Wage inequality in a small open economy: reallocation and factor substitution

Xi Chen * Umut Kilinc†

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Abstract

While there is an extensive theoretical literature on firm export behavior, much less predictions exist for firm import behavior and the corresponding labor market implication. In this paper, I extend the previous studies by proposing a theoretical trade model that incorporates three key elements of an open economy: heterogeneous firms, trade in intermediate inputs and labor market frictions. The two distinctive features of this new model are found in the specification of production technology and in the form of rent sharing between firms and workers. First, we consider a production function that labor and imported intermediates are imperfect substitutes. Second, we introduce in the wage bargaining process an information asymmetry between employee and employer regarding the ability of their firm to penetrating the international market. These features allow us to generate new results on the effects of trade liberalization and to highlights the fundamental difference between export and import.

Keywords: Trade in intermediate inputs; Factor substitution; Labor market frictions; Wage inequality

*Xi Chen: STATEC, 13, rue Erasme, L-1468 Luxembourg, E-mail: xi.chen@statec.etat.lu.
†Umut Kilinc: STATEC, E-mail: umut.kilinc@statec.etat.lu

1 Introduction

The relationship between globalization and employment is of increasing importance to policy makers. Over the past decade international trade contributed significantly to economic growth at the global level. However, effects of globalization at the local level are highly contested. Much of the public concern about globalization in developed countries relates to labor issues. In response, governments are investing in social policies to minimize adverse effects of globalization. For instance, the European Commission set up in 2014 the *European Globalisation Adjustment Fund* with an annual budget of 150 million euros. The good performance of these measures requires a deep understanding of the trade-employment relationship. This paper will put unemployment and wage inequality in an open economy perspective, and investigate the labor market implications of globalization on both empirical and theoretical fronts.

The effects of globalization have been extensively studied in the economic literature. However, the labor market implications of globalization remain difficult to characterize and to measure. some recent contribution on the topic including Helpman et al (2010) and Amiti and Davis (2011), offer new insights by combining two strands of literature: the heterogeneous firm model of Melitz (2003) and the labor market frictions. Unlike previous studies based on the Heckscher-Ohlin framework, these models analyze the implication of trade on wage inequality and on unemployment by focusing on the reallocation effect across heterogeneous firms. Trade liberalization allows more productive firms to access new markets, to reduce costs and to raise profit, which results in an expansion of their output and employment. According to Helpman et al (2010), the opening of trade also strengthens the correlation between firm productivity and work ability, which in turn changes the dispersion of wages within an industry. Typically, the reallocation effect implies a higher wage in trading firms.

In this paper,we go a step further by focusing on a second dimension of trade activities, namely the imports of intermediate inputs (Amiti and Konings, 2007; Kasahara and Lapham, 2013). Often trade agreements are bilateral and aim to reduce symmetrically the trade barriers for both exporting final goods and importing intermediate inputs. In order to study the latter, Amiti and Davis (2011) and Kasahara and Lapham (2013) introduce a framework that models explicitly firms' decision to import. A typical result of this model is that the imported intermediate goods allow firms to reduce the marginal cost of the final goods production, thus raise firms' productivity and revenues. In this type of models, the usual reallocation mechanism remains and the effect of imports on the labor market is very similar to the effect of exports.

Various empirical studies, however, highlight the asymmetry between the export and

the import regarding the labor market implications. Compared to the export of final goods, the import of intermediate inputs may affect the local labor market by an additional channel. Firms' decision to import intermediate inputs dependents on and affects their production technology. In particular, a crucial parameter is the elasticity of substitution between intermediate input and labor, which constraints the cost structure and regulates the effects of importing inputs from a foreign source. For example, if intermediate inputs and labor are complementary in the production, an increase of intermediate input demand may not raise proportionally firms' productivity. Thus, the trade liberalization of imported intermediate inputs may not necessarily increase the wage in trading firms. Therefore, this could create a distortion on the classical reallocation mechanism and lead to different labor market outcomes. Although the impact of import activities raises concerns among policy makers and attracts attention of numerous applied economists, theoretical analysis of import effects is rare in the heterogeneous firm literature.

In this paper, we propose a theoretical trade model with imported intermediate inputs and factor substitution. The novel contribution of this paper is the extension of heterogeneous firm model by allowing imperfect substitutability between inputs. In doing so, our model can be used to analyze the asymmetric effects of imports and exports on the labor market. The remaining of the paper is organized as the follows. we first provide in Section 2 a brief literature review of the main building blocks of our model. Then, in Section 3, we describe a firm-level trade dataset and present empirical evidence to motivate our theoretical framework. We introduce the theoretical model and solve for the equilibrium in Section 4. Section 5 concludes.

2 Literature review

Research in the field of international trade has moved from a country and sector perspective to the firm-level. New findings on firms trade behavior show that more productive, larger and more capital intensive firms have a higher probability to become an exporter, see for example Bernard and Jensen (1999). Following the empirical evidence, the seminal paper of Melitz (2003) provides a highly tractable theoretical framework for modelling firms export decisions, in which heterogeneous firms face sunk costs of entry and uncertainty concerning their productivity. The Melitz model is the main workhorse for dealing with various issues in international economics. The basic model has been extended in several aspects. For instance, Helpman et al. (2004) introduce an additional dimension of firms internationalization, namely Foreign Direct Investment (FDI). Chen and Olland (2014) propose a model with an additional heterogeneity in the cost structure.

