade data. The database contains data on output and on trade related items, such as imports, export and apparent consumption. The data is arranged at the 4-digit level pertaining to the manufacturing sector, which comprises 127 manufacturing categories in Revision 3 and 137 categories in Revision 4. Data includes domestic output, Total imports, Total exports, Apparent consumption, Imports from developing and emerging industrial economies, Imports from industrialized economies, Exports to developing and emerging industrial economies and Exports to industrialized economies.

After cleaning the data, we end up by having an unbalanced panel data between 1990 and 2013. Countries included in our sample are 26 countries **and 127 manufacturing sectors and subsectors**[4]. Twelve of them are considered as developed countries according to the World Bank classification, and the remaining are developing countries.

3.2.1. Variables used in Levinsohn-Petrin estimation

Our main variables used to estimate the Total Factor productivity (equation 1) are: revenue measured by total output in US$ per sector, the freely variable input is the number of employees per sector, the proxy variable input is reflected by the total intermediate inputs

[4] List of countries and industries included in our sample are in the Appendix, Table A.1. and Table A.2.

(materials) measured as the difference between the final output and the value added in US$. Finally, the capital variable is measured by using the Perpetual Inventory Method[5] based on Berlemann and Wesselhöft (2014) where:

$$Capital\ Stock_{t-1} = \frac{Investment\ _t}{GDP\ growth_t + depreciation\ rate} \quad (3)$$

The GDP growth is used as a proxy for the investment growth rate. The capital is assumed to have a depreciation rate of 5, 10 or 20% respectively as suggested by Levinsohn and Petrin (2003). All variables in this stage are assumed to be in logarithms. GMM estimator is used to estimate the Production function.

3.2.2. Variables used to test the effect of international competition on TFP

In equation (2), our dependent variable is the *Total factor productivity (TFP) in logarithms which* is the estimated variable from Levinsohn-Petrin equation.

The international trade can be affected by different types of restrictions as tariffs, quotas, licenses, prohibition, and exchange controls, among others. This complexity of commercial policies suggests that attempts to rely on a single indicator of trade orientation tend to generate disagreements. Thus, results have to be robust to the way in which openness is measured (Edwards, 1998). That's why, to measure trade liberalization, we rely on two main indicators:

- *Import penetration* measured as the ratio between the value of world imports and total output per sector. This variable is measured in logarithms.
- *Tariffs* measures the average level of MFN tariff protection (in percentage points). Data on tariffs are obtained from the World Integrated Trade Solution (WITS) database, the World Bank.
- *Openness* measured as the ratio between the summation of Imports and exports per sector to the sector output. This variable is measured in logarithms.

We also use the following variables:

[5] The basic idea of the Perpetual Inventory Method is to interpret an economy`s capital stock as an inventory. The stock of inventory increases with capital formation (investments). The amount by which the capital stock falls per period is the depreciation rate.

- *GDP per capita in PPP constant terms* measured in logarithms. As used in Edwards (1998), this variable captures the existence of TFP convergence, and its coefficient is expected to be negative as predicted by Edwards (1998).
- *Size* is a dummy variable that takes the value of 1 if number of employees exceeds 1000 (large sectors), zero otherwise (medium-sized sectors).
- *Number of establishments* is the total number of establishments per sector and is used as an indicator for domestic competition.
- *Development level* is a dummy variable that takes the value of 1 if it is a developed country according to World Bank classification and takes the value of Zero if it is a developing country.

4. Stylized facts

In this section, we explore descriptive statistics and graphical analysis of our main variable of interest TFP and then of the relationship between the TFP and different indicators used to reflect international competition.

In Table 1, we show summary statistics of the main variables used in the model explored in Equation 2.

Table 1. Summary statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Indicators for international competition					
Import penetration	5872	2.49	15.196	0.0001	480.57
Tariffs	3865	6.86	16.56	0	350
Other explanatory variables					
GDP per Capita	6333	25379.25	14557.49	1073.83	68422.79
Number of establishments	5540	1020.19	3070.61	1	98482
Size	6333	0.84	0.36	0	1
Development level	6333	0.32	0.46	0	1

4.1. TFP distribution by Development Level and Sector Size

In figure 1, the left distribution shows the TFP distribution and then it is divided according to the development level. It is quite clear that the distribution has a heavy right tail. A feature of the log transformation of the TFP is that it squashes the right tail of the distribution. Thus, the distribution of log TFP is no longer heavy-tailed. We can see that the TFP in developed countries are more concentrated than those of developing countries, even after transforming it to a logarithmic scale plotted on the left graph.

