Import Competition and Quality-Adjusted Productivity: Evidence from Hungary's Pre-accession Import Tariffs*

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Abstract

I propose an empirical model to estimate physical productivity from sales data. The model addresses the concerns associated with unobserved prices and demand conditions in revenue productivity. Unlike De Loecker (2011), our model builds on recent evidence on the effect of exporting on firm-level prices by distinguishing between the export and domestic demand markets and integrating both to the supply function. I apply this framework to study the effects of a reduction in tariffs on EU imports on the efficiency of manufacturing firms in Hungary during the period 1996-2003. I find that a 10-percentage point reduction in import tariffs on similar products manufactured by a firm raises the firm's physical productivity by 0.97%. This is in contrast to 2.1% when revenue productivity is used. Additionally, I offer a general framework that can be applied in recovering physical productivity from revenue data when firms sell in both domestic and export markets.

Keywords: Import competition, production function, imperfect competition, trade liberalization

JEL Classification: D24, L11, L25

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1 Introduction

How do manufacturing firms react when faced with increased competition from imports? Do they tend to eliminate inefficiencies in order to be competitive when faced with such competition? While a number of existing papers have attempted to address a similar question (Fernandes (2007), Topalova and Khandelwal (2011), Trefler (2004) etc), these papers typically rely on productivity estimates from a revenue production function as sales quantity is unobserved. In these studies, firm-level prices are unobserved, so firm-level sales revenue is deflated using an industry price index and used as the dependent variable in the productivity estimation. This leads to estimates of efficiency with two shortcomings (Levinsohn and Melitz, 2002 and De Loecker, 2011). First, the coefficients of the inputs may be biased if the price error defined as the difference between a firm's price and the industry's price index is correlated with any production input. This price error is expected to be larger in industries with larger scope of product differentiation. Second, even if this biased is absent, the productivity estimates will reflect true efficiency and components of unobserved prices and demand conditions which may bias the true productivity. These complexities casts some doubts on the preciseness of existing findings. Given the policy relevance of this question in the face of renewed public interests and debates on free trade agreements, it is important that precise measures of efficiency are employed in understanding the economic benefits of trade policies at the firm. Hence, a call for re-evaluations of papers that rely on productivity estimates from sales revenue data.

In this paper, we study the impact of the gradual reduction in import tariffs charged on EU imports on manufacturing firms efficiency in Hungary during the period (1996-2003) leading to Hungary's accension into the EU. By doing so, we make two contributions. First, we propose a novel empirical model that estimates quantity productivity from revenue data, thus overcoming the drawbacks from revenue productivity already discussed above. Our framework nests De Loecker (2011) empirical model[1] and revenue productivity model, and we show that each of these models is a special case of our framework under certain conditions, thus offering a more general empirical model for estimating physical productivity from revenue data. The key difference between our model and that proposed in De Loecker (2011) is that we integrate both the domestic and foreign markets demand conditions (i.e. foreign and domestic demand shocks) to the supply function of the firm, while De Loecker (2011) makes no distinction between foreign and domestic demand shock. This is particularly important given the recent empirical evidence on the strong relationship between exporting and firm-level prices (Garcia-Marin and Voigtländer, 2019). Infact, we show (theoretically) that neglecting the export markets may bias physical productivity estimates for exporters (see equation 12). Our strategy is driven by the observation that firm's in our data are exporters and also subject to export tariffs with their major trade partner (EU) during this period[2].

Our second contribution lies in a better identification of the effects of import competition on productivity. Unlike other similar studies that identify tariffs at the industry level and argues for exogeneity of tariffs, we identify import tariffs at the firm-product level. In reality, and most importantly in our setting, it is difficult to argue that average industry level tariffs negotiations is exogenous (i.e. not influence by industrial policies, or lobbying by organized sectors etc.), so we leverage on our approach by constructing firm-level exposure to tariffs on imports from the EU and control for time-varying industry effects. This is necessary in our setting for two reasons. First, since export and import tariffs are likely correlated at the industry-level (Trefler, 2004), the industry-year fixed effects, controls for the industry-level export and import tariffs at the 2-digit level. Second, It

[1] As will be discussed in details later, De Loecker (2011) proposed an empirical model which integrates demand address to a firm with the firm's production function, I show that their framework cannot be applied if firms are exporters.

[2] Garcia-Marin and Voigtländer (2019) finds that Chilean firms reduces their prices after the became more efficient from exporting. Moreover, there is a new and growing literature that finds that firms maybe capacity constrained which is reflected by an increasing marginal cost structure. For example, see Ahn and McQuoid, 2017, Almunia et al., 2018 etc. When faced with rising foreign demand shocks, firms could raise their prices due to increasing marginal costs, or simply because their average cost is lower than their competitors abroad. So firms would still be competitive with slightly higher prices.

is possible that some industries received subsidies during this period or were protected due to political lobbying or other unobserved considerations. Thus, our approach enables us control for unobserved time-varying industry effects which may bias our results. By applying our empirical model to study the effects of a reduction in EU import tariffs[3] on manufacturing firms' productivity in Hungary between the period 1996-2003, we provide the first study to our knowledge, that investigates the impact of EU pre-accession import tariffs on efficiency of manufacturing firms[4]. We recover both revenue and physical productivity which we call *quality-adjusted productivity (QA productivity)*[5] and compare the impact of import competition on these two measures of productivity. Our findings imply that a 10 percentage point reduction in import tariffs increase physical productivity by 0.97 percent and revenue productivity by 2.1 percent (see column (3) and (7) in Table 5). Clearly, revenue productivity overstates the impact of import competition on firm-level efficiency.

The new empirical model consists of conventional variables (labour, capital, material inputs) and a proxy for unobserved firm-level prices- *domestic market share in its industry*. We verify that our price proxy replicates similar pattern in studies that observe firm-level prices. In the spirit of Foster et al. (2008), we examine the correlation between our price proxy, revenue productivity and quality-adjusted productivity. While we find a strong positive correlation between our proxy for prices and revenue productivity, the correlation between the proxy and quality-adjusted productivity is negative, consistent with Foster et al. (2008) in their study for the US.

The mechanisms through which import competition may affect productivity are numerous. First, increased competition from imports may force firms to be creative in eliminat-

[3]By import tariffs, we imply the tariffs faced by a manufacturing firm on its output. This tariff captures the import competition faced by a firm in its domestic market. This is different from the import tariffs on the imported inputs used in production by a firm.

[4]Some papers looked at the effect of exporting on productivity during the EU accession period in some Central and Eastern European countries. For example, De Loecker (2007) studies the effect of exporting on productivity in Slovenia during the pre-accession period, ours do not focus on exporting but the effects of EU's import competition on efficiency

[5]QA productivity, physical productivity or quantity productivity refers to the same thing and will be used interchageably in this paper

ing inefficiencies and use inputs efficiently. However, it may reduce demand for domestic high-end output and thus impede the amount of domestic learning spillovers which may negatively affect productivity growth (Lucas Jr, 1993, Young, 1991, Stokey, 1991). Second, reduction in import tariffs, may reduce the cost of imported inputs and may result to increased use of such inputs which raises productivity (Halpern et al. (2015), Goldberg et al. (2010) etc). Third, liberalization may incentivise firms to invest in technologies that enhances productivity (Bustos (2011), Goh (2000)). However, it may reduce these incentives if liberalization reduces the market share of firms.

We begin our analysis in section 2 where we present our simple empirical setup and derive a structural econometric equation for the estimation of physical productivity from revenue data. We consider the demand side of a two country world - *home and foreign* with a representative consumer in each that faces a standard CES utility function and choose varieties to consume subject to a budget constraint. The usual demand system for each variety emerges which depends negatively on the price and positively on quality of the variety. On the supply side, we consider a firm which produces with a Cobb-Douglas technology, sells in the domestic market and then decides whether to export. The firm's problem is to choose prices in domestic and export markets (if it exports). We derive the total revenue that emerges in equilibrium and show how to recover physical productivity. Our physical productivity estimate is the conventional revenue productivity adjusted with the domestic market share of the firm within its industry. For industries where products are homogeneous (large elasticity of substitutiton which we denote by σ), our estimation equation converges to revenue productivity equation.

In section 3, we present our data and discuss several cleaning procedures and restrictions on our sample. We use Hungarian manufacturing firm-level panel data which comes from three sources: (1) balance sheet data for the period 1993-2003 from Hungarian Tax Authority (APEH), (2) trade data for the period 1993-2003 assembled by Hungarian customs, (3) Product level import tariff data charged on imports from the EU for the period 1996-2003 from Hungarian trade ministry. We provide a detailed descriptive statistics of each of our datasets in the relevant subsections.

In section 4, we estimate our empirical model and standard revenue production function using standard proxy methods pioneered by Olley and Pakes (1996) and extended in Levinsohn and Petrin (2000) and Ackerberg et al. (2015) (henceforth OP, LP and ACF respectively). We recover our physical and revenue productivity measures, and we perform some comparative analysis between physical and traditional revenue productivity.

In section 5, we estimate the effect of the reduction in import tariffs charged on EU imports on the efficiency of Hungarian manufacturing firms. One of the main strengths of our methodology is that we construct variations in tariffs at the firm-level. By doing this, we are able to control for possible unobserved time-varying industry (NACE 2 digits) effects that jointly affect average industry tariffs and productivity. However, our analysis in this section poses two potential shortcomings. First, we focus only on exporters because we do not observe products sold by non-exporters. So, we assume that products sold in the export markets are the same as those sold in the domestic market. If exporters have different product mix in the export and domestic markets, it is likely that such patterns exist at a highly disaggregated level of product definition[6]. Therefore, we match every 6-digit product exported by a firm to its corresponding tariffs. Second, while our main framework was developed for single-product firms, we apply it to multi-product firms. This will likely overestimate productivity for multiproduct firms if productivity is strongly associated with producing multiple products[7]. Internalizing these potential shortcomings, we proceed with our analysis by restricting our data to periods between 1996-2003 as this was the period Hungary entered a gradual tariffs reduction agreement

[6] According to the European commision webpage (ec.europa.eu/taxation_customs/business/calculation-customs-duties/what-is-common-customs-tariff/combined-nomenclature_en), HS-2 product "18" is described as *"Cocoa and Cocoa Preparations"*; HS-4 product "1806" is *"Chocolate and other food preparations containing cocoa"*, HS-6 "1806 10" is *Cocoa powder, containing added sugar or sweetening matter* and for CN-8 "1806 10 15" is *Containing no sucrose or containing less than 5 % by weight of sucrose ("including invert sugar expressed as sucrose) or isoglucose expressed as sucrose "*. Our point here is that product mix across markets if it exists maybe be more pronouced at a finer level of disaggregation due to taste preferences across markets.

[7] In the appendix, we extend our framework to multiproduct firms. This introduces an additional parameter to the estimation equation (see equation A.23) which captures the number of varieties in each period. We do not observe the number of varieties at the firm level in each period.

with the EU. We identify the tariffs faced by an exporter by computing the simple average of the tariffs on products the firm produced at each time period. We employ two empirical strategies. The first strategy is a direct method as in Fernandes (2007) where we estimate the effect of tariffs on productivity directly in a single production function estimation[8]. The second strategy which we call the two-step approach follows a non-parametric form where we start with estimating the productivity as residuals from a production function estimation and then we project the productivity estimates on tariffs while controlling for some variables of interest as discussed later. Our aim in this exercise are two-folds. First, we want to evaluate the effect of lowering tariffs on firm-level productivity and secondly, to show that this effects is over-estimated when using revenue productivity measures. We sum up the discussions in section 6 and provide additional information and results in the appendix.

1.1 Literature Review

We build on the vast and growing literature on production function estimation at the plant level. Starting with Olley and Pakes (1996) (OP) which shows how to control for the simultaneity bias when estimating production functions by relying on investments as proxy for unobserved productivity. Given the lumpy nature of investment data, Levinsohn and Petrin (2000) (LP) showed that material inputs (which are less lumpy) could be used as proxy for productivity in the Olley and Pakes (1996) framework. Their work have been extended by Ackerberg et al. (2015) (ACF) which argued that the coefficient of labor cannot be identified in the first stage of OP and LP framework and shows how to identify labor in the second stage. Other literatures have proposed an adjustment to this framework. For example, Bond and Söderbom (2005) have shown (for the Cobb-Douglas production function) that under the scaler unobservable assumptions in the LP and OP framework, using gross output function cannot identify coefficients of perfectly variable inputs without input price variation except further assumptions are imposed. Thus, they

[8]For more details on motivation and identification, we refer the reader to Fernandes (2007).

propose estimation of a value-added production function. De Loecker (2013) suggests including lagged export dummy in the productivity process of the OP and LP procedure as lag of export status may be correlated with lag of productivity. These literatures typically relies on deflating sales revenue with industry price index which poses a threat to identification of production inputs and may bias productivity estimates in industries with high scope of product differentiation. Relative to these literatures, we propose a new production function estimation equation that controls for unobserved prices and demand shifters.