There are, however, two important questions that the Melitz-type model does not

provide answers for. First, Melitz (2003) assumes perfect competition in the labor market. All firms in his model face the same labor cost and neither trade decisions nor productivity affects workers real wage. The second missing component of the basic Melitz model is pointed out by Bernard et al. (2007): "The empirical literature on firms in international trade has been concerned almost exclusively with exporting, largely due to limitations in datasets based on censuses of domestic production or manufacturing. As a result, the new theories of heterogeneous firms and trade were developed to explain facts about firm export behavior and yield few predictions (if any) for firm import behavior."

The first limitation of Melitz (2003)'s model has been addressed in Helpman and Itskhoki (2010) and Helpman et al (2010). For instance, Helpman et al (2010)'s model introduces a search and matching friction, where heterogeneous firms face an uncertainty on *ex post* match-specific workers' ability shocks. Using the search theory, this model is able to generate a wage variation for *ex ante* homogeneous workers and can be used to analyze the impact of trade on the wage distribution. In this framework, wages are the outcome of a bargaining process and the opening of a closed economy raises the profit of exporting firms. In consequence, trade liberalization increases the negotiated wage in exporting firms. The opposite outcome of trade liberalization is experienced by domestic firms. An important implication of this finding is that international trade may affect sectorial wage inequality, which is absent from neoclassical trade models. [1]

The second limitation of Melitz (2003)'s model (including Helpman et al, 2010) is that only export activities are considered, while import activities are more likely to have a significant impact on labor market outcomes. A trade model that incorporates firms' import behavior and imperfect labor market is proposed by Amiti and Davis (2011). In this model, they consider a different form of labor friction, where firms make decisions under a fair wage constraint. Following Akerlof (1982), the wage formation in Amiti and Davis (2011) is represented by a function of firm's profit. The main prediction of this model is similar to these in Helpman et al (2010). Although Amiti and Davis (2011) consider firms' import behaviour, but both trade activities in their model affect symmetrically the wage through the realized profits. This is because the production function in Amiti and Davis (2011)'s model has a Cobb-Douglas form, where the intermediate input and labor are perfect substitutes. The additional imported intermediate input decreases linearly the marginal cost and increases linearly productivity. Thus, the transmission of import liberalization to the wage is independent of firms' production technology.

The current research in the area, including Egger and Kreickemeier (2009), Helpman

[1] Another important finding of Helpman et al (2010) is that the relationship between the wage inequality and the trade openness has an inverse U-sharp. The trade openness may first increase the sectorial wage inequality and decrease it later.

and Itskhoki (2010), Helpman et al (2010), Amiti and Davis (2011), and Helpman et al. (2013), either consider only the export activities or treat the export and the import symmetrically. These models highlight the reallocation effects of trade liberalization, where trading firms differ from domestic firms in terms of productivity, profit and size. Trade liberalization of autarky economy triggers this segmentation, which leads to a differentiation of wage setting practice across different firms. Thus, these models predict that the opening of trade either by reducing the export or import barriers will increase the wage inequality. However, some empirical studies suggest that the effects of import may substantially differ from export (see Biscourp and Kramarz, 2007). Therefore, the objective of this paper is to propose a heterogeneous firm model with labor market frictions that is able to distinguish the effects of import from export.

3 Data and descriptive statistics

In this section, we provide descriptive statistics calculated using a firm-level trade dataset to illustrate the effects of importing intermediate inputs and exporting final goods on the wage and employment. [2] The empirical investigation is focus on Luxembourg. There are two reasons why understanding the relationship between globalization and employment is important in the case of Luxembourg. First, as a small open economy, firms operating in Luxembourg rely heavily on trade activities: Luxembourg is the OECD member country with highest trade-to-GDP ratio. In particular, Luxembourg has the highest imports penetration of goods and services among OECD countries (see the OECD report, 2010). Second, the labor market condition in Luxembourg is deteriorated after the recent crisis: the national unemployment rate reached its historic high of 7.1 in 2013. The changes in labor market affect directly the social cohesion in the country. One concern is the increasing income inequality, which has been highlighted in the OECD report (2012) as well as in Gornick and Jäntti (2013).

Both the calibration of theoretical model and the econometric analysis require a matched dataset that includes trade transaction records, firm-level production and worker information. The main firm-level data for Luxembourg is recorded in the Structural Business Survey (SBS). The data set provides firms' annual production information on revenues, employment, payroll, investments and intermediate materials, among others. The trade data in Luxembourg are directly collected by the STATEC (the national statistical office of Luxembourg) in the program of International Trade in Goods Statistics (ITGS). The information on imports/exports quantities as well as on origins/destinations

[2] This section is incomplete. We only provide a first glance at the data, the structural econometric analysis will be added in a future version.

is recorded at the firm-level for each product category. The sample that is used for producing the following tables and figures only contains firms engaging in trade activities. It is a match of SBS and ITGS as well as some macro indicators such as GDP, population, tariffs. The product level data is aggregated over firms.

