12 A Heckscher-Ohlin-Melitz Model of Offshoring and Exporting

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1 Introduction

Since the seminal work of Melitz (2003), the international trade literature has placed much emphasis on the theme of firm heterogeneity. This has helped us gain insights on many trade issues by understanding differences in firm behavior in relation, among others, to exporting (Melitz, 2003) and importing or offshoring (Carluccio et al., 2015). The key mechanism to explain these differences in firm behavior is based on the interaction between the presence of fixed costs and differences in firm size, ultimately determined by exogenously given productivity differences: exporters, for example, are those firms that are productive enough to generate a large export volume that helps them finance the fixed costs involved in reaching export markets.

Since the crucial mechanisms highlighted in this literature are based on firm size, it is perhaps somewhat surprising that not much effort has been placed on understanding how firm behavior along one dimension affects firm behavior on some other dimension, e.g., importing.[1] For example, a reduction in export barriers will lead some firms to gain size and thus make it profitable for them to import some inputs in the presence of the fixed costs involved in this activity. Similarly, a reduction in import barriers for intermediates will make some firms import more inputs; this will reduce their costs and make them gain market share at home and abroad. Simultaneous exporting and importing is actually empirically pervasive: Bernard et al. (2009) report that out of the 39.4 percent of US manufacturing firms that engaged in exporting in the year 2000, 77.7 percent also imported, while only 22.3 percent were pure exporters.

This paper takes on this issue by examining how both the export and import behavior of firms respond to changes in the trade environment. We look into the extent to which export (import) barriers not only affect exporting (importing) decisions, but also how they affect importing (exporting) decisions. For this purpose, we produce a model in which monopolistic

[1] Kasahara and Lapham (2013) is one of the few papers that takes complementarities between these two activities seriously, by estimating a structural model of exporting and importing with data on Chilean plant.

firms with different productivities produce differentiated goods. Supplying goods to any market is subject to fixed and variable costs, which gives rise to a decision to export. Each firm makes its variety with a continuum of intermediate inputs, which are made in turn with skilled and unskilled labor. Inputs differ in their skill intensities, whereas countries differ in their relative factor endowments. This creates comparative advantage and an incentive for firms to import the comparative-disadvantaged inputs they use. However, importing inputs is also subject to fixed and variable costs, which gives rise to a decision to import.

Carluccio et al. (2015) show that in a variant of this model without exporting costs, reductions in offshoring costs imply skill upgrading within firms. As costs for offshoring intermediate inputs fall from prohibitive levels, firms located in a skill-abundant country start importing the most labor-intensive intermediates and specialize in producing the more skill-intensive ones domestically. This leads to an increase in the relative demand for skilled workers within firms. Adding variable and fixed costs of exporting gives rise to to the aforementioned complementarities between exporting and importing decisions. Moreover, these complementarities imply that reductions in exporting costs will have indirect effects on firm's demand for skilled workers, by changing their demand for imports.

We calibrate our model to capture some features of French trade in the manufacturing sector, and run a number of comparative statics exercises consisting in changing the parameters that capture trade frictions, both on the importing and exporting side. As discussed above, our results confirm that the presence of scale economies in interaction with fixed costs does not allow for thinking about import and export barriers separately: (i) reducing barriers to importing intermediate inputs raises exports through the reduction of intermediate-input costs; (ii) reducing barriers to exporting raises imports of intermediate inputs through increases in the size of exporting firms; (iii) a larger size via exports makes offshoring additional inputs profitable, thus changing relative factor demands and the skill premium.

Our work is a direct extension of Carluccio et al. (2015), who find strong empirical support for their model. In comparison with this reference, we introduce fixed and variable costs to exporting, which creates a link between the exporting and importing decisions of firms. Some of our intuitions resemble those in Helpman (1984) and Feenstra and Hanson (1997), where firms' vertical production structures are disintegrated along the lines of factor-proportions-driven comparative advantage. In comparison with these works, we introduce firm heterogeneity à la Melitz (2003) into the theoretical framework. It is the interplay between factor-proportions comparative advantage and the Melitz workhorse that gives rise to the intuitions we highlight here.