Our paper is not the first to integrate the demand-side of the economy to the supply-side in estimating a production function. Klette and Griliches (1996) developed the framework to integrate the demand-side with the supply-side of the economy, thus, addressing the problems caused by deflated sales proxy for firm-level production function estimation in differentiated products. Their focus was on estimating the returns to scale and not productivity. Levinsohn and Melitz (2002) builds on this framework, to obtain and interpret credible estimates of productivity. They show that productivity estimates based solely on sales revenue is bias as it reflects price and demand shifters, however they offer no application to their procedure. De Loecker (2011) is the first to apply this methodology in the study of the effect of quota reduction on efficiency of Belgian textile manufacturers. Their estimating equation is a reduced form expression of deflated sales revenue on production inputs (capital, labour and materials), industry output, unobserved demand shifter and productivity. They recover the elasticity of substitution from the coefficient of industry output which they use to back-out quantity productivity from their reduced-form estimates of productivity. Their framework assumes that the unobserved demand shifter can be summarised by a product and sector fixed effect, a proxy for prices and an unobserved error term which they assume to be exogoneous. They exploit the multi-products nature of their data and constructs a proxy for prices which reflects the extend to which a firm is exposed to the rapid easing of quotas in the EU during the period 1994 to 2002. They find that their methodology predicts weaker effect of trade liberalization on firm-level productivity. Relative to these papers, we offer a general framework for addressing this problem of unobserved prices. Our model nest De Loecker (2011)'s model and shows that their main estimating equation is a special case of ours under the assumption that firms do not export[9]. By allowing for exporting, we show that our estimating equation is equivalent to De Loecker (2011) model with an additional term which reflects the firms' export intensity. Unlike their framework, ours do not rely on estimates of the industry elasticity of substitution or precise observation of industry output variable to back out physical productivity.

Our paper is also related to Rho and Rodrigue (2016). The main similarity is that both papers estimate a model-consistent productivity under the assumption that firms endogenously responds to idiosyncratic demand shocks in the foreign market. While their paper focuses on understanding the impact of investment on exporting, we focus on how increased import competition faced by firms affect physical productivity. In addition, they normalize domestic demand shocks to one, while we assume it to be different across firms and time. This is important in our setting as our objective is to investigate the relationship between firm-level variation in domestic demand shocks and productivity.

Demidova et al. (2012) uses a similar estimation approach as ours in studying the effects of productivity and country-specific export demand shocks on export destination. While theirs introduces destination-specific export demand shocks non-parametrically in their material function, we incorporate both domestic and export demand shocks addressed to a firm in a structural empirical model. Besides, our focus is different from theirs. While we are interested in a more precise estimate of productivity and how import competition impacts it, theirs focus on the effects of interaction between productivity and country-specific export demand shocks on a firm's export destination.

Our paper is also related to Foster et al. (2008) which investigates the distinction between quantity and revenue productivity. In their framework, they observed both physical output and sales revenue at the firm level in addition to input variables. They estimate

[9]This may not be a concern in De Loecker (2011) if Belgium textile manufacturers are not export-oriented

quantity and revenue productivity and perform a number of comparative analysis between their estimates. One finding that emerges from their study is that the correlation between plant prices and revenue productivity is positive with a correlation coefficient of 0.16, however this correlation with physical productivity is negative with a coefficient of -0.54. The findings in our paper is consistent with theirs. Our proxy for prices is negatively correlated with quality-adjusted productivity and positively correlated with revenue productivity. The similarity between both findings support the notion that revenue productivity may reflect rising firm-level prices and also implies that domestic market shares of a firm within its industry is strongly correlated with unobserved prices.

A number of new and growing literature have proposed a new measure of firm-level productivity in an environment with very rich data. For example, Garcia-Marin and Voigtländer (2019) constructs marginal costs of products within a plant using the methodology proposed in De Loecker and Warzynski (2012) and test for efficiency gains from exporting. Atkin et al. (2017) constructs different measures of productivity from a field experiment on rug manufacturers in Egypt. Relative to these papers, our measure provides a credible alternative in an environment without such rich data.

This paper is also related to the vast and growing literature studying the impact of trade liberalization on productivity of firms (Topalova and Khandelwal (2011)- Indian firms, Fernandes (2007)- Colombian firms, Lileeva and Trefler (2010)-Canadian firms, Bustos (2011)-Argentine firms, De Loecker et al. (2016) - Indian firms, Trefler (2004)-Canadian firms, among many). Most of these papers use either revenue productivity (Topalova and Khandelwal, 2011, Fernandes, 2007) or labor productivity (Trefler, 2004) and finds a positive effect of trade liberalization on productivity. We argue that using revenue productivity may overestimate the effect of trade liberalization and we introduce a methodology that corrects for this potential bias.

Some other studies have analyzed the effect of import competition on product quality and prices such as Amiti and Khandelwal (2013) and Bas and Strauss-Kahn (2015), both finds a positive effect of import competition on quality upgrading. McManus and Schaur

(2016) find a positive effects of import competition on workplace injury rates in the US. Our paper differs as we focus on physical productivity. This work is also related to Khandelwal (2010). Both papers use market shares as proxy for quality conditional on prices[10] and investigates different questions.

To our knowledge, this paper is the first to provide a general framework for estimating quantity productivity from sales revenue data in an environment where firms exports.

2 Empirical Framework

In this section, I start with a model of demand and supply side, derive the estimating equation of interest for single producers and discuss the advantages of my framework. In the appendix, I also show an extension of the framework to multiproduct producer under some restrictive assumptions.

2.1 Demand

Consider a world consisting of two countries home h and foreign f and a representative industry with many firms producing differentiated goods. Our analysis is focused on firms in the home country. Consumers in both countries have the constant elasticity of substitution (CES) preferences with same industry elasticity of substitution between varieties denoted by $\sigma > 1$. Consumers in country $i = \{h, f\}$ spends R_i in nominal terms on varieties in the industry. A representative consumer in each country i maximizes its utility given by:

$$U_i = \left[\int_{\omega \in \Omega} \tilde{q}_i(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}} \quad \text{for } i \in \{H, F\} \tag{1}$$

We assume U_i to be differentiable and quasi-concave. The quantity of each consumed variety is denoted by $\tilde{q}_i(\omega)$ which is measured in units of utility. For each industry, I assume that all varieties are measured in similar physical units such that $\tilde{q}_i(\omega)$ can be

[10] Khandelwal (2010) assumes that firms produce choosing price and quality, while our setup assumes that firms are endowed with quality and choose price to maximize its profit, consistent with Johnson (2012) .

seperated into a demand shifter $\zeta_h(\omega)$ which we call *quality* and physical units $q_i(\omega)$ such that $\tilde{q}_i(\omega) = \zeta_h(\omega)q_i(\omega)$. The product quality $\zeta_h(\omega)$ can be seen as a single dimensional metric of the representative consumer's valuation of product characteristics in one physical unit of the product (Johnson, 2012). Thus, product quality acts as a demand shifter for physical quantities. Changes in $\zeta_i(\omega)$ across time could result from either changes in the quality embodied from the good or changes in consumer's relative valuation of the product. For foreign consumers, we assume $\zeta_f(\omega) = \zeta_h(\omega)\nu_f$ such that $\nu_f \geq 0$ is the foreign demand shock. This allows for changes in idiosyncratic preferences for product ω across countries. Consumers in both countries are subject to the budget constraint: $\int_{\omega\in\Omega} p_i(\omega)q_i(\omega)d\omega = R_i$. Where $p_i(\omega)$ and R_i are the price of variety ω and income in country i respectively . This setup generates the usual demand system faced by each firm i as :

$$q_i(\omega) = \zeta_i(\omega)^{\sigma-1}\chi_i p_i(\omega)^{-\sigma} \tag{2}$$

Where $\chi_i = P_i^{\sigma-1}R_i$ is the aggregate level of demand in the sector in country i , this can be interpreted as the position of the demand curve common to all firms and $P_i = [\int_{w\in\Omega} \zeta_i(\omega)^{\sigma-1}p_i(\omega)^{1-\sigma}d\omega]^{\frac{1}{1-\sigma}}$ is a summary of the prices of all available varieties in an industry in country i. We assume that firms are small relative to the industry they belong so they have no power to exert any influence on this industry price index P_i and take it as given.

2.2 Supply

We assume that all firms j are heterogenous in their productivity levels A_j and produces a single variety j under monopolistic competition. To avoid the abuse of notations we henceforth denote j in place of ω such that $q_i(\omega) \equiv q_{ij}$. Firms produce with a Cobb-Douglas technology using labor L_j, physical capital K_j and material inputs M_j. We follow the literature and assume that labor L_j and capital K_j are predetermined (Halpern et al.,

2015) and material is a perfectly variable input[11] and can be freely adjusted at any point in time. Firm $j's$ production function in the current period is:

$$q_j = A_j K_j^{\alpha_k} L_j^{\alpha_l} M_j^{\alpha_m}$$

where $A_j = exp(a_j + \mu_j)$ and μ_j is the measurement error and idiosyncratic shock to production. Our assumption on M_j implies that the total variable cost is given by :

$$TVC_j = q_j^{\frac{1}{\alpha_m}} A_j^{-\frac{1}{\alpha_m}} K_j^{-\frac{\alpha_k}{\alpha_m}} L_j^{-\frac{\alpha_l}{\alpha_m}}$$

Note here that we do not assume any specific marginal cost structure. Firms may export some of their output to the foreign market by paying a fixed export costs f_F which reflects additional cost incurred by doing business abroad. We assume that the price which exporters receive (p_{jf}) is different from that paid by foreign consumers such that $p^*_{jf} = p_{jf}\tau_j$, where $\tau_j > 1$ is the import tariff or shipping cost. Firm's problem is to maximize profits choosing prices in both domestic and foreign markets subject to the demand curve in equation (2). We can rewrite this problem as:

$$\max_{q_{jh} q_{jf}} \left\{ q_{jh}^{\frac{\sigma-1}{\sigma}} (\zeta_{jh}^{\sigma-1} \chi_h)^{\frac{1}{\sigma}} + \frac{q_{jf}^{\frac{\sigma-1}{\sigma}} (\zeta_{jf}^{\sigma-1} \chi_f)^{\frac{1}{\sigma}}}{\tau_j} - \frac{(q_{jh} + q_{jf})^{\frac{1}{\alpha_m}}}{A_j^{\frac{1}{\alpha_m}} K_j^{\frac{\alpha_k}{\alpha_m}} L_j^{\frac{\alpha_l}{\alpha_m}}} - f_h - f_f \right\} \tag{3}$$

This yields the price equation:

$$p_{jh} = \left(\frac{\sigma}{\sigma - 1}\right)^V \left[\frac{1}{\alpha_m} (A_j K_j^{\alpha_k} L_j^{\alpha_l})^{-\frac{1}{\alpha_m}}\right]^V \zeta_{jh}^{1-\frac{V}{\alpha_m}} (\chi_h + \tau^{-\sigma} \nu_f \chi_f)^{\frac{V(1-\alpha_m)}{\alpha_m}} \tag{4}$$

Where $V = \frac{\alpha_m}{\alpha_m - \sigma(\alpha_m - 1)}$. Provided $\alpha_m \neq 1$, a change in the demand shifter has an effect on prices. Foreign demand shock has an effect on unobserved firm level prices (p_{jh}) making it imperative to integrate the foreign demand system into the supply function of the firm. We derive the firm-level domestic, foreign and total revenue that emerges from

[11] In literature on production function estimations, materials have been assumed as a perfectly variable input. See Ackerberg et al. (2015) and Levinsohn and Petrin (2000) for more details

this framework (see appendix) respectively below:

$$R_{jh} = Z^{V(\sigma-1)}(A_j K_j^{\alpha_k} L_j^{\alpha_l})^{\frac{V(\sigma-1)}{\alpha_m}} \zeta_{jh}^{\frac{V(\sigma-1)}{\alpha_m}} \chi_h(\chi_h + \tau_j^{-\sigma}\nu_{jf}^{\sigma-1}\chi_f)^{\frac{V}{\alpha_m}-1} \tag{5}$$

$$R_{jf} = Z^{V(\sigma-1)}(A_j K_j^{\alpha_k} L_j^{\alpha_l})^{\frac{V(\sigma-1)}{\alpha_m}} \zeta_{jh}^{\frac{V(\sigma-1)}{\alpha_m}} \chi_f \nu_{jf}^{\sigma-1}\tau_j^{-\sigma}(\chi_h + \tau_j^{-\sigma}\nu_{jf}^{\sigma-1}\chi_f)^{\frac{V}{\alpha_m}-1} \tag{6}$$

$$R_{jT} = \begin{cases} Z^{V(\sigma-1)}(A_j K_j^{\alpha_k} L_j^{\alpha_l})^{\frac{V(\sigma-1)}{\alpha_m}} (\zeta_{jh}^{\sigma-1}\chi_h)^{\frac{V}{\alpha_m}} & \text{if firm sells at home} \\ Z^{V(\sigma-1)}(A_j K_j^{\alpha_k} L_j^{\alpha_l})^{\frac{V(\sigma-1)}{\alpha_m}} \zeta_{jh}^{\frac{V(\sigma-1)}{\alpha_m}} (\chi_h + \tau_j^{-\sigma}\nu_{jf}^{\sigma-1}\chi_f)^{\frac{V}{\alpha_m}} & \text{if firm sells in both} \end{cases} \tag{7}$$

where T denotes total and $Z = (\frac{\sigma-1}{\sigma})\alpha_m$. Our aim in this exercise is to derive an empirical equation which estimates physical productivity from total revenue data. There are 3 unobservable variables in equation (7b) - $\zeta_{jh},\ \tau_j\ and\ \nu_{jf}$. We can reduce the unobservables by dividing equation (5) by (6)

$$\nu_{jf}^{\sigma-1}\tau_j^{-\sigma} = \frac{R_{jf}\chi_h}{R_{jh}\chi_f} = \frac{R_{jf}/P_{sf}^{\sigma-1}R_{sf}}{R_{jh}/P_{sh}^{\sigma-1}R_{sh}} \tag{8}$$