Table 1 and 2 summarize the main variables of interest in our data set and their correlations. Note that the partial correlations are computed by controlling for 2-digit industry and time fixed-effects.

Table 1: Firm-Level Production and Trade Statistics for 2000-2011

#Firms	150	#Observations	1522
Variables	Description	Mean	Std
Real Wage Per Employee	in logs	0.31	0.28
Export Intensity	ratio	0.54	0.37
Import Intensity	ratio	0.39	0.21
Total Wages Paid	in logs	4.70	1.39
#Employees	in logs	4.39	1.34
Real Sales/#Employees	ratio	2.01	0.76
Imported Goods' Prices	in logs	-3.54	2.13
Int.Inputs/Revenues	ratio in logs	-0.43	0.34
Real GDP Per Capita	thousand Eur	30.67	4.55
R. GDP Per Cap.*Export Int.		16.40	11.41
Distance	log KMs	6.21	0.61
Exchange Rate	ratio	0.32	0.62
Real GDP	billion EUR	1758.68	966.55
Population	million in log	3.65	0.64
Tarrifs	1 to 10	1.66	0.56
EU Membership	dummy	0.87	0.22

Table 2: Partial correlation matrix among firm characteristics

	Export Intensity	Import Intensity	Total Wages Paid	#Employees	Real Sales/ #Employees	Imported Goods' Prices	Int.Inputs/ Revenues
Real Wage Per Employee	-0.120	-0.079	0.199	-0.004	0.376	0.057	-0.062
Export Intensity		0.417	0.019	0.044	0.178	-0.060	0.225
Import Intensity			-0.167	-0.154	0.213	-0.115	0.302
Total Wages Paid				0.979	0.043	0.167	-0.026
#Employees					-0.034	0.158	-0.013
Real Sales/#Employees						-0.033	0.517
Imported Goods' Prices							-0.125

In the below scatter plots, each point represents a firm in a given year. The linear lines are weighted by firm size. Figure 1 and 2 show that the export intensity and the import intensity affect the average wage in very different ways.

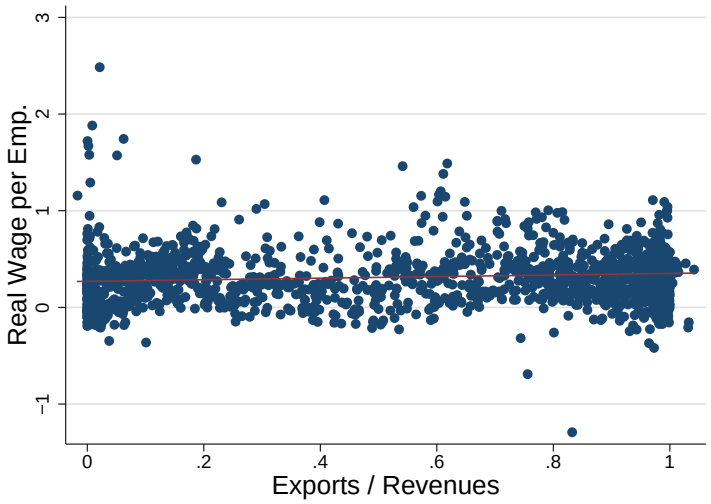

Figure 1: Real Wage Per Employee vs. Export Intensity

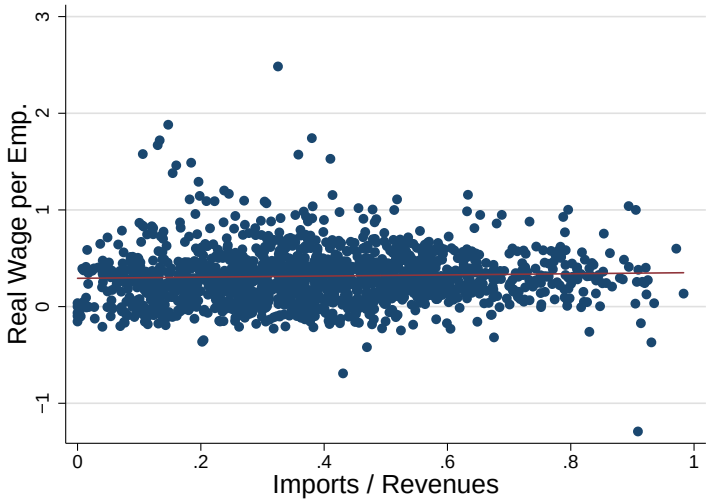

Figure 2: Real Wage Per Employee vs. Import Intensity

Figure 3 shows that more intensely exporting firms seem to be larger in terms of number of employees. Assuming exporters are more productive, this provides some evidence that trade generates allocative efficiency gains, which is a classical prediction of the trade model.