Figure 1. TFP Kernel density distribution per development level

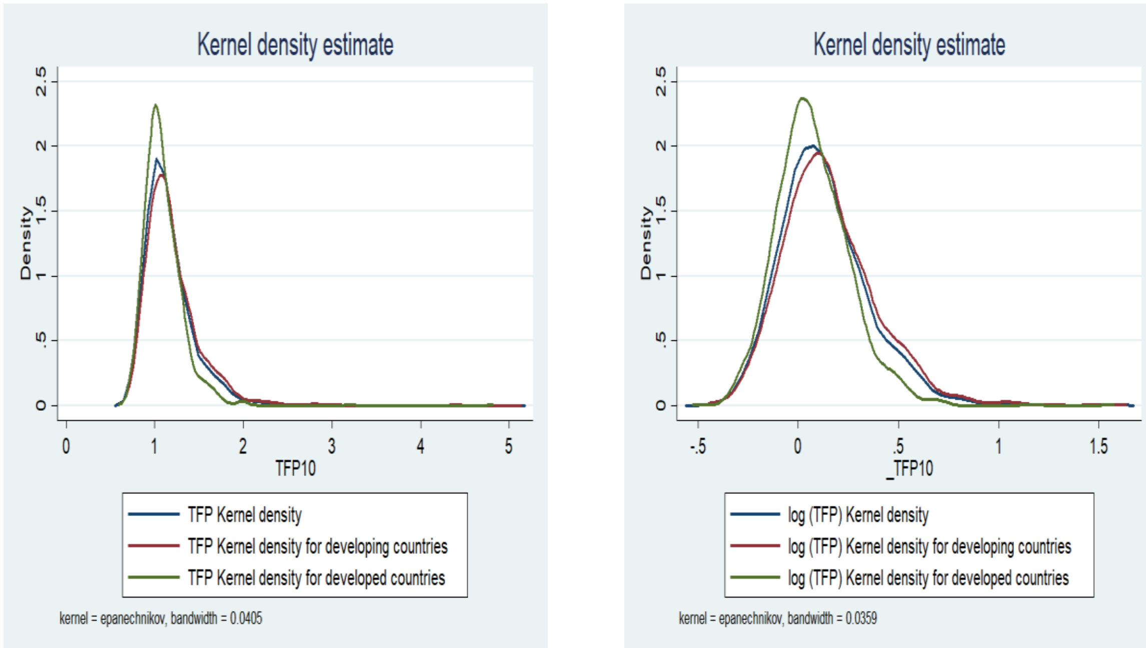
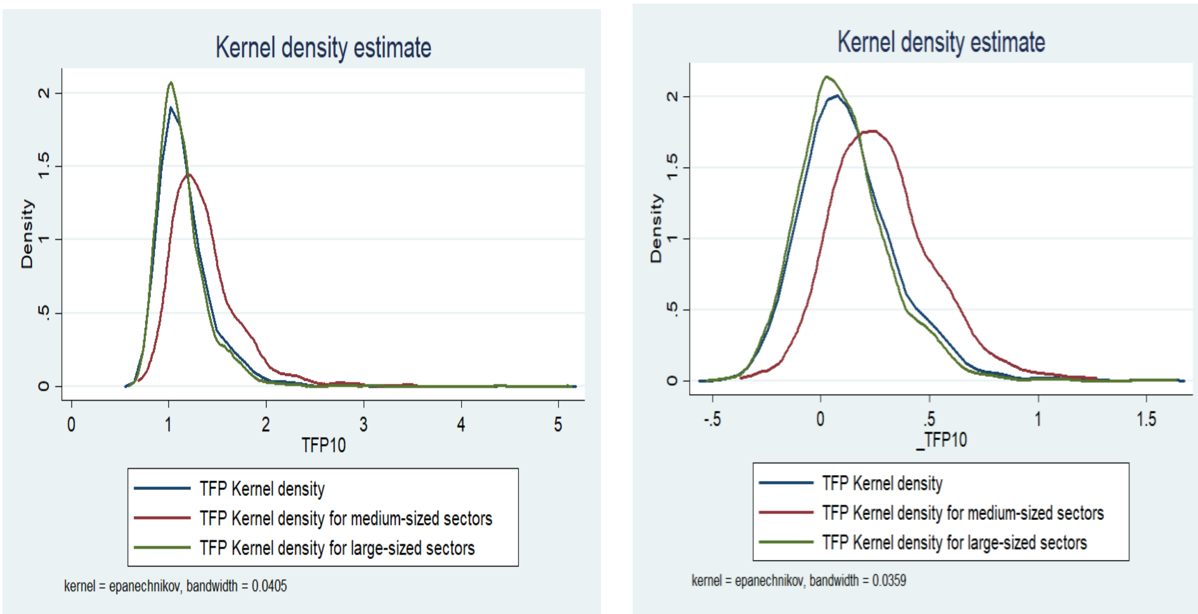