Equation (8) can be interpreted as the competitiveness of a firm in the export market relative to the domestic market. This relative competitiveness can be increasing due to either a decrease in the tariffs faced by a firm or an increase in the export demand. We substitute equation (8) in (7) and simplify to obtain:

$$\frac{(R_{jh} + R_{jf})}{P_{sh}} = A_j K_j^{\alpha_k} L_j^{\alpha_l} M_j^{\alpha_m} \zeta_{jh} \left(\frac{R_{jh}}{R_{sh}}\right)^{\frac{1}{|\sigma-1|}} \tag{9}$$

Denote $D_{jh} = \frac{R_{jh}}{R_{sh}}$ the domestic market share of the firm within its industry; $\frac{1}{|\sigma-1|}$ yields an estimate of the industry elasticity of demand. Taking logs of equation 9 and including a time subscript we derive:

$$\tilde{r}_{jt} = \alpha_l l_{jt} + \alpha_k k_{jt} + \alpha_m m_{jt} + \beta d_{jt} + ln\zeta_{jht} + a_{jt} + \mu_{jt} \tag{10}$$

Equation (10) is our new production function estimation equation, where $\beta = \frac{1}{|\sigma-1|}$ and all lower-case variables are in log terms. The demand shifter ζ_{jh} is unobserved, but positively correlated with domestic market shares d_{jt}[12]. Therefore, part (but not all) of the variation in quality ζ_{jh} is captured by variations in the domestic market shares (d_{jt}). In addition, d_{jt} also captures variation in prices not related to product quality[13]. Note, α_l, α_k and α_m are structural parameters of the production function and the industry elasticity of substitution can be recovered from $\beta = \frac{1}{|\sigma-1|}$. In the following subsections, we compare our estimating equation 10 with standard revenue productivity equation and De Loecker (2011) quantity productivity equation.

2.3 Relationship with Revenue Productivity

We show here that the revenue-based measure of productivity is a special case of our measurement of productivity. In other words, our estimating equation (10) nests revenue-based productivity under the assumption of perfect substitution between varieties within an industry. As $\sigma \to \infty$, β tends to zero, so equation (10) can be re-written as:

$$\tilde{r}_{jt} = \alpha_l l_{jt} + \alpha_k k_{jt} + \alpha_m m_{jt} + \omega_{jt} + \mu_{jt} \tag{11}$$

where productivity $\omega_{jt} = a_{jt} + ln\zeta_{jht}$ is the revenue productivity. Clearly ω_{jt} is a combination of physical productivity and the demand shifter. Equation (11) implies that in an homogeneous goods sector, firms facing high demand can be misinterpreted to be more productive than firms facing low demand, consistent with Foster et al. (2016) that use firm-level data from an homogeneous goods industry in the US and finds that older firms

[12] Domestic market share is derived as: $\frac{r_h(\omega)}{R_h} = \zeta_h(\omega)^{\sigma-1} P_h^{\sigma-1} p_i(\omega)^{1-\sigma}$. This can be re-expressed as $ln\left(\frac{r_h(\omega)}{R_h}\right) = (\sigma-1)ln(\zeta_h(\omega)) + (\sigma-1)ln(P_h) + (1-\sigma)\left(Vln\left(\frac{\sigma}{\sigma-1}\right) + Vln\left[\frac{1}{\alpha_m}(A_j K_j^{\alpha_k} L_j^{\alpha_l})^{-\frac{1}{\alpha_m}}\right] + \left(1-\frac{V}{\alpha_m}\right)ln(\zeta_h(\omega)) + \left(\frac{V(1-\alpha_m)}{\alpha_m}\right)ln(\chi_h + \tau^{-\sigma}\nu_f\chi_f)\right)$. Taking the first-order condition with respect to $\zeta_h(\omega)$, we obtain $dln(D_{jh})/d\zeta_h(\omega) = [(\sigma-1) + (1-\sigma)(1-V/\alpha_m)]\zeta_h(\omega)^{-1} > 0$ for $0 < \alpha_m < 1$.

[13] The price proxy d_{jt} reflects both output prices and quality, consistent with Khandelwal (2010) that instruments quality with market shares conditional on prices.

face high demand but are less productive compared to younger firms that face low demand. This suggests that even in homogeneous goods sector, controlling for the demand shifter is imperative in estimating physical productivity.

2.4 Relationship with De Loecker (2011)

We also show the relationship between our framework and De Loecker (2011). From equations (5, 6 and 7), our estimating equation (10) can be expressed as:

$$\tilde{r}_{jt} = \underbrace{\beta_l l_{jt} + \beta_k k_{jt} + \beta_m m_{jt} + \beta_s q_{st} + \varepsilon^*_{jt} + a^*_{jt}}_{\text{de Loecker (2011)}} + \frac{1}{\sigma} ln\left(1 + \frac{R_{jf}}{R_{jh}}\right) + u_{it} \tag{12}$$

For exports sales equal to zero ($R_{jf} = 0$), we obtain equation (4) in De Loecker (2011). That is:

$$r_{jt} = \beta_l l_{jt} + \beta_k k_{jt} + \beta_m m_{jt} + \beta_s q_{st} + a^*_{jt} + \varepsilon^*_{jt} + u_{it}$$

where $\beta_q = \frac{\sigma-1}{\sigma}\alpha_q$ for $q = \{l, k, m\}$; $\beta_s = \frac{1}{\sigma}$; $a^*_{jt} = a_{jt}\frac{\sigma-1}{\sigma}$ and $\varepsilon^*_{jt} = \frac{\sigma-1}{\sigma}\zeta_{jt}$. The variable $(1+\frac{R_{jf}}{R_{jh}})$ captures the competitiveness of a firm in the foreign market relative to its home market. If not controlled may overstate productivity for high export-oriented firms. Note that equation (10) is isomorphic to equation (12), we choose the functional form in (10) because of two reasons. First, we do not observe industry output quantity, and the second is its ease to estimate as we need not rely on estimates of the industry elasticity of substitution.

Before moving to the estimation procedure, I discuss the data sets and cleaning specifics, together with some descriptive statistics in the next section.

3 Data

In this section, we describe our data sources, cleaning procedure and present some descriptive statistics.

3.1 Data

We use 3 datasets from Hungary. The first is production data which is a panel of the universe of Hungarian firms' balance sheet data for the period 1993-2003. The second is a panel of export data consisting of firm-product and export destination information for the period 1993-2003[14]. The third is data on import tariffs charged on EU imports for the period 1996-2003. We also complement this with data on producer price index (PPI) by industry publicly available at the online database of Hungarian statistical office and aggregate Hungarian imports data from the World's bank WITS data base[15].

3.1.1 Production Data

The production dataset comes from Hungarian Tax Authority (APEH) and include balance sheet and income statement information such as net value of sales and exports, fixed assets, wage bills, costs of goods and material inputs, and average annual employment, among others. For the purpose of this paper, we focus on manufacturing firms[16] with at least one employee and delete observations from non-manufacturing firms and manufacturing firms with less than one employee. We drop observations for which total export sales is greater than total sales as we consider this a reporting error and we are unsure about how to treat these observations. We merge this data with industry producer price index (PPI) at the 2-digit NACE identifier and create new variables for deflated total sales, exports sales and material inputs using the PPI. We construct domestic sales by substracting exports from total sales. In the appendix, we discuss a number of data cleaning procedure and treatment of missing values for sales, capital, employment and material inputs. After the cleaning, the manufacturing sectors consist of 58550 unique firms and 269454 firm-year observations. Out of these, approximately 40% of firms exported at least once throughout our sample period. We classify these firms as exporters.

[14]Hungary joined the EU in 2004, and so we could not observe exports and destination data.

[15]See $https://wits.worldbank.org/CountryProfile/en/Country/HUN/Year/1996/TradeFlow/Import$

[16]In appendix, I describe the sectors we considered in this work.

Table (1) shows some descriptive statistics of the production data. We observe an increasing pattern for total sales, exports and material inputs thoughout the sample period. The fraction of exporters ranges between 0.42 to 0.54, however these exporter's share of total sales lies between 93% to 96% of total sales. This suggests that the impact of trade liberalization on exporting firms can be generalised to all firms considering the weight of exporter's total sales in aggregate output. In column (9), We show that the average annual growth of wage per worker increased over the time period studied with mild decline in some periods. Overall, the observed patterns are consistent with existing studies.

Since the domestic market share of a firm within its industry is crucial in this work, we describe the patterns of this variable over time. We proceed by computing the fraction of domestic sales within an industry attributed to the top 1%, 5% and 10% of firms in each year. We then summarise its distribution across industries in table (2). For example under Top 1%, in 1993, the minimum across industries for the fraction of domestic market share attributed to the top 1% of firms within an industry is 20%, the maximum is 38.5% and the median is 29%. This implies that in the median industry, the top 10%, 5% and 1% of firms contributed 73.5%, 60.5% and 29% of total domestic sales in 1993. This pattern is consistent across all the years in our data. The results implies that the domestic sales within an industry is heavily concentrated in very few number of large firms - *superstar firms* using the parlance in Mayer and Ottaviano (2008). The efficiency of such firms may be overstated if revenue productivity is used as our measure of firm-level efficiency[17].

3.1.2 Trade Data

This dataset comes from Hungarian statistical Office. It is assembled from customs declarations filled out when exporting or importing. It consists of a complete set of firm-level transactions on export and import shipments in Hungary at a highly disaggregated

[17]By using quantity productity as the measure of efficiency, Foster et al. (2016) showed that older firms have higher demand but are less productive when compared with younger firms which typically have lower demand.

Table 1: Summary Statistics of Production Data

Year	Average Employment	Total Sales	Exporters Share	Total Exports	No. of Firms	Ratio of Exporters	Material Input	Wage Growth%
1993	53	10.71	0.94	2.44	13185	0.44	1.06	-
1994	54	12.19	0.94	2.91	15810	0.43	1.37	-4.03
1995	39	13.07	0.94	3.53	17668	0.42	1.93	-14.55
1996	34	10.12	0.93	3.28	19681	0.42	2.21	-10.28
1997	33	10.97	0.93	4.11	20982	0.43	2.91	-1.07
1998	32	12.01	0.93	4.83	23493	0.42	3.78	0.23
1999	31	15.29	0.95	5.52	24283	0.42	4.42	6.25
2000	30	16.15	0.96	6.39	25414	0.43	5.71	5.11
2001	38	14.76	0.95	6.84	19094	0.54	6.69	37.76
2002	36	19.90	0.96	8.03	20136	0.53	7.47	18.36
2003	34	21.51	0.96	9.27	21154	0.52	8.24	2.15

Total sales, exports and materials are aggregate in trillions of HUF. Exporters share is the fraction of of total sales attributed exporters. Wages growth is the year-by-year growth of average wage/worker expressed in percentages.

level (Combined Nomenclature-10). That is, we observed the range of products exported by a firm, the export destination, quantity and sales value . We also observe firm-level imports, the source country, quantity and purchase value for same period. The total number of observations is 12,117,483. Since we are not interested in imports, we keep only the data on exports which amounts to 2,466,408 observations[18]. Table (3) show a summary statistics of the trade data. We see that the largest fraction of Hungarian manufacturing exports goes to the EU during the period covered in our data. This is also true for Hungarian imports from the EU as shown in figure (1). Between 73% to 79% of Hungarian manufacturing export destination is the EU, and between 55% to 66% of imports are from the EU during the period 1996-2003. This implies that the EU is Hungary's biggest trading partner during the period 1996-2003. The second export destination are a group of countries consisting mainly of central and eastern european countries (see table notes below the table).