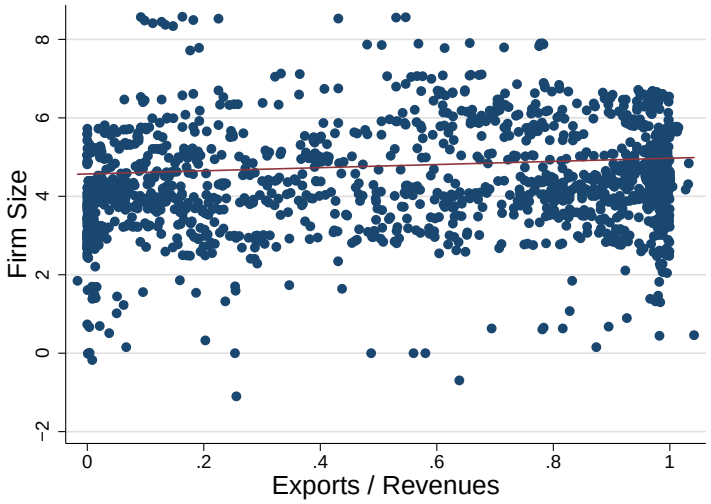

Figure 3: Number of Employees vs. Export Intensity

It is also interesting that firms exporting to distant destinations seem to pay higher wages to their employees (see Figure 4). This can be explained by fact that one needs more technical staff to be able to export from Luxembourg to, for instance, China. This requires someone who can speak Chinese, knowing the local legal legislation, specialized to manage transportation to distant location, and do marketing in China. All these tasks require more number of specialists whose wages are usually higher than usual employees. This implies that the trade is costly and can play a significant role in determining the wage in the trading firms.

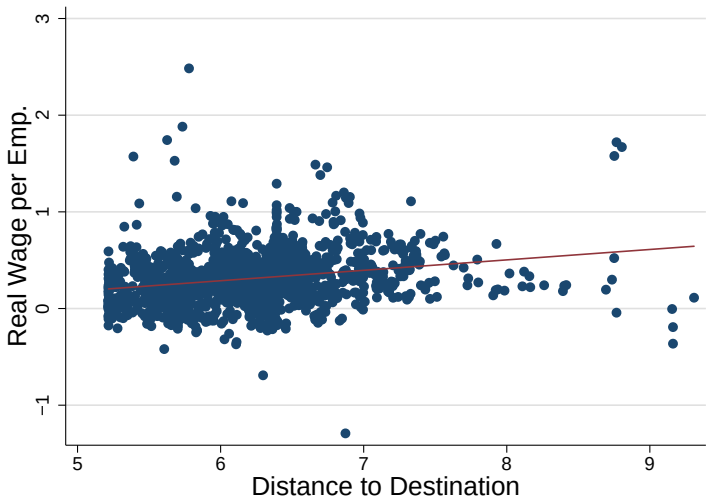

Figure 4: Real Wage Per Employee vs. Distance to Destination

Figure 5 suggests that more intensely exporting firms are also the ones that import

more. This shows that firms' abilities to export and to import are correlated. For instance, the export and import costs can be shared, such as the trade-specialized labor can work for export activities as well as for import activities.

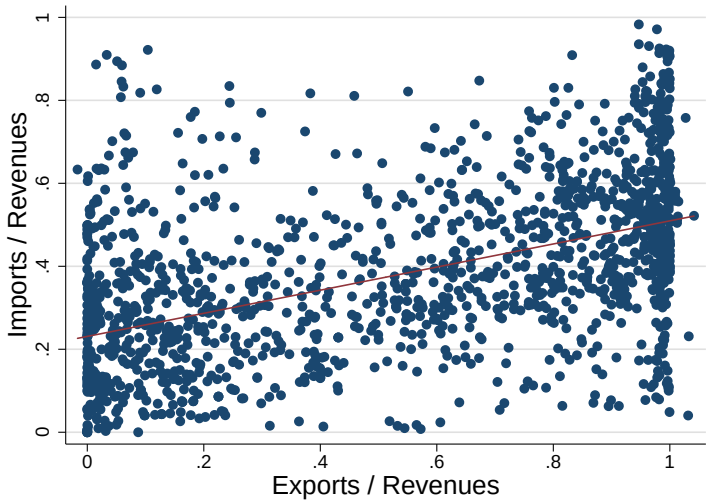

Figure 5: Number of Employees vs. Export Intensity

4 Theoretical model

Our theoretical model is based on the framework proposed by Amiti and Davis (2011), which incorporates three key elements. First, it consider a continuum of heterogeneous firms (Melitz, 2003). Second the trade activities include both exporting final goods and importing intermediate inputs (Kasahara and Lapham, 2013). Third, the model also allows for labor market frictions (Egger and Keickemeier, 2009; Helpman et al, 2010).

Our model, however, differs from the one in Amiti and Davis (2011) in two aspects. The first difference is found in the specification of final good production technology, where the two inputs, labor and imported intermediates are imperfect substitutes. Formally, the production function in our model is characterized by a CES functional form, and we show that the elasticity of substitution between labor and imported intermediates plays a crucial role in determining the effect of trade liberalization. This new feature also allows us to make a clear distinction between the effects of export and import. The second difference is found in the form of rent sharing between firms and workers. The novelty of our specification is that we introduce in the wage bargaining process an information asymmetry between worker and employer concerning firms' ability to import and to export. More specifically, the fair wage constraint in our model depends only on the *ex ante* total factor productivity (TFP). We call this case the limited information

wage bargaining, and we compare it to Amiti and Davis (2011)'s full information wage bargaining.