Figure 2. TFP Kernel density distribution per sector size



In figure 2, we plot Kernel distribution by considering differences in sector size, whether it is medium or a large sector size. We can see from the left graph that large-sized sectors have higher TFP concentration than medium sized sectors, with heavy right-tailed distribution. On the right graph, where TFP are plotted on a logarithmic scale, we have a more symmetric distribution, with still a more concentrated one for large-sized sectors.

4.2. Relationships between TFP and main international competition indicators

From the graph in figure 3, a positive relationship is shown between the import penetration and the TFP in natural logarithms. Below in figure 4, we depict approximatively a negative relationship between Tariffs and TFP in natural logarithms. To validate or reject these relationships, we will estimate the following models.

Figure 3. Log (TFP) and Log (Import penetration)

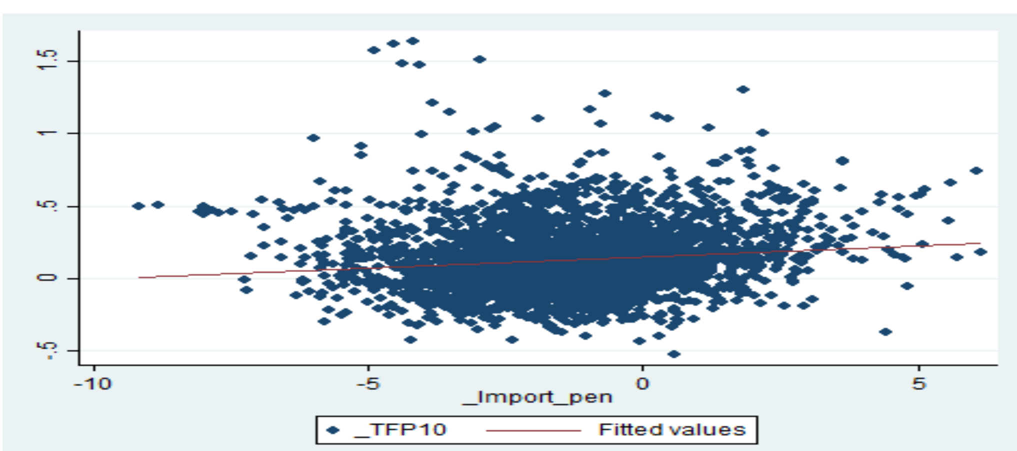
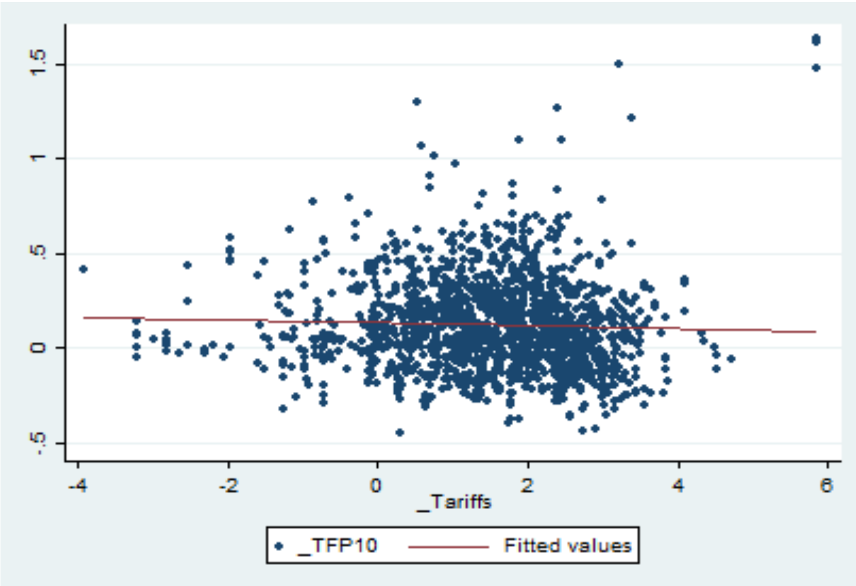