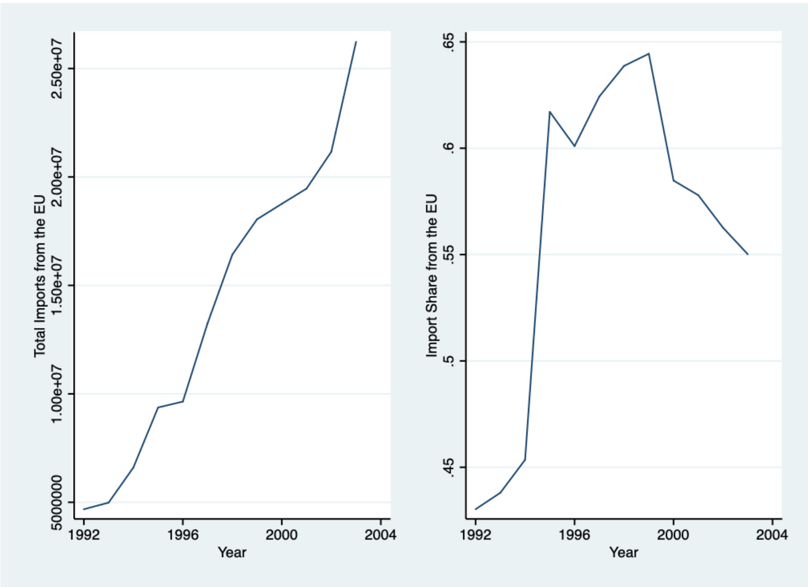
[18] We follow the basic cleaning detailed Békés et al. (2011). Detailed stylized facts about both datasets are contained in their paper.

Table 2: Summary Statistics For Domestic Market Share

	Distribution of Domestic Market Shares								
	Top 1%			Top 5%			Top 10%		
Year	Min	Med	Max	Min	Med	Max	Min	Med	Max
1993	0.201	0.291	0.385	0.439	0.605	0.786	0.591	0.735	0.871
1994	0.217	0.274	0.485	0.459	0.635	0.818	0.595	0.746	0.888
1995	0.216	0.300	0.568	0.518	0.632	0.787	0.649	0.766	0.889
1996	0.208	0.310	0.541	0.475	0.630	0.786	0.625	0.759	0.881
1997	0.180	0.302	0.607	0.480	0.618	0.830	0.630	0.753	0.899
1998	0.233	0.345	0.604	0.505	0.617	0.816	0.644	0.754	0.889
1999	0.211	0.317	0.565	0.511	0.593	0.782	0.657	0.734	0.875
2000	0.161	0.335	0.728	0.485	0.585	0.857	0.625	0.713	0.912
2001	0.168	0.310	0.493	0.449	0.543	0.794	0.625	0.713	0.912
2002	0.170	0.310	0.479	0.474	0.558	0.763	0.623	0.687	0.864
2003	0.167	0.304	0.465	0.480	0.552	0.775	0.633	0.696	0.860

Notes: This table shows the distribution of domestic market shares across periods in our data. In each industry and in each year, I construct the fraction of total domestic sales attributed to the Top 1%, 5% and 10% firms. For each year, I show the range (min and max) and median of this value across industry for top 1%, 5% & 10% firms

Figure 1: Total Imports and Share of Imports from the EU (1992-2003)



The LHS figure is the total imports from the EU and RHS figure is the share of imports from the EU

3.1.3 Tariff Data

Our tariffs dataset comes from Hungarian trade office. The data consists of raw files of a highly disaggregated (CN-10) product tariffs charged on EU imports, bilateral product tariffs with members of Central European Free Trade Association (CEFTA) and, tariffs charged on other Central European countries including Israel and Turkey during the period 1996-2003. This tariffs capture the differential exposure of Hungarian products to different tariffs with the EU and other countries. I aggregate the tariffs with the EU by taking simple averages at the HS-6 level for each year. Column (6) of table (3) shows the average import tariffs charged on EU imports. Clearly, tariffs are reducing during the period leading to Hungary's entry into the EU. Average tariffs fell by over 75% between 1996-2003[19]. In figure (2) we plot the average bilateral tariffs (in percentages) with the EU and Group 2 countries. The figure shows a strong positive co-movements between both tariffs. It also suggests that any of these tariffs can be used as a measure of trade liberalization. Since Hungary's biggest trading partner is the EU, we choose the tariffs with the EU in our analysis.

Table 3: Share of Hungarian Exports Across Different Destinations

Year	European Union	Group 2 Countries	United States	Other Countries	Mean Tariff on EU imports(%)
1996	0.73	0.12	0.04	0.15	8.13
1997	0.76	0.10	0.03	0.13	6.03
1998	0.77	0.10	0.05	0.12	5.32
1999	0.79	0.09	0.06	0.09	4.67
2000	0.78	0.08	0.05	0.07	4.04
2001	0.78	0.09	0.05	0.08	3.03
2002	0.79	0.09	0.04	0.08	2.89
2003	0.77	0.11	0.03	0.09	1.99

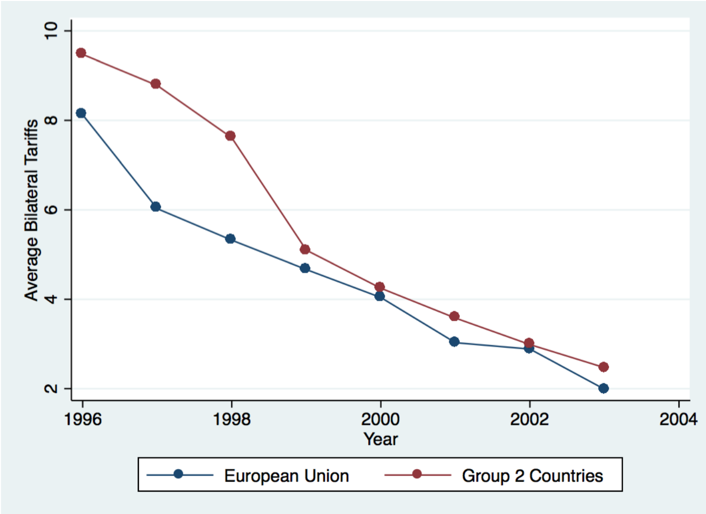
This table shows the shares of Hungarian manufacturing exports across several destinations. European Union includes all countries that were part of the EU between the period 1996-2003 including Norway, Switzerland and Liechtenstein. Group 2 countries consist of the following: Czech Republic, Slovakia, Slovenia, Romania, Israel, Turkey, Estonia, Bulgaria, Latvia, Lithuania, Croatia and Poland. Other countries consist of every other countries not listed here.

3.1.4 Data Merging

We use our data in the following order:

[19]Hungary joined the EU in 2004 so tariff drop to zero. However we do not observe the exports to any destinations and so we restrict the second part of the analysis to period between 1996-2003

Figure 2: Import Tariffs



See notes below Table (3) for a list of countries under Group 2

Step 1: We proceed by aggregating the trade data at the HS-6 digit level [20], and we merge this data with the production data (using unique firm-year identifiers). Since our interest here is to identify the products exported by a firm[21], we drop the destination information. Some firms have zero exports in the balance sheet data and positive exports in the trade data. These firms are assumed to be intermediaries (Ahn et al., 2011) which help other firms to facilitate trade. There are other firms with positive exports in the balance sheet data but do not appear in the trade data. These are likely to be firms that use intermediaries for exporting. We drop these two types of firms.

Step 2: In the tariff data, we consider only import tariffs charged on EU imports. Since the tariff data starts from 1996, I dropped years between 1993 to 1995 in the merged data in Step 1 and merge it with our tariff data using year and HS-6

[20] As earlier stated, we aggregate at this level because the CN-10 classification for tariffs and exports is noisy. In some years, we do not observe some CN-10 tariffs which was observed in the previous period, in some other cases we observe new CN-10 not in the previous period. This pattern is rarely present at the 6-digit level

[21] As already discussed in the introduction, we assume that the product mix across markets, if it exists, is likely to be pronounced at a finer level of product disaggregation (8-digits and above) due to taste preferences across markets. Thus, similar 6-digit level products are sold in both domestic and export markets.

product code identifiers. Our new data ranges from 1996-2003 . We compute the tariffs faced by each exporting firm in each year by taking averages of the tariffs of each products it exports in a given year. Finally, we average over the number of HS-6 digit products in each given year for each firm. This leaves us with 39128 observations and 11038 unique firm identifiers. Each observation in this new data represents a firm in a given year , its average tariffs with the EU and other firm level characteristics.

Step 3: During the late nineties, a large number of firms were part of the supply chain for large firms in the EU, thus domestic sales may not matter to them. These export platforms are pronounced in the auto manufacturing industry and may have little presence in other industries . Since we do not observe these firms in the data, and in order to address this potential concern, we create a sub-sample from the sample described in Step 2 by excluding firm's in *Motor vehicles, trailers and semi-trailers* and *Other transport equipments* industries (NACE 2 industry 34 and 35), and firms with over 70% of export share from our sample. This new subsample consists of 27829 observations and 9071 unique firm identifiers. This will be our main sample. We also report the results for the full sample in the appendix.

4 Estimation Strategy

In this section, we describe the estimation procedure and identification that provides estimates of productivity. Our procedure relies on the proxy methods developed in Olley and Pakes (1996) and extended by Levinsohn and Petrin (2000) and Ackerberg et al. (2015). The main estimating equation is given by:

$$\tilde{r}_{jt} = \alpha_l l_{jt} + \alpha_k k_{jt} + \alpha_m m_{jt} + \beta d_{jt} + a_{jt} + ln\zeta_{jht} + \mu_{jt} \tag{13}$$

All variables are as defined in Section 2. Our goal here is to obtain consistent estimates of the firm-level productivity. Since we do not observe the demand shifter ζ_{jht}, we need to construct a variable which approximates it. As already mentioned, changes in ζ_{jht} across time could result from either changes in the quality embodied in the good or changes in consumer's relative valuation of the product. We already assumed that firms are endowed with quality (as in Johnson, 2012), so that any variation in ζ_{jht} will result from consumer's relative valuation of the product[22]. We argue that the variation in demand addressed to a product will depend on the availability of substitutes. As the decline in tariffs on EU imports is likely to increase the net number of competing varieties addressed to a firm (Melitz, 2003), ζ_{jht} will reflect a firm's exposure to the prevailing import tariffs[23]. We approximate ζ_{jht} with an industry dummy α_s, year dummy α_t, average tariffs faced by a firm $\bar{\tau}_{jt}$ and an unobservable firm-specific demand shock $\tilde{\zeta}_{jht}$ which I assume to be independent and identically distributed (iid) across firms over time. That is:

$$\zeta_{jht} = \alpha_s + \alpha_t + \rho\bar{\tau}_{jt} + \tilde{\zeta}_{jht}$$

The highly disaggregated multi-product nature of our data makes it possible to construct each producer's exposure to trade policy in each time period. In some specification, we control for industry-time dummies instead of a separate industry and time fixed effects to addressed a potential concern that industry export and import tariffs may be correlated. The industry-time dummies controls for any time-variant industry effects that maybe correlated with firm level characteristics such as unobserved industrial policies such as subsidies, tax preferences, average industry tariffs, endogeneity of industry level tariffs etc. We then rewrite our main estimating equation as:

$$\tilde{r}_{jt} = \alpha_l l_{jt} + \alpha_k k_{jt} + \alpha_m m_{jt} + \beta d_{jt} + a_{jt} + \alpha_s + \alpha_t + \rho\bar{\tau}_{jt} + \mu^*_{jt} \tag{14}$$

[22]Even if quality is changing over time, this will be captured by a firm's domestic market share within its industry.

[23]This reasoning is consistent with De Loecker (2011) that approximates the unobserved demand shifter with a product dummy, a product group dummy, average exposure of a producer to EU quotas and an i.i.d. demand shock

Where $\mu_{jt}^{*} = \mu_{jt} + \tilde{\zeta}_{jht}$ is the zero-mean shocks that are uncorrelated with the regressors. To study the effect of trade liberalization on productivity, we can estimate equation (14) directly or we employ a two-step method where we estimate $\tilde{r}_{jt} = \alpha_l l_{jt} + \alpha_k k_{jt} + \alpha_m m_{jt} + \beta d_{jt} + a_{jt} + \mu_{jt}$ and recover the productivity estimates a_{jt} in a first step and then regress the recovered productivity on average tariffs $\bar{\tau}_{jt}$ whilst controlling for some covariates in the second step. We provide a detailed discussion on this in section 5. We estimate equation 14 borrowing insights from Ackerberg et al. (2015)[24].

We use firm-level sales revenue data deflated by NACE 2-digit industry-specific price indices as the dependent variable[25] and we also deflate other nominal variables using same price indices. I specify an endogenous process for productivity which depends on lagged productivity[26]. The law of motion of productivity is assumed to follow a first-order markov process as defined below:

$$a_{jt} = f(a_{jt-1}) + \xi_{jt} \tag{15}$$

where ξ_{it} is the innovation term. This specification ensures that we control for any time-invariant effects that may be correlated with unobserved productivity and inputs. The innovation term ξ_{it} is by OP/LP assumption uncorrelated with the firm's lagged choice variables.