4.1 Demand of final goods

The demand side follows the classical framework of monopolistic competition (Dixit and Stiglitz, 1977). The consumer's preferences over a continuum of final good variaeties is characterized by a CES function:

$$U = \left(\int_{\omega \in \Omega} q(\omega)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}},$$

where ω is an index over the set of available variaties Ω; $\sigma > 1$ is the the elasticity of substitution between varieties. The Marshallian demand of a variety ω is given by:

$$q(\omega) = RP^{1-\sigma} p(\omega)^{-\sigma}, \tag{1}$$

and the corresponding revenue function is:

$$r(\omega) = RP^{1-\sigma} p(\omega)^{1-\sigma}, \tag{2}$$

where R is the aggregate revenues or the total disposal income within a country. P is the aggregate price index given by $P = \left(\int_{\omega \in \Omega} p(\omega)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$. The aggregate demand is $Q = U = RP$.

4.2 Production of final goods with imported intermediates

The world is comprised of $n + 1$ symmetric countries. Within each country there two sectors of production, the intermediates sector and the final goods sector. Our focus is on the latter sector. Thus, we make a series of simplifying assumptions on the intermediate production (similar to Amiti and Davis, 2011). The intermediate goods are produced within each country with a unique input, labor, under the constant returns to scale and the free entry condition. The labor employed in this sector is considered as the numéraire, thus one unit of labor produces one unit of intermediate good and the wage as well as the local price of intermediates equal unity. The demand and offer of intermediates are frictionless.

There are M final good producers in a country. Before the production, each producer i pays a sunk cost of entry, f_e and draws its type η_i. The type is a firm-specific triplet that contains information on TFP, iceberg-type costs of export and import, which are

denoted by ϕ_i, τ_{xi} and τ_{mi}, respectively. The type is distributed with a joint probability density function $g(\eta)$. After observing its type, firm could choose to exit immediately because the market is not profitable, and there is also a constant rate δ that firm is forced to exit due to some natural disasters. If firm decides to produce a final good, two types of inputs are required. The production function is:

$$q_i = \phi_i \left[\alpha l_i^{\theta} + (1-\alpha) x_i^{\theta}\right]^{\frac{1}{\theta}}, \tag{3}$$

where the elasticity of substitution between labor (l) and intermediate input (x) is given by $s = \frac{1}{1-\theta}$; α is the labor share. A firm can choose to employ only domestic intermediates that are denoted by $x_i = x_{0i}$ with the numéraire price of unity. The intermediates can be also sourced from n foreign countries with a firm-specific transport cost of τ_{mi} and a fixed import cost of f_m. In this case,

$$x_i = \left[x_{0i}^{\frac{\gamma-1}{\gamma}} + n(\tau_{mi}^{-\gamma} x_{0i})^{\frac{\gamma-1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}} = B_{mi} x_{0i},$$

where $B_{mi} \equiv (1+n\tau_{mi}^{1-\gamma})^{\frac{\gamma}{\gamma-1}}$, which can be viewed as an import induced factor-augmenting shock. $\gamma > 1$ is the elasticity of substitution between the domestic and imported intermediate inputs.

Defining an importer indicator d_{mi} that equals zero when the firm uses only domestic intermediates and equals one when imported intermediates are used. The production function (3) can be rewritten as:

$$q_i = \phi_i \left[\alpha l_i^{\theta} + (1-\alpha)(B_{mi}^{d_{mi}} x_{0i})^{\theta}\right]^{\frac{1}{\theta}}. \tag{4}$$

The dual representation of this production technology is:

$$C_i = \frac{q_i}{\phi_i} \left[\alpha^{-1} w_i^{\rho} + (1-\alpha)^{-1} p_{mi}^{\rho}\right]^{\frac{1}{\rho}}, \tag{5}$$

where C_i is the cost of producing q_i units of final goods; w_i is the wage of labor and p_{mi} is the implicit price index of intermediate input with $p_{mi} \equiv \frac{1}{B_{mi}^{d_{mi}}}$. In the dual form, the elasticity of substitution between l and x is given by $s = 1 - \rho$. The marginal cost is denoted by $c \equiv \frac{\partial C}{\partial q}$. We now can compare the marginal cost of a domestic firm ($c_{di} \equiv c_{i|d_{mi}=0}$) with an importer of same type ($c_{mi} \equiv c_{i|d_{mi}=1}$):

$$c_{mi} = \left[\frac{\alpha^{-1} w_i^{\rho} + (1-\alpha)^{-1}(1+n\tau_{mi}^{1-\gamma})^{\frac{\rho\gamma}{\gamma-1}}}{\alpha^{-1} w_i^{\rho} + (1-\alpha)^{-1}}\right]^{\frac{1}{\rho}} c_{di}.$$

At this stage, the main difference between our model and the one in Amiti and Davis (2011) is that the production technology restricts the degree of cost reduction due to the imported intermediates. In Amiti and Davis (2011)'s model, the production function has a Cobb-Douglas form, then cost reduction factor depends only on γ but not on technology parameters neither on wage: $c_{mi} = (1 + n\tau_{mi}^{1-\gamma})^{\frac{\gamma}{\gamma-1}} c_{di}$. This difference can be illustrated by Figure 6. When the elasticity of substitution $s > 1$ that labor and intermediates are substitutes, then the cost reduction effect of import is magnified. In contrast, when inputs are complements ($s < 1$), the cost reduction effect is limited.