In comparison with references that combine Heckscher-Ohlin features with the Melitz model (Bernard et al., 2007), allow for within-sector heterogeneity in factor intensities (Crozet and Trionfetti, 2013), or posit a positive correlation between productivity and factor intensities (Harrigan and Reshef, forthcoming), firm heterogenity in relative factor intensities arises in our model as an equilibrium outcome. To our knowledge, the only other reference in which Heckscher-Ohlin forces operate in a comparable way to ours is Ma et al. (2014), which develops a multi-product version of Bernard et al. (2007) in which a firm's products differ by skill intensity.

Regarding the offshoring literature, Antràs et al. (2014) produce a multi-country heterogeneous-firm offshoring model à la Eaton and Kortum (2002) that features complementarities between sourcing locations. Our model instead features complementarities between exporting and importing decisions.

2 Model

Assume there are two countries, home and foreign (denoted with an asterisk). Countries are endowed with two production factors, skilled workers H and unskilled workers L. The home country is relatively abundant in skills: $H / L > H^* / L^*$. We assume symmetry: $H = L^*$ and $H^* = L$. Countries are identical in preferences, technologies and parameter values.

Consumers maximize utility Q over varieties of a final good in a Dixit-Stiglitz fashion:

$$Q = \left[\int_{\omega \in \Omega} q(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where $\sigma > 1$ is the elasticity of substitution between varieties. We will use the ideal price index P of Q as the numéraire. Each final-good producer is a monopolist over the variety she produces, and makes the final good by assembling a continuum of intermediate inputs with a Cobb-Douglas production function:

$$q(\gamma) = \gamma \exp\left[\int_0^1 \ln x(z) dz \right], \tag{2}$$

where $x(z)$ denotes the quantity of intermediate good z used in the production of the final-good variety. Firms are heterogeneous in the sense that the productivity shifter γ is firm-specific. Intermediate inputs are produced using skilled and unskilled labor with the following Cobb-Douglas technologies:

$$y(z) = \frac{1}{\tau^i} \frac{h(z)^z}{z^z} \frac{l(z)^{1-z}}{(1-z)^{1-z}}, \tag{3}$$

where $y(z)$ denotes the quantity produced of intermediate good z; $h(z)$ and $l(z)$ denote, respectively, the skilled and unskilled labor allocated to the production of intermediate good z. Notice that skill intensity is continuously increasing in z.

The parameter τ^i can take two values, depending on where intermediate inputs are produced. Final-good producers can produce the intermediate inputs in-house, in which case $\tau^i = 1$. They can also offshore some intermediate inputs and then ship them back to be assembled into the final good at home.[2] In this case, $\tau^i = \tau^o > 1$. Offshoring intermediate inputs is also subject to a fixed cost f^o per variety. All fixed costs are in terms of the numéraire.

Final-good producers have to pay a fixed cost f^s in order to supply goods in their domestic markets, and an additional fixed cost f^x to export. Besides, there is an iceberg trade cost τ on final goods. Firms must also pay a fixed cost f^e before picking a draw γ from the distribution of productivities, which we assume Pareto for tractability purposes. There is free entry into the final-good industry. Intermediate-input and factor markets are competitive.

Given the amount of symmetry we impose on the model, the equilibrium outcomes in one country will be the mirror image of the outcomes in the other one. Henceforth we focus our discussion on home, the skill-abundant country.

Firm behavior

Notice that offshoring behavior will respond to comparative advantage: firms in the (skill-abundant) home country will be interested in offshoring the most unskilled-labor-intensive inputs. The more productive a given home firm, the larger the range of unskilled-labor-intensive inputs it will offshore. Low-productivity firms may decide not to offshore any inputs, as the fixed cost f^o might make this unprofitable. The first input that will be offshored by home's firms is the most labor-intensive one, as this earns them the largest cost reductions.[3] We denote with $\left[0, z(\gamma)\right]$ the range of offshored inputs by a home firm with productivity γ. Notice that this information can be summarized with $z(\gamma)$, the least unskilled-labor-intensive input offshored.