We commence by assuming that materials m_{it} is directly related to unobserved produc-

[24]ACF proposed an extension of OP/LP procedure. Specifically, they argue that labor elasticity can be identified in the first stage of OP and LP under 3 very restrictive data generating process (DGP) namely: (1) a case where there is i.i.d. optimization error in l_{it} (after m_{it} or i_{it} have been choosen) and not in m_{it} or i_{it} (2) a case where there is i.i.d. shocks to the price of labor or output after i_{it} or m_{it} is chosen but before l_{it} is chosen, (3) in the case of OP procedure, labor is non-dynamic and chosen at $t - v$ $(0 < v < 1)$ as a function of productivity in period $t - v$ ω_{it-v} while i_{it} is chosen at t. The main contribution of ACF is the identification of labor in the second stage of OP/LP.

[25] In unreported specifications, I test for the robustness of our results by estimating a value-added production function where m_{jt} do not enter the estimating equation. This is because Bond and Söderbom (2005) have shown (for the cobb-douglas function) that under the scalar unobservable assumption, the procedure in ACF, LP and OP using the gross output production function cannot identify coefficients of perfectly flexible inputs without input price variation except further assumptions are imposed.

[26]We highlight that De Loecker (2013) emphasis the importance of including exporting in the endogenous productivity process if the aim is to estimate efficiency gains from exporting. They also suggest inclusion of investment and the interaction between investment and exporting. We are not interested in efficiency gains from exporting and our data do not contain variables on investment.

tivity, labor input, import tariffs, and our proxy for price and demand shifter- *domestic market shares*. Specifically, as assumed in OP/LP, capital in period t is determined through its choice of investment in period $t-1$ (i.e. k_{it}=g(k_{it-1}, i_{it-1})), and as in ACF, l_{jt} is chosen either in period $t-1$, $t-q$ (such that $0 < q < 1$) or t. The crucial thing here is that material inputs is chosen conditional on l_{it}. What is new here is that we introduce a new variable to the ACF framework by assuming that the firm observes its domestic demand in either period t or $t-q$ before choosing its material inputs. In otherwords, material inputs is chosen conditional on $k_{jt}, l_{jt}, d_{jt}, a_{jt}, \bar{\tau}_{jt}$ [27]. This gives rise to the function of material inputs as:

$$m_{jt} = g_t(k_{jt}, l_{jt}, d_{jt}, a_{jt}, \bar{\tau}_{jt}) \tag{16}$$

This relies on the assumption that input demand is monotonically increasing in productivity under monopolistic competition [28] conditional on k_{jt}, l_{jt}, d_{jt}, and $\bar{\tau}_{jt}$. With the monotonicity assumption, I can invert equation (16) and derive a function that proxies for productivity as:

$$a_{jt} = g_t^{-1}(k_{jt}, l_{jt}, d_{jt}, m_{jt}, \bar{\tau}_{jt}) = h_t(k_{jt}, l_{jt}, d_{jt}, m_{jt}, \bar{\tau}_{jt}) \tag{17}$$

The estimation consists of two stages as in Ackerberg et al. (2015) except for the fact that I obtain both demand and supply parameters in the second stage. In the first stage of the procedure, we estimate the equation of the form:

$$\tilde{r}_{jt} = \phi_t(k_{jt}, l_{jt}, d_{jt}, m_{jt}, \bar{\tau}_{jt}) + \alpha_s + \alpha_t + \mu_{it} \tag{18}$$

where $\phi_t(k_{jt}, l_{jt}, d_{jt}, m_{jt}, \bar{\tau}_{jt}) = \alpha_k k_{jt} + \alpha_l l_{jt} + \alpha_m m_{jt} + \beta d_{jt} + \rho \bar{\tau}_{jt} + h_t(m_{jt}, k_{jt}, l_{jt}, d_{jt}, \bar{\tau}_{jt})$. In some specifications, we control for industry-year dummies to ensure that any unob-

[27] We also checked for the case where market shares are identified in the first stage of Ackerberg et al. (2015), and we obtained similar estimates

[28] De Loecker (2011) verifies that this assumption hold for the case where the demand side is integrated in the production function estimation

servable industry level time-varying effects which may be jointly correlated with import tariffs do not bias our results. There is a possibility that importing intermediate inputs is correlated with material demand or firms that imports more inputs faces lower tariffs. Since importing is strongly correlated with productivity (Halpern et al., 2015), I include importers dummy in the material function in some specifications to ensure that this channel does not bias our estimates. Foreign firms are more productive in using imported inputs than domestic firms (Halpern et al., 2015), in an unlikely scenario where ownership status is correlated with import competition, our estimates of $\bar{\tau}_{jt}$ will be biased. So, we also include foreign ownership dummy in the material function in some specifications where a firms is classified as foreign-owned if foreigners owns over 50 percent of the firm's equity.

In principle, none of the input variables can be identified in the first stage. We compute $\hat{\phi}_t(.)$ from first stage estimation where $h_t(m_{jt}, k_{jt}, l_{jt}, d_{jt}, \bar{\tau}_{jt})$ is proxied by a third-order polynomial function of its components. In the second stage, we provide moment conditions to identify the parameters of interest after obtaining the innovation term. We commence by using $\hat{\phi}_t(.)$ and together with initial guess of the coefficient vector $\boldsymbol{\alpha_z} = \{\alpha_k, \alpha_l, \alpha_m, \beta, \rho\}$ and for any other candidate vector of $\tilde{\boldsymbol{\alpha}}_{\boldsymbol{z}}$, productivity is computed as:

$$a_{jt}(\tilde{\boldsymbol{\alpha}}_{\boldsymbol{z}}) = \hat{\phi}_t(.) - (\tilde{\alpha_k} k_{jt} - \tilde{\alpha_l} l_{jt} - \tilde{\alpha_m} m_{jt} - \tilde{\beta} d_{jt})$$

We use our productivity process (equation 15) to recover the innovation term ξ_{jt} by a non-parametric regression of $a_{jt}(\tilde{\boldsymbol{\alpha}}_{\boldsymbol{z}})$ on its own lag $a_{jt-1}(\tilde{\boldsymbol{\alpha}}_{\boldsymbol{z}})$. We define the moment condition below and iterate over candidate vector $\tilde{\boldsymbol{\alpha}}_{\boldsymbol{z}}$

$$\boldsymbol{E}\left\{ \xi_{jt}(\tilde{\alpha_k}, \tilde{\alpha_m}, \tilde{\alpha_m}, \tilde{\beta}, \tilde{\rho}) \begin{pmatrix} k_{jt} \\ l_{jt-1} \\ m_{jt-1} \\ d_{jt-1} \\ \bar{\tau}_{jt-1} \end{pmatrix} \right\} = 0 \tag{19}$$

Thus equation (19) states that for the optimal $\tilde{\boldsymbol{\alpha}}_{\boldsymbol{z}}$, the innovation term ξ_{it} is uncorrelated with our instruments $(k_{jt}\ l_{jt-1}\ m_{jt-1}\ d_{jt-1}, \bar{\tau}_{jt-1}\ )'$. The optimal values of $\tilde{\boldsymbol{\alpha}}_{\boldsymbol{z}}$ gives us our coefficient of interest[29].

We also estimate revenue productivity using similar procedure as above. The only difference with our previous estimation procedure is the exclusion of domestic market shares in the productivity estimation. We also recover both physical and revenue productivity using the estimated parameters $\hat{\alpha}_l, \hat{\alpha}_k, \hat{\alpha}_m$, and $\hat{\beta}$ and perform a comparative analysis.

4.1 Properties of the Productivity Estimates

In this section, we compare our estimated quality-adjusted productivity and revenue productivity to highlight differences and similarities between these two measures. Our main objective here is to show that firm-level domestic market shares within its industry provides a good proxy of unobserved prices and would replicate similar patterns as prices. It thus, suggests the importance of controlling for unobserved prices and demand shifters in productivity estimation.

4.1.1 Comparison Between Quality-Adjusted and Revenue Productivity

We focus on correlations and standard deviation. Table (4) presents the summary statistics for quality-adjusted productivity, revenue productivity, domestic market share (our proxy for price), sales revenue and capital. The first important point to note is that the two productivity measures are strongly correlated and exhibits high dispersion. Unsurprisingly, revenue TFP has a higher dispersion than our Quality-Adjusted TFP measure. This is because the former is a combination of the later and firm-level prices. Firms may have responded to decreased import tariffs with the EU differently through changes in their prices, thereby causing more dispersion in revenue productivity than quantity productivity.

[29] If we are interested in recovering the industry elasticity of substitution, this can be done by estimating equation (18) for each industry and retrieving the industry elasticity of substitution from the domestic market share $\hat{\beta} = \frac{1}{|\sigma - 1|}$. However, this is not of interest to this paper.

We also observe, a strong positive correlation between revenue productivity and do-

Table 4: Summary Statistics for Productivity Measures, Sales and Capital

	Correlations				
	Quality-Adjusted Productivity	Revenue Productivity	Sales Revenue	Capital	Market Shares
Quality-Adjusted Productivity	1.00				
Revenue Productivity	0.45**	1.00			
Sales Revenue	0.10**	0.34**	1 .00		
Capital	0.01**	-0.06**	0.80**	1.00	
Domestic Market Shares	-0.20**	0.25**	0.77**	0.58**	1.00
	Standard Deviations				
	0.777	1.083	1.936	2.356	1.944

Notes: This table shows the correlation and standard deviations for our firm-level variables. All variables are in logs. $**$, $*$ and † are 1%, 5% and 10% significant levels respectively.

mestic market share (price proxy). This is not surprising because prices are expected to have a strong positive correlation with revenue productivity. Interestingly, we observe a negative correlation between our quality-adjusted productivity and domestic market shares, consistent with more productive firms having lower marginal costs and charging lower prices. These results are consistent with the findings in Foster et al. (2016) for the United States. By comparing large and small firms, their paper reports that older firms have larger demand (thus market shares) and lower physical productivity when compared with younger firms which typically have lower demand. The strength of the negative correlation is weaker than that in Foster et al. (2008). This is either because our price proxy is noisy and does not perfectly capture variations in prices or because we use different datasets.

Finally, we observe that sales has a stronger correlation with revenue TFP than it has with quality-adjusted TFP consistent with Foster et al. (2008) which is unsurprising since revenue TFP reflects prices and demand conditions. In Table (10) in the appendix, we repeat the same exercise in Table (4) for same variable but where we remove industry-year fixed effects from each variable to ensure that aggregate industry intertemporal movements do not drive our results. Clearly, the results are very similar. In conclusion, by using firm-level datasets for Hungary and a model-driven proxy for prices, our results are similar to existing pattern for the US as documented by Foster et al. (2008) and Foster et al. (2016).

5 Effects of Trade Liberalization on Productivity

In this section, we study the impact of reduction in tariffs charged on imports from the EU on firm level productivity during the period between 1996 and 2003[30]. Due to some data limitations, we focus on firms with at least two observations during the period studied. We merge the tariff data to the products manufactured by each firm at the HS-6 level and construct a measure of tariffs faced by each firm for each year during the period of our study by taking simple averages of the tariffs on the products exported by the firm. Our data limitation poses three potential shortcomings. First, we do not observe the product mix of non-exporters so we cannot match our tariff information to non-exporters. However, we do not consider this an issue as total sales attributed to exporting firms ranges between 93% to 96% of total sales attributed to all firms during the period 1996-2003 studied (see table 1). Second, we observe products exported by exporting firms but we do not know whether exporters have different product mix in the domestic and foreign markets. This is clearly not a concern if products mix in domestic and foreign markets are differentiated at a very disaggregated level (HS-6 and above)[31]. If firms sell different product (at HS-4 or below) mix in the export and domestic markets, then our measure of firm-level exposure to import tariffs maybe bias. Third, while the framework we developed in section 2 is for single product firms, we apply it to also multiproduct firms. Though we showed how our framework extends to multiproduct firms under some restrictive but standard assumptions (See appendix A), we do not apply this extension due to the limitations on our data. This will likely overestimate productivity for multi-product firms. Thus, we remind the reader about these caveats in the interpretation

[30] Hungary joined the EU in 2004 and from this period, all tariff was set to zero.

[31] For example if a firm sells HS-8 product 66022021 in the domestic market and product 66022022 in the international market, both products are the same at the HS-6 classification.

of our results. We compare the impact of trade liberalization on quality-adjusted and revenue productivity and examine whether foreign-owned firms benefit more or less from trade liberalization compared to domestic firms.

As already discussed in section 4, we employ two estimation strategies- *two-steps strategy* and *direct method*. In what follows, we describe these strategies in detail. In the first step of the two-steps strategy, we seperately estimate the quality-adjusted and revenue productivity using the methods described in Section 4. In the second step, we project the recovered productivity estimates against the tariffs faced by each firm. While the quality-adjusted productivity allows the productivity response to be isolated from the demand response, the revenue productivity does not since it captures both price and demand variations. Before proceeding to the regression equation, we remind the reader about the underlying assumption that the tariff setting process is exogenous to the firm. This assumption is plausible given that the chances of a single firm in Hungary to influence trade decisions at the EU level is quite slim.