Figure 4. Log (TFP) and Log (Tariffs)



5. Results and discussions

5.1. Estimation of Equation (1)

Based on Levinsohn & Petrin's method and using raw materials as intermediate input proxy, total factor productivity was estimated in Table 2.

Table 2. Levinsohn-Petrin productivity estimator

Dependent variable represents revenue.

VARIABLES	Output (log)
Number of employees (log)	0.0675***
	(0.00897)
Capital stock (log)	0.0377***
	(0.0118)
Materials (log)	0.954***
	(0.0292)
Observations	3,481

Notes. Standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

As shown in the table above, the variables used in the production function to estimate the TFP are highly positive and significant in explaining the level of output per sector j in Country i at Year t.

5.2. Estimation of Equation (2)

After estimating the TFP, we proceed to test the effect of trade liberalization on TFP. Table 3 shows the Generalized Least Squares (GLS) estimation by using Country-sector fixed effects. The higher the import penetration, the higher the TFP per sector. These results stand in line with the theory since firms, and hence sectors, become more productive when they are engaged in international trade. However, when it comes to trade protection measured by tariffs, we find that it has a negative effect on TFP. Although all two of the indicators used in this study are proxies for international competition (trade), not all of them capture the same aspect of trade policy, and hence, not the same effect on total factor productivity. The coefficient of GDP per capita is negative and significant. This result implies that TFP exhibits convergence. The small value of the estimated coefficients suggests that this convergence process is slow. The number of establishments, reflecting domestic competition, exerts a negative impact on the TFP. This result shows that more concentrated market structure has a positive impact on sectors TFP. More concentrated markets encourage firms to adopt new technologies for innovation, which increases their productivity. This result stands in line with (Peltzman, 1977; Grossman and Helpman, 1991; Scherer, 1999).

Table 3. Effect of trade liberalization on TFP

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	**Log (TFP)**	**Log (TFP)**	**Log (TFP)**	**Log (TFP)**	**Log (TFP)**	**Log (TFP)**
Import penetration (log)	0.0245***	0.0174**	0.0220***			
	(0.00678)	(0.00786)	(0.00656)			
GDP per capita in PPP constant terms (log)	-0.0840***	-0.0457**	-0.0577**	-0.120*	-0.0942	-0.0861
	(0.0260)	(0.0198)	(0.0265)	(0.0664)	(0.0755)	(0.0835)
Number of establishments (log)		-0.0372**			-0.0277*	
		(0.0161)			(0.0165)	
Tariffs				-0.00070*	-0.000724**	-0.000946**
				(0.000400)	(0.000364)	(0.000462)
Constant	-0.0712***	-0.066***	-0.00147***	0.0146***	0.0125***	-0.00402
	(0.0114)	(0.0105)	(0.000527)	(0.00159)	(0.00258)	(0.00269)
Year dummies	Yes	Yes	No	Yes	Yes	No
Observations	3,227	2,887	3,227	2,111	1,819	2,111
Number of countries	20	16	20	14	11	14

Notes. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. All columns include country-sector fixed-effect. Standard errors are clustered by country. The model is estimated by Generalized Least Squares (GLS) estimation.

5.3. Does the sector size matter in the effect of trade liberalization on TFP?

In this subsection, we will test the effect of trade liberalization on TFP by considering different sectors sizes.