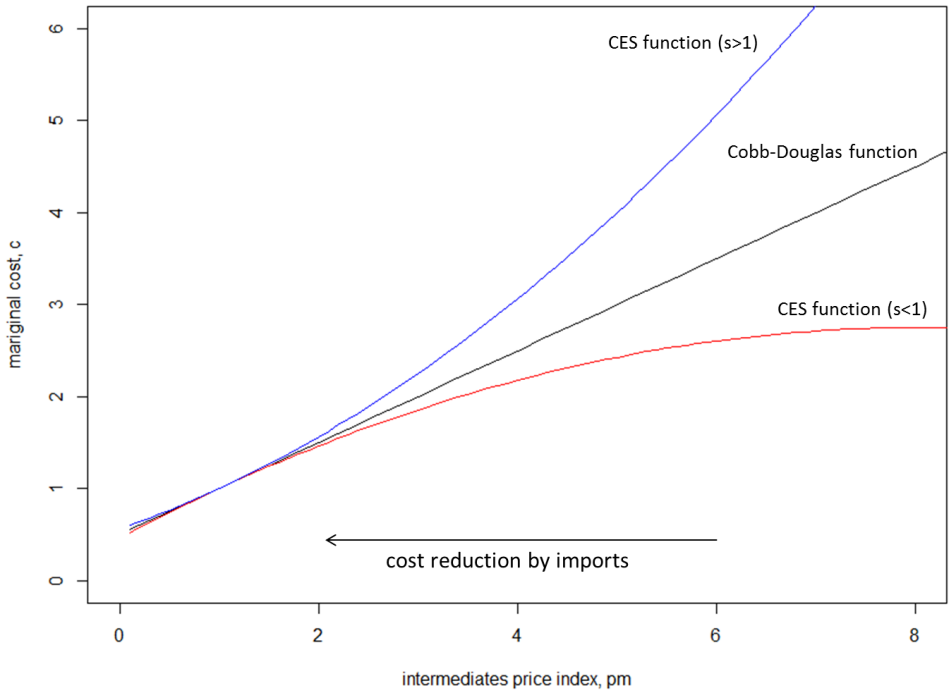

Figure 6: Cobb-Douglas vs. CES function

4.3 Equilibrium in the open economy

In this section, we provide the equilibrium condition under the assumption of homogeneous wage. This assumption is relaxed in the next section. Within a country each firm's pricing rule is given by $p_i = \frac{\sigma}{\sigma-1} c_i$, this rule is mainly dependent on firms' marginal cost. When a firm who serves only its home market and uses only the domestic intermediates, the revenues earned are:

$$r_{di} = RP^{\sigma-1} \left(\frac{\sigma}{\sigma - 1} \right)^{1-\sigma} c_{di}^{1-\sigma}. \tag{6}$$

For a firm that imports intermediates, the revenues are:

$$\begin{aligned} r_{mi} &= RP^{\sigma-1}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} c_{mi}^{1-\sigma} \\ &= \Gamma_{mi} r_{di}, \end{aligned} \tag{7}$$

with $\Gamma_{mi} \equiv \left[\frac{\alpha^{-1}w^{\rho}+(1-\alpha)^{-1}(1+n\tau_{mi}^{1-\gamma})^{\frac{\rho\gamma}{\gamma-1}}}{\alpha^{-1}w^{\rho}+(1-\alpha)^{-1}}\right]^{\frac{1-\sigma}{\rho}} > 1$ captures import gains. For a firm that exports final goods, but use only domestic intermediates, the revenues are:

$$\begin{aligned} r_{xi} &= r_{di} + n\tau_{xi}^{1-\sigma} r_{di} \\ &= \Gamma_{xi} r_{di}, \end{aligned} \tag{8}$$

with $\Gamma_{xi} \equiv 1 + n\tau_{xi}^{1-\sigma} > 1$ captures export gains. Finally, when a firm is fully engaged in both trade activities, its revenues are:

$$r_{mxi} = \Gamma_{mi}\Gamma_{xi} r_{di}. \tag{9}$$

Comparing 7 and 8, we can see that both trade activities: importing intermediates and exporting final good, raise firms' revenues, but the mechanism is very different. The imports of a firm raise its revenues by reducing the marginal cost. The exports raise revenues by expanding firm's market share. The export factor (Γ_{xi}) depends only on the transport cost and the demand parameter, while the import factor (Γ_{mi}) also depends on the production technology, in particular the factor substitution. Thus, a trade liberalization, for example a reduction of import and export transport cost (τ_{mi} and τ_{xi}) or an increase of trade partners (n) will yield very different market outcomes via the two transmission channels.