The second stage involves a regression of the form:

$$\omega_{jt}^{i} = k + \rho\bar{\tau}_{jt} + \alpha_{st} + \beta X_{jt} + \epsilon_{jt}, \quad i \in \{C, N\} \tag{20}$$

where we now denote productivity by ω_{jt}^{i}, C and N are revenue and physical productivity respectively, α_{st} is an industry time fixed effect, $\bar{\tau}_{jt}$ is average tariffs, and X_{jt} are controls such as lagged productivity or ownership dummy. Our main coefficient of interest is ρ which measures the effects of import competition on productivity. Since $\omega_{jt}^{C} = \omega_{jt}^{N} + (p_{jt} - P_{sht} - \zeta_{jht})$, equation (20) implies that regressing revenue productivity on tariffs relies on the strong assumption that firm-level tariffs are uncorrelated with prices. This clearly overstates the effect of import competition on revenue productivity[32]

[32]To see this more clearly, by using revenue productivity in 20, the estimating equation takes the form:

$$\omega_{jt}^{N} + (p_{jt} - P_{sht} - \zeta_{jht}) = k + \rho\bar{\tau_{jt}} + \alpha_{st} + \beta X_{jt} + \underbrace{\gamma\underbrace{(p_{jt} - P_{sht} - \zeta_{jht})}_{\Omega} + \epsilon_{jt}^{*}}_{\epsilon_{jt}}$$

and sheds some light on the importance of integrating the demand system in production function estimation if quantity data is unobserved. We include industry-year dummies to control for any industry-level time-variant heterogeneity that are simultaneously correlated with tariffs charged on imports from EU and productivity. Such heterogeneity may include industry level tariffs charged on Hungarian exports in the EU market, or endogeneity from organized industry lobbying for preferential protection etc. In the estimation, we use either contemporaneous or lagged tariff variables.

The second estimation strategy is the direct method which we already described in section 4. Here, the effects of import competition on productivity is estimated in a single production function equation.

5.1 Estimation Results

We present our findings for Table (5), (6) and (7) using both contemporaneous and lagged average tariffs. It is important to note that the expected sign of ρ is negative if import competition increases productivity. We present the results for the direct approach for both quality-adjusted and revenue productivity in Table (5). Columns (1) to (4) presents the estimates for QA productivity, and columns (5) to (8) presents that for revenue productivity. Our preferred specification is column (3) and (7) where we control for year, industry and importer's dummies. Our results imply that a 10 percentage point reduction in tariffs is associated with an increase in firm-level productivity by 0.97 percent when QA productivity is used. However, same 10 percentage point reduction in tariffs is associated with revenue productivity by 2.1 percent. This pattern is consistent even when we control for industry-time dummies (columns 2 and 6), foreign ownership dummy (columns 4 and 8) and when we do not control for importers dummy (columns 1 and 5). Our findings are inline with the results in De Loecker (2011), that while trade liberalization increases physical productivity, its effect is overstated when revenue productivity is used as the

Therefore $\rho = \rho^{true} + \gamma \frac{cov(\bar{\tau}_{jt}, \Omega)}{var(\bar{\tau}_{jt})}$. Since $cov(\bar{\tau}_{jt}, \Omega) < 0$ and ρ^{true} is expected to be negative, then we clearly see that ρ overstates the effects of tariffs on productivity.

measure of efficiency.

We present the results from the first stage of the two-steps approach in Table (9) in the appendix, and the results of the second-stage (equation (20)) in Table (6) and (7) for QA and Revenue Productivity respectively. We use both contemporaneous (columns 1-2) and lagged tariffs (columns 3-7). In our preferred specification (column 2 of Table (6)), the estimates suggest that a 10 percentage points reduction in tariffs on imports from the EU is associated with a rise in quality-adjusted productivity by 1.3 percent. This estimated effect rises to 1.8 percent if revenue productivity was used instead (column 2 of Table 7). If firms are eliminating internal inefficiency as a result of increased competition, we should expect higher efficiency gains from domestic firms than from foreign firms. This is because foreign firms are already exposed to foreign competitions and may have eliminated most inefficiencies prior to the trade policy. In column 6 of both Table 6 and 7 , we interact tariffs with a dummy that takes the value of 1 if the firm is a foreign firm and 0 if otherwise. Our estimates for QA productivity in column 6 of Table (6) implies that a 10 percentage points reduction in tariffs on imports from the EU is associated with an increase in QA productivity by 0.59 percent for domestic firms, and 0.13 percent for foreign firms. Column 6 of Table (7) presents the same analysis using revenue productivity, the estimates imply that a 10 percentage points reduction in import tariffs is associated with an increase in revenue productivity by 0.76 percent for domestic firms and 0.20% for foreign firms. This results suggests that efficiency gains from import competition is weaker for foreign-owned firms compared to domestic firms. Similar to the previous cases, we find this effect to be stronger when revenue productivity is our measure of efficiency. Overall, our estimates are highly significant and similar in magnitudes to the ones reported in Topalova and Khandelwal (2011) and Fernandes (2007).

We conduct a number of robustness checks to test the sensitivity of our results to a slightly modified specification and data restrictions. In the previous analysis (Table 6, 7) robust standard errors were clustered at the industry level. So, we repeat the analysis with robust standard errors clustered at the firm level and report the result in the appendix

Table (11), we find our results to be similar. Second, we drop the importer's dummy in the first-step estimation of the two-step approach, and our results remain unchanged as reported in Table (13) of the appendix. Finally, we use the full sample which contains firms in the automobile industry and firms with over 70% share of exports in their total sales, and report the estimates in the appendix Table 12. The results remains unchanged and consistent with our two-step approach results.

In summary, our results suggest the presence of true efficiency gains from trade liberalization and that standard measures overstates productivity response to trade liberalization. This indicates that controlling for unobserved prices result to closer measures of true efficiency gains from trade liberalization.

Table 5: Estimating the Effects of Trade Liberalization on Productivity

	Direct Method							
Dep. var:	QA Productivity				Revenue Productivity			
Log Sales	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Capital	0.040***	0.038***	0.038***	0.035***	0.048***	0.047***	0.047***	0.044***
	(0.000)	(0.002)	(0.001)	(0.002)	(0.000)	(0.001)	(0.001)	(0.001)
Log Labor	0.117***	0.115***	0.117***	0.122***	0.161***	0.162***	0.161***	0.165***
	(0.004)	(0.004)	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)
Log Materials	0.483***	0.456***	0.477***	0.468***	0.837***	0.836***	0.833***	0.830***
	(0.000)	(0.004)	(0.000)	(0.000)	(0.001)	(0.004)	(0.001)	(0.005)
Tariffs	-0.109***	-0.140***	-0.097***	-0.064***	-0.219***	-0.235***	-0.211***	-0.187***
	(0.001)	(0.007)	(0.002)	(0.005)	(0.000)	(0.005)	(0.002)	(0.005)
Log Domestic MS	0.429***	0.460***	0.431***	0.435***				
	(0.000)	(0.001)	(0.000)	(0.000)				
Importers dummy			0.079***	0.067***			0.059***	0.051***
			(0.000)	(0.000)			(0.001)	(0.000)
Foreign-Owned				0.104***				0.079
				(0.000)				(0.001)
Year FE	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Industry FE	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Industry Year FE	No	Yes	No	No	No	Yes	No	No
Observations	27829	27829	27827	27807	27829	27829	27827	27807

Notes: This table reports the results of the effect of tariff reductions on firm-level productivity employing the direct appoach. Foreign is a dummy that takes the value 1 if a firm is over 50% foreign owned and 0 if otherwise. I exclude firms in industry 34 and 35. (That is: "Motor vehicles, trailers and semi-trailers" and Other transport equipments) and firms with export sales greater than 70% of total sales to ensure that our results are not driven by export platform firms. Bootstrap standard errors are reported in parentheses. $*$, $**$ and $***$ indicates 10%, 5% and 1% significance. MS=market share

6 Conclusion

In this paper, we provide new evidence on the effect of import competition on manufacturing firm's productivity in Hungary. By exploiting the import tariff reduction charged on imports from the EU during the periods (1996-2003) leading to Hungary's EU acces-

Table 6: Estimating the Effects of Trade Liberalization on Productivity

Dependent Variable:	Quality-Adjusted Productivity						
	Two-Steps Approach						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tariffs	-0.115***	-0.129***					
	(0.012)	(0.015)					
Lagged Tariffs			-0.108***	-0.050*	-0.053*	-0.059**	-0.026***
			(0.016)	(0.029)	(0.026)	(0.027)	(0.008)
Lagged Productivity				0.646***	0.644***	0.644***	0.102***
				(0.017)	(0.017)	(0.017)	(0.011)
Foreign x Lag Tariffs						0.046***	
						(0.014)	
Importers dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	No	No	No	No	No	No	Yes
Industry-Year FE	No	Yes	No	No	Yes	Yes	Yes
Year FE	Yes	No	Yes	Yes	No	No	No
Industry FE	Yes	No	Yes	Yes	No	No	No
Observations	27827	27827	19442	19442	19442	19433	19442
R-squared	0.132	0.163	0.093	0.532	0.546	0.546	0.275

Notes This table reports the results of the effect of tariffs cut on firm-level productivity. Foreign is a dummy that takes a value=1 if firm is foreign-owned and 0 if domestic or state-owned. I excluded firms in industry 34 and 35 (i.e. "Motor vehicles, trailers and semi-trailers" and Other transport equipments) and firms with export sales more than 70% of its total sales to ensure that our results are not driven by export platform firms. In column 1-7 robust standard errors are clustered at the industry level in parentheses. $*$, $**$ and $***$ indicates 10%, 5% and 1% significant levels.

Table 7: Estimating the Effects of Trade Liberalization on Productivity

Dependent Variable:	Revenue Productivity						
	Two-Steps Approach						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tariffs	-0.164***	-0.177***					
	(0.012)	(0.015)					
Lagged Tariffs			-0.160***	-0.065**	-0.068**	-0.076**	-0.029***
			(0.018)	(0.030)	(0.027)	(0.029)	(0.010)
Lagged Productivity				0.638***	0.635***	0.635***	0.101***
				(0.018)	(0.018)	(0.018)	(0.012)
Foreign x Lag Tariffs						0.057***	
						(0.018)	
Importers dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	No	No	No	No	No	No	Yes
Industry-Year FE	No	Yes	No	No	Yes	Yes	Yes
Year FE	Yes	No	Yes	Yes	No	No	No
Industry FE	Yes	No	Yes	Yes	No	No	No
Observations	27827	27827	19442	19442	19442	19433	19442
R-squared	0.138	0.168	0.096	0.519	0.533	0.533	0.280

Notes This table reports the results of the effect of tariffs cut on firm-level productivity. Foreign is a dummy that takes a value=1 if firm is foreign-owned and 0 if domestic or state-owned. I excluded firms in industry 34 and 35 (i.e. "Motor vehicles, trailers and semi-trailers" and Other transport equipments) and firms with export sales more than 70% of its total sales to ensure that our results are not driven by export platform firms. In column 1-7 robust standard errors are clustered at the industry level in parentheses. $*$, $**$ and $***$ indicates 10%, 5% and 1% significant levels.

sion, we make important contributions to the literature.

First, we propose a novel empirical model for estimating physical productivity from sales revenue data for exporting firms. Our framework integrates the demand-system in the domestic and foreign markets with the supply-side, which makes it possible to estimate the impact of trade liberalization on physical productivity at the firm-level. We introduce this framework to overcome some potential estimation bias associated with estimating productivity from sales revenue because we do not observe output in our data.

Our highly disaggregated data sets enable us overcome potential endogeneity concerns (such as unobserved industry lobbying[33] or domestic policies) in existing studies. While most related studies approximate average tariffs faced by a firm with a 3- or 4-digits industry level tariffs, our unique dataset ensures that we exploit variation in tariffs at the firm-level. Therefore, we control for time-varying industry characteristics while exploiting the variation in average firm-level tariffs on productivity. This is particularly important for identification in our setting because the tariffs cuts is part of the prerequisites to join the EU. It is likely that industry-specific domestic policies that are correlated with productivity were simultaneously implemented.

Second, our results imply that import competition from the EU has a strong effect on productivity, even after controlling for unobserved firm-fixed effect, time-varying industry effects and general economic conditions that affects all firms. We also find that this effect is stronger when we use revenue productivity as our measure of efficiency compared to when quality-adjusted productivity is used. In addition, we find that this effect is in general weaker for foreign firms compared to domestic firms. When we use quality-adjusted productivity, this effect is weaker for foreign firms compared to when revenue productivity is employed. The intuition is that foreign firms have experience with international competitions and may have eliminated internal inefficiencies prior to trade liberalization. Therefore, an increase in import competition may have induced rising

[33]See Mitra et al. (2002) and Goldberg and Maggi (1999) for empirical findings on industry lobbying for trade protection in a developing and developed country respectively. See Grossman and Helpman (1994) for theoretical findings

markups rather than true productivity gains. Overall, this suggests that revenue-based measure of productivity overstates the impact of trade liberalization, consistent with the literature (De Loecker, 2011).