Table 4. Effect of import penetration on TFP per size

VARIABLES	(1) Log (TFP)	(2) Log (TFP)	(3) Log (TFP)	(4) Log (TFP)
Import penetration (log)	0.0246***	0.0174**	0.0208**	0.00748
	(0.00676)	(0.00789)	(0.00978)	(0.0112)
Size	0.00170	1.20e-05	0.00124	-0.00115
	(0.00284)	(0.00231)	(0.00290)	(0.00224)
GDP per capita in PPP constant terms (log)	-0.0847***	-0.0457**	-0.0859***	-0.0475**
	(0.0255)	(0.0196)	(0.0258)	(0.0201)
Number of establishments (log)		-0.0372**		-0.0373**
		(0.0161)		(0.0162)
Size*Import penetration			0.00574	0.0143
			(0.00843)	(0.00988)
Constant	-0.0765***	-0.0662***	-0.0753***	-0.0627***
	(0.0116)	(0.00959)	(0.0120)	(0.00936)
Year dummies	Yes	Yes	Yes	Yes
Observations	3,227	2,887	3,227	2,887
Number of countries	20	16	20	16

Notes. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. All columns include country-sector fixed-effect. Standard errors are clustered by country. The model is estimated by Generalized Least Squares (GLS) estimation.

From Table 4, we can show that the sector size does not matter for the impact of trade openness on the TFP productivity. TFP in medium and large sectors are affected in the same way following periods of trade liberalization.

5.4. Does the development level matter?

In this subsection, we will test the effect of trade liberalization on TFP by considering different development levels.

By using the World bank thresholds[6] for defining low- and middle-income countries, namely the developing countries, and the high-income countries, the developed ones, we distinguish the effect of trade liberalization on TFP for both levels of development.

[6] The World Bank defines income groups according to their level of GNI per capita in current USS$ as follows: Low-income countries less than 995 US$, Middle-income countries from 996 to 12055 US$ and High-income countries higher than 12,055 US$.

Table 5. Effect of import penetration on TFP per level of development

	(1)	(2)	(3)	(4)
VARIABLES	**Log (TFP)**	**Log (TFP)**	**Log (TFP)**	**Log (TFP)**
Import penetration (log)	0.0245***	0.0216***	0.0174**	0.0138
	(0.00679)	(0.00771)	(0.00786)	(0.00868)
Development level	-0.00233	-0.00235	-0.000960	-0.000939
	(0.00165)	(0.00174)	(0.00181)	(0.00200)
Development level* Import penetration(log)		0.0206**		0.0229***
		(0.00853)		(0.00765)
GDP per capita in PPP constant terms (log)	-0.0834***	-0.0813***	-0.0457**	-0.0434**
	(0.0258)	(0.0259)	(0.0197)	(0.0202)
Number of establishments (in log)			-0.0371**	-0.0368**
			(0.0161)	(0.0160)
Constant	-0.0709***	-0.0703***	-0.0661***	-0.0655***
	(0.0113)	(0.0114)	(0.0104)	(0.0107)
Year dummies	Yes	Yes	Yes	Yes
Observations	3,227	3,227	2,887	2,887
Number of countries	20	20	16	16

Notes. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. All columns include country-sector fixed-effect. Standard errors are clustered by country. The model is estimated by Generalized Least Squares (GLS) estimation.

From Table 5, we find that being a developed country enhances the effect of international competition on the TFP rather being a developing country. This could be explained by the fact that trade openness benefits more the developed countries rather than the developing ones. Sectors in the developed countries are on average more productive and hence tougher import competition after trade liberalization will increase the average productivity in the sector. However, in developing countries, as sectors are less productive, fiercer competition will not lead to an increase in the average productivity in the sector as sectors in these countries would not be able to acquire more developed techniques in production.

6. Conclusion

This paper studies the impact of trade liberalization and fiercer international competition on TFP in the manufacturing sector in different countries between 1990 and 2013. The results show that tougher import competition increases the total factor productivity in the manufacturing sector and lower tariffs restrictions lead to higher TFP. On one hand, when we disentangle the trade openness effect by the size of the sector, we found that sector size does not matter for the level of TFP. On the other hand, the level of development of the countries does matter. When we differentiate the results by the development level of the country, we find that developed countries benefit more than developing countries from higher international competition. This reflects that there exist many obstacles in developing countries that prevent gains in productivity increase after trade openness.

These results would provide us with new evidence regarding the hypothesis that international competition enhances total factor productivity and the extent at which increasing international competition is beneficial for developing countries in the manufacturing sectors.