Given the pricing rule, the profit can be expressed as: $\pi_i = \frac{r_i}{\sigma} - F_i$, where F_i is the fixed production cost. We summarize the profit of a firm, accordingly to its import and export status, as follows:

$$\pi_i = \begin{cases} 0 & \text{exit} \\ \frac{r_{di}}{\sigma} - f & \text{domestic only} \\ \Gamma_{mi}\frac{r_{di}}{\sigma} - (f + nf_m) & \text{import intermediates} \\ \Gamma_{xi}\frac{r_{di}}{\sigma} - (f + nf_x) & \text{export final goods} \\ \Gamma_{mi}\Gamma_{xi}\frac{r_{di}}{\sigma} - (f + nf_m + nf_x) & \text{import and export} \end{cases} \tag{10}$$

The fixed costs are denoted by f, f_m and f_x for domestic production, importing

intermediates and exporting final goods, respectively. For solving this model, we follow Melitz (2003) by defining a zero cutoff profit (ZCP) condition for the domestic market: $\pi_i(\phi^*) = \frac{r_{di}(\phi^*)}{\sigma} - f = 0$, which implies that $r_{di}(\phi^*) = \sigma f$. ϕ^* is the TFP level at which a domestic firm earns zero profit. Thus, any firm with a TFP level of ϕ_i earns $r_{di}(\phi_i) = \left(\frac{\phi_i}{\phi^*}\right)^{(\sigma-1)} \sigma f$. This implies that we can rewrite the potential profits of the ϕ_i-producer as:

$$\pi_i(\eta_i, \phi^*) = \begin{cases} 0 & \text{exit} \\ \left(\frac{\phi_i}{\phi^*}\right)^{(\sigma-1)} f - f & \text{domestic only} \\ \Gamma_{mi}\left(\frac{\phi_i}{\phi^*}\right)^{(\sigma-1)} f - (f + nf_m) & \text{import intermediates} \\ \Gamma_{xi}\left(\frac{\phi_i}{\phi^*}\right)^{(\sigma-1)} f - (f + nf_x) & \text{export final goods} \\ \Gamma_{mi}\Gamma_{xi}\left(\frac{\phi_i}{\phi^*}\right)^{(\sigma-1)} f - (f + nf_m + nf_x) & \text{import and export} \end{cases} \tag{11}$$

The global ZCP condition is a relationship between the average profit $\overline{\pi}$ and the cutoff productivity level ϕ^*:

$$\overline{\pi}(\phi^*) = \frac{1}{1 - G_\phi(\phi^*)} \int_{\phi^*}^{\infty} \int_{\tau_m} \int_{\tau_x} \pi(\eta, \phi^*) g(\eta) d\tau_m d\tau_x d\phi. \tag{12}$$

$G_\phi(\phi) = \int_0^\phi g_\phi(u)du$ with $g_\phi(\phi) = \int_{\tau_m}\int_{\tau_x} g(\eta)d\tau_m d\tau_x$, which is the marginal probability density. As in Melitz (2003), this ZCP condition and the classical free entry condition:

$$\overline{\pi}(\phi^*) = \frac{\delta f_e}{[1 - G_\phi(\phi^*)]}, \tag{13}$$

identify a unique combination of $\overline{\pi}$ and ϕ^* (the proof is similar to Amiti and Davis, 2011).

Given the equilibrium value of ϕ^*, we can characterize firm's import and export decisions by defining three cutoff productivity level, ϕ_m^*, ϕ_x^* and ϕ_{mx}^*. A firm who has ϕ_m^* is indifferent to import intermediate inputs from an outside source or only use the domestic input: $\Gamma_{mi}\left(\frac{\phi_i}{\phi^*}\right)^{(\sigma-1)} f = (f + nf_m)$, which yields:

$$\phi_m^* = \left(\frac{f + nf_m}{f}\right)^{\frac{1}{\sigma-1}} \overline{\Gamma}_m^{\frac{1}{1-\sigma}} \phi^*. \tag{14}$$

Note that $\left(\frac{f+nf_m}{f}\right)^{\frac{1}{\sigma-1}} > 1$ captures the extra fixed cost paid by an importing firm and

$\overline{\Gamma}_m^{\frac{1}{1-\sigma}} = \int_{\tau_m} \left[\frac{\alpha^{-1} w^{\rho} + (1-\alpha)^{-1} (1 + n\tau_{mi}^{1-\gamma})^{\frac{\rho\gamma}{\gamma-1}}}{\alpha^{-1} w^{\rho} + (1-\alpha)^{-1}} \right]^{\frac{1}{\rho}} g_{\tau_m}(\tau_m) d\tau_m < 1$ captures the average marginal cost reduction due to the import. Thus, a firm's decision to import depends on the trade-off between the two opposite effects. In a similar way, we can obtain the following relationships:

$$\phi_x^* = \left(\frac{f + nf_x}{f} \right)^{\frac{1}{\sigma-1}} \overline{\Gamma}_x^{\frac{1}{1-\sigma}} \phi^*, \tag{15}$$

and

$$\phi_{mx}^* = \left(\frac{f + nf_m + nf_x}{f} \right)^{\frac{1}{\sigma-1}} \overline{\Gamma}_m^{\frac{1}{1-\sigma}} \overline{\Gamma}_x^{\frac{1}{1-\sigma}} \phi^*. \tag{16}$$

We now examine the impact of the trade liberalization. In our model, a decrease in the average variable export cost $\overline{\tau}_x = \int_{\tau_x} \tau_{xi}\ g_{\tau_x}(\tau_x) d\tau_x$ or in the fixed costs (f_x, fm) will yield similar results as in Melitz (2003) and Amiti and Davis (2011). However, our model will yield a different outcome in the case of a decrease in the average variable import costs $\overline{\tau}_m = \int_{\tau_m} \tau_{mi}\ g_{\tau_m}(\tau_m) d\tau_m$ or an increase in the number of trading partners. This is because when the elasticity of substitution differs from unity, the effects of decreasing $\overline{\tau}_m$ and increasing n are magnified with $s > 1$ and weakened with $s < 1$.