Our proxy for unobserved prices in the production function equation is the firm's domestic market share. We show that this proxy exhibits some of the empirical properties of prices in studies that observed firm level prices. For example, we find that our price proxy has a strong positive correlation with revenue productivity and a negative correlation with quality-adjusted productivity, consistent with Foster et al. (2008) that finds similar patterns of correlation for observed firm-level prices, quantity and revenue productivity using data from the US. This correlation also suggests that firms with large demand are less productive than firms with smaller demand. Thus, revenue productivity leads to a misinterpretation of this relationship, consistent with Foster et al. (2016) that finds that older firms face larger demand than younger firms and these older firms are less productive than younger firms when quantity productivity is used.

We do not investigate the underlying mechanisms behind the productivity gains due to trade liberalization, but existing studies points to the direction of imported inputs (Halpern et al., 2015), imported machinery (Koren and Csillag, 2017), and managerial strategy (Bloom et al., 2015). Further work on firm-level mechanisms would be an interesting direction to explore.

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Appendix

A Extension to Multiproduct Producers

Our aim in this subsection is to show how our framework can be extended to a multi-products setting. In the previous section, we assumed that each firm produces a single product. We will now consider an additional channel - *multiproducts* - besides productivity and markups which could explain the dispersion in firm sizes. We show how our framework extends to the case where firms produce more than one product since we anticipate this to be the case in most firms[34]. By relying on the following restrictive but standard assumptions in the literature (Foster et al. (2008), De Loecker (2011), Levinsohn and Melitz (2002)): (1) identical production functions across products; (2) equal proportion of inputs are used in producing each product; (3) the number of varieties produced by a firm is constant; I show the relationship between a given product k of firm j q_{jkt} to its total input usage as[35]:

$$q_{jkt} = (\rho_{jkt} L_{jt})^{\alpha_l} (\rho_{jkt} K_{jt})^{\alpha_k} (\rho_{jkt} M_{jt})^{\alpha_m} A_{jt} \tag{A.21}$$

where ρ_{jkt} is defined as the share of product k in firm j's total input use. I further assume that inputs are spread across products in exact proportion to the number of products produced. So $\rho_{jkt} = S_j^{-1}$, where S_j is the number of products produced by firm j . The total variable cost is:

$$TVC_{jkt} = q_{jkt}^{\frac{1}{\alpha_m}} L_{jt}^{-\frac{\alpha_l}{\alpha_m}} K_{jt}^{-\frac{\alpha_k}{\alpha_m}} A_{jt}^{-\frac{1}{\alpha_m}} S_j^{\gamma}$$

Where $\gamma = \frac{\alpha_l + \alpha_k}{\alpha_m}$. On the demand side, for simplicity, we assume the consumer valuation is embodied on the brand and not the specific product so ζ_{ijt} (where $i = \{h, f\}$) is the same for every product of a firm. The demand for each product can be derived as:

$$q_{ijkt} = p_{ijkt}^{-\sigma} \zeta_{ijt} \chi_{st} \tag{A.22}$$

In similar steps as the single product case, firm's maximize profit by choosing prices p_{ijkt} for each product in both the foreign and domestic market subject to demand system in equation(A.22). The price that emerges for each variety is similar to equation (4) with an additional term (S_j^V). This implies that by keeping quality fixed and splitting inputs

[34] I do not observe the number of products produced by a firm in the balance sheet data, but the export data shows that approximately 79.2 percent of exporting firms export at least 2 or more products at the CN-9 digit levelThe remaining 20.8 percent may be multiproduct firms if the sell different product mixes at home and abroad. Aggregating at the HS-6 digit level, we see that approximately 77% of exporting firms export at least two products

[35] We suppress the country subscript since we are dealing with only firms in the home country

over the production of more products, firms can increase the price of its unit output (Levinsohn and Melitz, 2002). This enables us to generate a system of product specific revenue in both foreign and domestic markets. The firm total revenue is derived by summing over the revenue for each of its product $R_{jt} = \sum_{k \in S_j} R_{jkt}$. Taking logs the estimating equation is:

$$\tilde{r}_{jt}^{v} = \alpha_l l_{jt} + \alpha_k k_{jt} + \alpha_m m_{jt} + \beta d_{jt} + a_{jt} + ln(\zeta_{jh}) + s_j^* + \mu_{jt} \tag{A.23}$$

This estimating equation is similar to equation (10). The only difference is the presence of the additional term $s_j^* = (1 + \alpha_m(1+\gamma))ln(S_j)$. For a single product firm $s_j^* = 0$, but for a multi-product firm it is some positive number which is constant over time. The derivation follows very closely from derivation of equation (10). Since we do not observe the varieties produced at the firm level, we are unable to control for the number of varieties in the estimation. Our aim in this subsection is to show how our framework can be extended to a multi-products setting.

B Model Solution

B.1 Detailed Derivation of Revenue Equations

The first order condition of the profit maximization equation (3) yields:

$$\left(\frac{\sigma-1}{\sigma}\right) q_{jh}^{-\frac{1}{\sigma}} (\zeta_{jh}^{\sigma-1}\chi_h)^{\frac{1}{\sigma}} = \frac{(q_{jh}+q_{jf})^{\frac{1-\alpha_m}{\alpha_m}}}{\alpha_m (A_j K_j^{\alpha_m} L_j^{\alpha_l})^{\frac{1}{\alpha_m}}} \tag{B.1}$$

$$\frac{1}{\tau_j}\left(\frac{\sigma-1}{\sigma}\right) q_{jf}^{-\frac{1}{\sigma}} (\zeta_{jf}^{\sigma-1}\chi_f)^{\frac{1}{\sigma}} = \frac{(q_{jh}+q_{jf})^{\frac{1-\alpha_m}{\alpha_m}}}{\alpha_m (A_j K_j^{\alpha_m} L_j^{\alpha_l})^{\frac{1}{\alpha_m}}} \tag{B.2}$$

Recalling that $q_{jh} = \zeta_{jh}^{\sigma-1}\chi_h p_j^{-\sigma}$ and $q_{jf} = \zeta_{jf}^{\sigma-1}\chi_f (p_j\tau_j)^{-\sigma}$ and substituting in equation B.1 we obtain

$$q_{jh}^{-\frac{1}{\sigma}} = \left(\frac{\sigma}{\sigma-1}\right) (\zeta_{jh}^{\sigma-1}\chi_h)^{-\frac{1}{\sigma}} \alpha_m^{-1} (A_j K_j^{\alpha_m} L_j^{\alpha_l})^{-\frac{1}{\alpha_m}} (\zeta_{jh}^{\sigma-1}\chi_h + \zeta_{jf}^{\sigma-1}\chi_f \tau^{-\sigma})^{\frac{1-\alpha_m}{\alpha_m}} (p_{jt}^{-\sigma})^{\frac{1-\alpha_m}{\alpha_m}} \tag{B.3}$$

We know that $(p_{jt}^{-\sigma})^{\frac{1-\alpha_m}{\alpha_m}} = q_{jh}^{\frac{1-\alpha_m}{\alpha_m}} (\zeta_{jh}^{\sigma-1}\chi_h)^{\frac{\alpha_m-1}{\alpha_m}}$ and substituting in equation B.3 we have

$$q_{jh} = Z^{\sigma V} \zeta_{jh}^{\sigma-1}\chi_h (A_j K_j^{\alpha_k} L_j^{\alpha_l})^{\frac{\sigma V}{\alpha_m}} (\zeta_{jh}^{\sigma-1}\chi_h + \zeta_{jf}^{\sigma-1}\chi_f \tau^{-\sigma})^{\frac{(\alpha_m-1)\sigma V}{\alpha_m}} \tag{B.4}$$

Where $Z = \frac{(\sigma-1)\alpha_m}{\sigma}$ and $V = \frac{\alpha_m}{\alpha_m - \sigma(\alpha_m - 1)}$. Recall revenue is $R_{jh} = p_j q_{jh} = q_{jh}^{\frac{\sigma-1}{\sigma}} \zeta_{jh}^{\frac{\sigma-1}{\sigma}} \chi_h^{\frac{1}{\sigma}}$. We already have the expression for q_{jh} in equation (B.4) so we can write

$$R_{jh} = Z^{V(\sigma-1)} \zeta_{jh}^{\sigma-1} \chi_h (A_j K_j^{\alpha_k} L_j^{\alpha_l})^{\frac{V(\sigma-1)}{\alpha_m}} (\zeta_{jh}^{\sigma-1} \chi_h + \zeta_{jf}^{\sigma-1} \chi_f \tau_j^{-\sigma})^{\frac{V}{\alpha_m}-1} \tag{B.5}$$

Similarly, substituting $q_{jh} = \zeta_{jh}^{\sigma-1} \chi_h p_j^{-\sigma}$ and $q_{jf} = \zeta_{jf}^{\sigma-1} \chi_f (p_j \tau_j)^{-\sigma}$ in equation (B.2) we have

$$q_{jf}^{-\frac{1}{\sigma}} = \left(\frac{\sigma}{\sigma-1}\right) (\zeta_{jf}^{\sigma-1} \chi_f)^{-\frac{1}{\sigma}} \alpha_m^{-1} \tau_j^{-\frac{1}{V}} (A_j K_j^{\alpha_m} L_j^{\alpha_l})^{-\frac{1}{\alpha_m}} (\zeta_{jh}^{\sigma-1} \chi_h + \zeta_{jf}^{\sigma-1} \chi_f \tau^{-\sigma})^{\frac{1-\alpha_m}{\alpha_m}} ((\tau_j p_{jt})^{-\sigma})^{\frac{(1-\alpha_m)}{\alpha_m}} \tag{B.6}$$

We know that $(\tau_j p_{jt})^{\frac{\sigma(\alpha_m-1)}{\alpha_m}} = (q_{jf} (\zeta_{jf}^{\sigma-1} \chi_f)^{-1})^{\frac{1-\alpha_m}{\alpha_m}}$ and substituting in B.6

$$q_{jf} = Z^{\sigma V} \zeta_{jf}^{\sigma-1} \chi_f \tau_j^{-\sigma} (A_j K_j^{\alpha_k} L_j^{\alpha_l})^{\frac{\sigma V}{\alpha_m}} (\zeta_{jh}^{\sigma-1} \chi_h + \zeta_{jf}^{\sigma-1} \chi_f \tau_j^{-\sigma})^{\frac{(\alpha_m-1)\sigma V}{\alpha_m}} \tag{B.7}$$

In a similar as above we can derive export sales as:

$$R_{jf} = Z^{V(\sigma-1)} \zeta_{jf}^{\sigma-1} \chi_f \tau^{-\sigma} (A_j K_j^{\alpha_k} L_j^{\alpha_l})^{\frac{V(\sigma-1)}{\alpha_m}} (\zeta_{jh}^{\sigma-1} \chi_h + \zeta_{jf}^{\sigma-1} \chi_f \tau_j^{-\sigma})^{\frac{V}{\alpha_m}-1} \tag{B.8}$$

Summing up equation (B.5 and B.8) and reminding the reader that $\zeta_{jf} = \zeta_{jh} \nu_{jf}$ obtain out total sales in equation(7).

$$R_{jT} = \begin{cases} Z^{V(\sigma-1)} (A_j K_j^{\alpha_k} L_j^{\alpha_l})^{\frac{V(\sigma-1)}{\alpha_m}} (\zeta_{jh}^{\sigma-1} \chi_h)^{\frac{V}{\alpha_m}} & \text{if firm sells at home} \\ Z^{V(\sigma-1)} (A_j K_j^{\alpha_k} L_j^{\alpha_l})^{\frac{V(\sigma-1)}{\alpha_m}} \zeta_{jh}^{\frac{V(\sigma-1)}{\alpha_m}} (\chi_h + \tau_j^{-\sigma} \nu_{jf}^{\sigma-1} \chi_f)^{\frac{V}{\alpha_m}} & \text{if firm sells in both} \end{cases} \tag{B.9}$$

Recall price equation is $p_{jt} = q_{jh}^{-\frac{1}{\sigma}} (\zeta_{jh}^{\sigma-1} \chi_h)^{\frac{1}{\sigma}}$. Substituting equation (B.1) into this equation, we can express price as:

$$p_{jt} = \frac{\sigma}{\sigma-1} \frac{1}{\alpha_m} (A_j K_j^{\alpha_k} L_j^{\alpha_l})^{-\frac{1}{\alpha_m}} (q_{jh} + q_{jf})^{\frac{1-\alpha_m}{\alpha_m}}$$

So,

$$R_{jT}^{-\alpha_m} = (p_{jt} q_{jT})^{-\alpha_m} = Z^{\alpha_m} (A_j K_j^{\alpha_k} L_j^{\alpha_l}) (q_{jh} + q_{jf})^{-1}$$

$$R_{jT}^{-\alpha_m} = Z^{\alpha_m} M_{jt}^{-\alpha_m} \implies Z^{\alpha_m} = M_{jt}^{\alpha_m} R_{jT}^{-\alpha_m} \tag{B.10}$$

To derive the estimation equation, we can substitute equation (8) and B.10 into B.9 rearrange and obtain the estimating equation.