Finally, this paper still needs to consider the effect of Institutions and other macroeconomic variables on the TFP. North (1991) argued that institutions are important determinants of entrepreneurship and growth. And we also need to run some robustness checks to ensure that suspected endogeneity problem did not affect our results.

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Appendix.

Table A.1. List of countries included in this study

Country Name	Freq.	Percent	Cum.
Albania	43	0.68	0.68
Austria	153	2.42	3.09
Bahamas, The	15	0.24	3.33
Belarus	1	0.02	3.35
Bulgaria	270	4.26	7.61
Chile	161	2.54	10.15
Czech Republic	104	1.64	11.80
Ethiopia	82	1.29	13.09
Finland	9	0.14	13.23
Georgia	260	4.11	17.34
Hungary	39	0.62	17.95
Israel	71	1.12	19.07
Italy	218	3.44	22.52
Japan	876	13.83	36.35
Korea, Rep.	1,184	18.70	55.05
Lebanon	24	0.38	55.42
Macedonia, FYR	271	4.28	59.70
Malaysia	503	7.94	67.65
Norway	113	1.78	69.43
Romania	1	0.02	69.45
Singapore	405	6.40	75.84
Slovak Republic	83	1.31	77.15
Spain	120	1.89	79.05
Trinidad and Tobago	35	0.55	79.60
Turkey	592	9.35	88.95
United States	700	11.05	100.00
Total	6,333	100.00	

Table A.2. List of industries included in this study

ISIC Code	Freq.	Percent	Cum.
Processing/preserving of meat	74	1.17	1.17
Processing/preserving of fish	51	0.81	1.97
Processing/preserving of fruit & vegeta	63	0.99	2.97
Vegetable and animal oils and fats	67	1.06	4.03
Dairy products	80	1.26	5.29
Grain mill products	53	0.84	6.13
Starches and starch products	37	0.58	6.71
Prepared animal feeds	45	0.71	7.42
Bakery products	73	1.15	8.57
Sugar	48	0.76	9.33
Cocoa, chocolate and sugar confectioner	53	0.84	10.17
Macaroni, noodles & similar products	47	0.74	10.91
Other food products n.e.c.	54	0.85	11.76
Distilling, rectifying & blending of sp	44	0.69	12.46
Wines	44	0.69	13.15
Malt liquors and malt	39	0.62	13.77
Soft drinks; mineral waters	55	0.87	14.64
Tobacco products	58	0.92	15.55
Textile fibre preparation; textile weav	44	0.69	16.25
Finishing of textiles	34	0.54	16.79
Made-up textile articles, except appare	47	0.74	17.53
Carpets and rugs	37	0.58	18.11
Cordage, rope, twine and netting	35	0.55	18.66
Other textiles n.e.c.	41	0.65	19.31
Knitted and crocheted fabrics and artic	53	0.84	20.15
Wearing apparel, except fur apparel	78	1.23	21.38
Dressing & dyeing of fur; processing of	22	0.35	21.73
Tanning and dressing of leather	41	0.65	22.37
Luggage, handbags, etc.; saddlery & har	46	0.73	23.10
Footwear	65	1.03	24.13
Sawmilling and planing of wood	67	1.06	25.19
Veneer sheets, plywood, particle board,	45	0.71	25.90
Builders' carpentry and joinery	59	0.93	26.83
Wooden containers	62	0.98	27.81
Other wood products; articles of cork/s	41	0.65	28.45
Pulp, paper and paperboard	45	0.71	29.16
Corrugated paper and paperboard	56	0.88	30.05
Other articles of paper and paperboard	54	0.85	30.90
Publishing of books and other publicati	36	0.57	31.47
Publishing of newspapers, journals, etc	38	0.60	32.07
Publishing of recorded media	12	0.19	32.26
Other publishing	23	0.36	32.62
Printing	61	0.96	33.59
Service activities related to printing	59	0.93	34.52
Reproduction of recorded media	49	0.77	35.29
Coke oven products	21	0.33	35.62
Refined petroleum products	46	0.73	36.35
Processing of nuclear fuel	12	0.19	36.54
Basic chemicals, except fertilizers	46	0.73	37.27
Fertilizers and nitrogen compounds	32	0.51	37.77
Plastics in primary forms; synthetic ru	44	0.69	38.47
Pesticides and other agro-chemical prod	28	0.44	38.91
Paints, varnishes, printing ink and mas	58	0.92	39.82
Pharmaceuticals, medicinal chemicals, e	68	1.07	40.90
Soap, cleaning & cosmetic preparations	57	0.90	41.80
Other chemical products n.e.c.	54	0.85	42.65
Man-made fibres	33	0.52	43.17
Rubber tyres and tubes	41	0.65	43.82
Other rubber products	47	0.74	44.56
Plastic products	93	1.47	46.03
Glass and glass products	67	1.06	47.09
Pottery, china and earthenware	46	0.73	47.81
Refractory ceramic products	39	0.62	48.43
Struct.non-refractory clay; ceramic pro	48	0.76	49.19
Cement, lime and plaster	54	0.85	50.04