4.4 Equilibrium under the wage bargaining

In this section, we relax the assumption of homogeneous workers. Following Akerlof (1982); Egger and Kreickemeier (2009), we assume that workers demand for fairness in the wage bargaining process, and the fair wage is a function of firms' *ex ante* productivity level, i.e., $w_i = w(\phi_i)$ with a normalization point $w(\phi^*) = 1$ and $\frac{\partial w}{\partial \phi} > 0$. This specification differs from the fair wage equation in Amiti and Davis (2011), in which the wage is determined as a function of profits. In Amiti and Davis (2011)'s model, the wage is negotiated under the condition that workers have the complete information on the firm's type, η_i, including productivity (ϕ_i) and costs of penetrating international market (τ_{mi}, τ_{xi}). In our model, we study the case where the firm-specific costs of penetrating international market are not public information. The fair wage depends only on productivity, thus this asymmetric information model assigns an extra bargaining power to firm in the wage negotiation.

In the following paragraphs, we first provides the new equilibrium conditions under the fair wage constraint. Then, we analyze numerically how the rent-sharing mechanism influences the equilibrium in the open economy and the effects of trade liberalization on the local labor market. Finally, we also compare the market outcomes under the full and limited information wage bargaining. [3]

[3]This section is incomplete. The numerical results are not included in this version.

We consider a fair wage: $w_i = w(\phi_i)$ and replace the homogeneous wage in the previous section by this function. Thus, two domestic firms will not only differ each other in their type, but also implicitly in their wage. In particular, the difference in terms of domestic revenues between a ϕ_i-firm and a ϕ^*-firm is:

$$\begin{aligned} r_{di}(\phi_i) &= \left[\frac{\alpha^{-1}w(\phi_i)^{\rho} + (1-\alpha)^{-1}}{\alpha^{-1} + (1-\alpha)^{-1}}\right]^{\frac{1-\sigma}{\rho}} \left[\frac{\phi_i}{\phi^*}\right]^{\sigma-1} r_{di}(\phi^*) \\ &= \Gamma_i \left[\frac{\phi_i}{\phi^*}\right]^{\sigma-1} r_{di}(\phi^*), \end{aligned}$$

where $\Gamma_i \equiv \left[(1-\alpha)w(\phi_i)^{\rho} + \alpha\right]^{\frac{1-\sigma}{\rho}} < 1$ can be viewed as a revenues shortfall under the fair wage constraint. Therefore, the new profit function is:

$$\pi_i(\eta_i, \phi^*) = \begin{cases} 0 & \text{exit} \\ \left(\Gamma_i \frac{\phi_i}{\phi^*}\right)^{(\sigma-1)} f - f & \text{domestic only} \\ \Gamma_i \Gamma_{mi} \left(\frac{\phi_i}{\phi^*}\right)^{(\sigma-1)} f - (f + nf_m) & \text{import intermediates} \\ \Gamma_i \Gamma_{xi} \left(\frac{\phi_i}{\phi^*}\right)^{(\sigma-1)} f - (f + nf_x) & \text{export final goods} \\ \Gamma_i \Gamma_{mi} \Gamma_{xi} \left(\frac{\phi_i}{\phi^*}\right)^{(\sigma-1)} f - (f + nf_m + nf_x) & \text{import and export} \end{cases} \tag{17}$$

Similar to the previous section, using the free entry condition (13), the model can be solved for $\overline{\pi}$ and ϕ^*. Note that the new equilibrium values of ϕ_m^*, ϕ_x^* and ϕ_{mx}^* can only be solved implicitly under the fair wage constrain.

5 Conclusion

This paper has outlined a new framework for characterizing firm trade behavior and the corresponding labor market implication. This model incorporates three key elements of an open economy: heterogeneous firms, trade in intermediate inputs and labor market frictions. Our model is an extension of Amiti and Davis (2011)'s model in two aspects. First, we use a CES function to specify the production technology in the final goods sector, which allows the imperfect substitution between labor and imported intermediate input. In this specification, the elasticity of substitution between the two inputs plays a crucial role for regulating the effects of trade liberalization and differentiates the effect of import from the effect of export. Second, we consider an alternative fair wage constraint, where the negotiated wage is a function of firm's *ex ante* productivity level and it does

not depend on firm's trade costs (limited information wage bargaining). This differ from Amiti and Davis (2011)'s model, in which the wage is a function of firm's realized profits (full information wage bargaining). The two cases yields significant different outcomes.

In ongoing work we are working on the numerical simulations. As we notice from last section that due to the highly nonlinear functions, it is impossible to obtain an explicit solution for the general model. Thus, we take special functional forms and experiment with some key parameters of the model, such as the elasticity of substitution between labor and intermediate input, the joint distribution of firm type, and the form of wage bargaining process. We are also developing the structure econometric model that can establish an empirical link between trade activities and wages, and show the different effects of import and export.

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