B.2 Comparison with De loecker (2011)

To derive De Loecker (2011) version of our estimating equation, we substitute equation (8) into B.9 and we obtain:

$$R_{jT} = Z^{V(\sigma-1)}(A_j K_j^{\alpha_k} L_j^{\alpha_l})^{\frac{V(\sigma-1)}{\alpha_m}} \zeta_{jh}^{\frac{V(\sigma-1)}{\alpha_m}} \chi_h^{\frac{V}{\alpha_m}} \left(1+\frac{R_{jf}}{R_{jh}}\right)^{\frac{V}{\alpha_m}}$$

Raise both sides of the equation to the power $\frac{\alpha_m}{V}$ We obtain:

$$R_{jT}^{\frac{\alpha_m}{V}} = Z^{\alpha_m(\sigma-1)}(A_j K_j^{\alpha_k} L_j^{\alpha_l})^{\sigma-1} \zeta_{jh}^{\sigma-1} \chi_h \left(1+\frac{R_{jf}}{R_{jh}}\right)$$

Substitute Z^{α_m} in equation (B.10) into the above equation, rearrange and we get:

$$R_{jT}^{\frac{\alpha_m}{V}} R_{jT}^{\alpha_m(\sigma-1)} = (A_j K_j^{\alpha_k} L_j^{\alpha_l} M_j^{\alpha_m})^{\sigma-1} \zeta_{jh}^{\sigma-1} P_{sh}^{\sigma} Q_{sh} \left(1+\frac{R_{jf}}{R_{jh}}\right)$$

$$\left(\frac{R_{jT}}{P_{sh}}\right)^{\sigma} = (A_j K_j^{\alpha_k} L_j^{\alpha_l} M_j^{\alpha_m})^{\sigma-1} \zeta_{jh}^{\sigma-1} Q_{sh} \left(1+\frac{R_{jf}}{R_{jh}}\right)$$

$$\frac{R_{jT}}{P_{sh}} = (A_j K_j^{\alpha_k} L_j^{\alpha_l} M_j^{\alpha_m})^{\frac{\sigma-1}{\sigma}} \zeta_{jh}^{\frac{\sigma-1}{\sigma}} Q_{sh}^{\frac{1}{\sigma}} \left(1+\frac{R_{jf}}{R_{jh}}\right)^{\frac{1}{\sigma}}$$

Taking logs we derive the equation:

$$\tilde{r}_{jt} = \underbrace{\beta_l l_{jt} + \beta_k k_{jt} + \beta_m m_{jt} + \beta_s q_{sht} + \varepsilon_{jt}^* + a_{jt}^*}_{\text{de Loecker (2011)}} + \frac{1}{\sigma} ln\left(1+\frac{R_{jf}}{R_{jh}}\right) + u_{it} \tag{B.11}$$

All the variables are as defined in section 2. If firms were non-exporters $R_{jf} = 0$ we are back to De Loecker (2011).

C Data, Production Function Estimates

C.1 Data Cleaning

We follow the cleaning procedures described in preceding literatures (Békés et al. (2011), Bisztray (2016) etc). Specifically, for firms that appear in more than one sector, we assign such firm in a sector in which it appears the most. We fill in missing values of sales, employment, capital, material inputs using the average of the 1 previous and 1 subsequent period's output values. When both or any do not exist, we use the average of 2 or 1 -previous and 2 or 1 forward period's value. We only consider manufacturing firms in our econometic exercise. We list in table 8, the manufacturing sectors.

Table 8: NACE 2.0 sectors and Description

Nace	description	Nace	description
15	Food and beverages	27	Basic metals
16	Tobacco products	28	Fabricated metal products
17	Textiles	29	Machinery and equipment n.e.cc
18	Wearing Apparels	30	Computer, electronic and optical products
19	Leather and related products	31	Electrical equipment
20	Wood except furniture	32	Consumer electronics & communication equip
21	Paper and paper products	33	Optical instruments and photographic equip.
22	Printing and production of recorded media	34	Motor vehicles, trailers and semi-trailers
23	Coke and refined petroleum products	35	Other transport equipment
24	Chemical products &pharmaceuticals	36	Furniture
25	Rubber and plastic products	37	Recycling
26	Other non-metallic mineral products		

C.2 Production Function Estimation

We estimate our quality-adjusted and revenue productivity using the proxy method proposed Levinsohn and Petrin (2000) with Ackerberg et al. (2015) corrections. (including export in the productivity estimates) and procedures. We use the stata prodest estimation function developed in Mollisi and Rovigatti (2017).

Table 9: Production Function Estimation (1st Stage of 2-Step Method)

Dep. Variable:	QA Productivity		Revenue Productivity	
Log Sales	(1)	(2)	(3)	(4)
Log Capital	0.043***	0.041***	0.041***	0.039***
	(0.012)	(0.013)	(0.009)	(0.010)
Log Labour	0.237***	0.235***	0.240***	0.238***
	(0.002)	(0.003)	(0.002)	(0.001)
Log Material	0.749	0.742***	0.769***	0.764***
	(0.000)	(0.001)	(0.001)	(0.002)
Log Domestic MS	0.038***	0.040***		
	(0.003)	(0.001)		
Importers dummy		0.125***		0.116***
		(0.003)		(0.002)
Observations	39128	39126	39128	39126
Sector FE	Yes	Yes	Yes	Yes

$*$, $**$ and $***$ indicates 10%, 5% and 1% significance. MS=market share

C.3 Some Additional Properties of Estimates

Table 10: Summary Statistics For Productivity Measures, Sales and Capital

	Correlations				
	Quality-Adjusted Productivity	Revenue Productivity	Sales Revenue	Capital	Domestic Market Shares
Quality-Adjusted Prod.	1.00				
Revenue Productivity	0.59**	1.00			
Sales Revenue	0.22**	0.41**	1.00		
Capital	0.01**	0.08**	0.74**	1.00	
Domestic Market Shares	-0.07**	0.39**	0.90**	0.64**	1.00
	Standard Deviations				
	0.58	0.98	1.97	2.31	1.93

Notes: This table shows the correlation and standard deviations of our firm-level variables using the truncated samples (1993 - 2003). All variables are in logs. We remove sector-year fixed effects from each variable prior to computing the statistics. $**$, $*$ and † are 1%, 5% and 10% significant levels respectively.

C.4 Additional Robustness Results

C.4.1 Clustering at the firm level

Table 11: Estimating the Effects of Trade Liberalization on Productivity(clustering at firm)

Dependent Variable:	Quality-Adjusted Productivity						
	Two-Steps Approach						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tariffs	-0.115***	-0.129***					
	(0.040)	(0.041)					
Lagged Tariffs			-0.108**	-0.050**	-0.053**	-0.059***	-0.026
			(0.042)	(0.023)	(0.023)	(0.022)	(0.039)
Lagged Productivity				0.646***	0.644***	0.644***	0.102***
				(0.011)	(0.011)	(0.011)	(0.020)
Foreign x Lag Tariffs						0.046	
						(0.040)	
Dependent Variable:	**Revenue Productivity**						
	Two-Steps Approach						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tariffs	-0.164***	-0.177***					
	(0.041)	(0.042)					
Lagged Tariffs			-0.160***	-0.065***	-0.068***	-0.076***	-0.029
			(0.043)	(0.024)	(0.024)	(0.023)	(0.040)
Lagged Productivity				0.638***	0.635***	0.635***	0.101***
				(0.011)	(0.012)	(0.012)	(0.021)
Foreign x Lag Tariffs						0.057	
						(0.042)	
Importers dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	No	No	No	No	No	No	Yes
Industry-Year FE	No	Yes	No	No	Yes	Yes	Yes
Year FE	Yes	No	Yes	Yes	No	No	No
Industry FE	Yes	No	Yes	Yes	No	No	No
Observations	27827	27827	19442	19442	19442	19433.000	19442
R-squared	0.132	0.163	0.093	0.532	0.546	0.546	0.275

Notes This table reports the results of the effect of tariffs cut on firm-level productivity. Foreign is a dummy that takes a value=1 if firm is foreign-owned and 0 if domestic or state-owned. I excluded firms in industry 34 and 35 (i.e. "Motor vehicles, trailers and semi-trailers" and Other transport equipments) and firms with export sales more than 70% of its total sales to ensure that our results are not driven by export platform firms. In column 1-7 robust standard errors are clustered at the **firm level** in parentheses. $*$, $**$ and $***$ indicates 10%, 5% and 1% significant levels.

C.4.2 Estimating with the Full Sample

Table 12: Estimating the Effects of Trade Liberalization on Productivity (Full Sample)

Dependent Variable:	Quality-Adjusted Productivity						
	Two-Steps Approach						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tariffs	-0.118***	-0.144***					
	(0.027)	(0.019)					
Lagged Tariffs			-0.099***	-0.045**	-0.050**	-0.063**	-0.023*
			(0.022)	(0.022)	(0.021)	(0.027)	(0.013)
Lagged Productivity				0.656***	0.655***	0.654***	0.146***
				(0.021)	(0.022)	(0.022)	(0.018)
Foreign x Lag Tariffs						0.082*	
						(0.042)	
Dependent Variable:	Revenue Productivity						
	Two-Steps Approach						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tariffs	-0.162***	-0.185***					
	(0.024)	(0.017)					
Lagged Tariffs			-0.143***	-0.060**	-0.065***	-0.076***	-0.026**
			(0.019)	(0.023)	(0.022)	(0.027)	(0.012)
Lagged Productivity				0.629***	0.628***	0.627***	0.139***
				(0.022)	(0.022)	(0.022)	(0.017)
Foreign x Lag Tariffs						0.066*	
						(0.034)	
Importers dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	No	No	No	No	No	No	Yes
Industry-Year FE	No	Yes	No	No	Yes	Yes	Yes
Year FE	Yes	No	Yes	Yes	No	No	No
Industry FE	Yes	No	Yes	Yes	No	No	No
Observations	39126	39126	28054	28054	28054	28044	28054

Notes: This table reports the results of the effect of tariffs on firm-level productivity using the full sample. Foreign is a dummy that takes a value 1 if firm is foreign-owned and 0 if domestic or state-owned. In column 1-7 robust standard errors are clustered at the industry level in parentheses. $*$, $**$ and $***$ indicates 10%, 5% and 1% significant levels.

C.4.3 Estimates Without Controlling For Importer's Dummy

Table 13: Estimating the Effects of Trade Liberalization on Productivity

Dependent Variable:	QA Productivity						
	Two-Steps Approach						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tariffs	-0.147***	-0.161***					
	(0.012)	(0.014)					
Lagged Tariffs			-0.135***	-0.059*	-0.061**	-0.069**	-0.015
			(0.021)	(0.031)	(0.028)	(0.030)	(0.010)
Lag Productivity				0.652***	0.650***	0.650***	0.109***
				(0.017)	(0.017)	(0.017)	(0.010)
Foreign x Lag Tariffs						0.059***	
						(0.014)	
Dependent Variable:	Revenue Productivity						
	Two-Steps Approach						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tariffs	-0.193***	-0.207***					
	(0.013)	(0.014)					
Lagged Tariffs			-0.185***	-0.073**	-0.075**	-0.085**	-0.015
			(0.022)	(0.032)	(0.029)	(0.031)	(0.010)
Lagged Productivity				0.644***	0.642***	0.641***	0.107***
				(0.018)	(0.018)	(0.018)	(0.011)
Foreign x Lag Tariffs						0.070***	
						(0.019)	
Importers dummy	No	No	No	No	No	No	No
Firm FE	No	No	No	No	No	No	Yes
Industry-Year FE	No	Yes	No	No	Yes	Yes	Yes
Year FE	Yes	No	Yes	Yes	No	No	No
Industry FE	Yes	No	Yes	Yes	No	No	No
Observations	27829	27829	19444	19444	19444	19435	19444

Notes This table reports the results of the effect of tariffs cut on firm-level productivity. Foreign is a dummy that takes a value=1 if firm is foreign-owned and 0 if domestic or state-owned. I excluded firms in industry 34 and 35 (i.e. "Motor vehicles, trailers and semi-trailers" and Other transport equipments) and firms with export sales more than 70% of its total sales to ensure that our results are not driven by export platform firms. In column 1-7 robust standard errors are clustered at the industry level in parentheses. $*$, $**$ and $***$ indicates 10%, 5% and 1% significant levels.