Table A.2. (Continued)

Articles of concrete, cement and plaste	63	0.99	51.03
Cutting, shaping & finishing of stone	58	0.92	51.95
Other non-metallic mineral products n.e	57	0.90	52.85
Basic iron and steel	70	1.11	53.96
Basic precious and non-ferrous metals	66	1.04	55.00
Casting of iron and steel	45	0.71	55.71
Casting of non-ferrous metals	38	0.60	56.31
Structural metal products	64	1.01	57.32
Tanks, reservoirs and containers of met	50	0.79	58.11
Steam generators	37	0.58	58.69
Metal forging/pressing/stamping/roll-fo	56	0.88	59.58
Treatment & coating of metals	69	1.09	60.67
Cutlery, hand tools and general hardwar	59	0.93	61.60
Other fabricated metal products n.e.c.	68	1.07	62.67
Engines & turbines(not for transport eq	46	0.73	63.40
Pumps, compressors, taps and valves	55	0.87	64.27
Bearings, gears, gearing & driving elem	49	0.77	65.04
Ovens, furnaces and furnace burners	40	0.63	65.67
Lifting and handling equipment	50	0.79	66.46
Other general purpose machinery	51	0.81	67.27
Agricultural and forestry machinery	48	0.76	68.02
Machine tools	56	0.88	68.91
Machinery for metallurgy	33	0.52	69.43
Machinery for mining & construction	50	0.79	70.22
Food/beverage/tobacco processing machin	39	0.62	70.84
Machinery for textile, apparel and leat	27	0.43	71.26
Weapons and ammunition	35	0.55	71.81
Other special purpose machinery	50	0.79	72.60
Domestic appliances n.e.c.	74	1.17	73.77
Office, accounting and computing machin	54	0.85	74.62
Electric motors, generators and transfo	64	1.01	75.64
Electricity distribution & control appa	67	1.06	76.69
Insulated wire and cable	64	1.01	77.70
Accumulators, primary cells and batteri	51	0.81	78.51
Lighting equipment and electric lamps	65	1.03	79.54
Other electrical equipment n.e.c.	72	1.14	80.67
Electronic valves, tubes, etc.	71	1.12	81.79
TV/radio transmitters; line comm. appar	67	1.06	82.85
TV and radio receivers and associated g	48	0.76	83.61
Medical, surgical and orthopaedic equip	66	1.04	84.65
Measuring/testing/navigating appliances	55	0.87	85.52
Industrial process control equipment	33	0.52	86.04
Optical instruments & photographic equi	60	0.95	86.99
Watches and clocks	34	0.54	87.53
Motor vehicles	52	0.82	88.35
Automobile bodies, trailers & semi-trai	53	0.84	89.18
Parts/accessories for automobiles	71	1.12	90.30
Building and repairing of ships	42	0.66	90.97
Building/repairing of pleasure/sport. b	29	0.46	91.43
Railway/tramway locomotives & rolling s	47	0.74	92.17
Aircraft and spacecraft	55	0.87	93.04
Motorcycles	24	0.38	93.42
Bicycles and invalid carriages	32	0.51	93.92
Other transport equipment n.e.c.	27	0.43	94.35
Furniture	84	1.33	95.67
Jewellery and related articles	51	0.81	96.48
Musical instruments	33	0.52	97.00
Sports goods	38	0.60	97.60
Games and toys	39	0.62	98.22
Other manufacturing n.e.c.	49	0.77	98.99
Recycling of metal waste and scrap	41	0.65	99.64
Recycling of non-metal waste and scrap	23	0.36	100.00
Total	6,333	100.00	