[2] Outsourcing intermediate inputs within the firm's country is not profitable due to the assumptions of identical technologies, competitive factor markets and the presence of variable and fixed costs for outsourcing.
[3] See Carluccio et al. (2015) for an extensive discussion of this issue.

Since domestic and offshored intermediates are produced under competitive conditions, $p(z) = w_H^z w_L^{1-z}$ and $p^*(z) = \tau^o (w_H^*)^z (w_L^*)^{1-z}$, where w_H and w_L are the returns to skilled and unskilled labor, respectively. The variable cost function of final-good monopolists is

$$VC(\gamma) = \frac{q(\gamma)}{\gamma} \exp\left[\int_0^{z(\gamma)} \ln p^*(z)dz + \int_{z(\gamma)}^1 \ln p(z)dz\right] =$$

$$= \frac{q(\gamma)}{\gamma} w_L^{(1/2 - z(\gamma) + z(\gamma)^2)} w_H^{(1/2 + z(\gamma) - z(\gamma)^2)} (\tau^o)^{z(\gamma)} = VC^*(\gamma). \quad (4)$$

Firms choose whether to export, $I \in \{0,1\}$, which intermediate goods to offshore, and the price for their final output, *p*, so as to maximize profits. Thus, their profit maximization problem is given by:

$$\max_{p,z,I\in\{0,1\}} \Pi(z) = \max_{p,z,I\in\{0,1\}} p(\gamma)q(\gamma) + Ip_x(\gamma)q^*(\gamma) - MC(\gamma)[q(\gamma) + I\tau q^*(\gamma)] - f^s - zf^o - If^x, \quad (5)$$

where

$$q = \frac{p^{-\sigma}}{P^{1-\sigma}} E \qquad q^* = \frac{p_x^{-\sigma}}{(P^*)^{1-\sigma}} E^*, \quad (6)$$

E and E^* are home and foreign expenditure, and $MC(\gamma) = \frac{1}{\gamma} w_L^{1/2 - z(\gamma) + z^2(\gamma)} w_H^{1/2 + z(\gamma) - z^2(\gamma)} \tau_o^{z(\gamma)}$.

Assuming an interior solution, the first-order conditions with respect to *p* and p_x yield

$$p = \frac{\sigma}{\sigma - 1} MC(\gamma), \qquad p_x = \frac{\sigma}{\sigma - 1} \tau MC(\gamma). \quad (7)$$

The first-order condition with respect to *z* is[4]

$$\frac{\partial \Pi}{\partial z} = -\frac{\partial MC}{\partial z}\left[\frac{p^{-\sigma}}{P^{1-\sigma}}\left(E + I\tau^{1-\sigma}E^*\right)\right] - f^o =$$

$$= -\frac{\partial MC}{\partial z}\left(\frac{\sigma}{\sigma - 1} MC\right)^{-\sigma} P^{\sigma - 1}\left(E + I\tau^{1-\sigma}E^*\right) - f^o \leq 0. \quad (8)$$

Here,

[4] We cannot rule out $\partial\Pi / \partial z < 0$ for all *z* for some (low) levels of γ. The condition $\partial\Pi / \partial z = 0$ evaluated at $z = 0$ implicitly defines the threshold-level of productivity from which home firms start to offshore some of the intermediates they use in the production of the final good.

$$\frac{\partial MC}{\partial z} = MC[(2z-1)\log(w_L / w_H) + \log(\tau^o)]. \tag{9}$$

Finally, I=1 iff $\Pi(z_x(\gamma), I=1) > \Pi(z_d(\gamma), I=0)$, where $z_x(\gamma)$ is the optimal level of offshoring given that the firm is an exporter and $z_d(\gamma)$ is the optimal level of offshoring for a non-exporting firm.

Equilibrium

The model's symmetry implies $P = P^*$, $w_L = w_H^*$, $w_H = w_L^*$, $z(\gamma) = 1 - z^*(\gamma)$. Thus, it is enough to consider the home country's equilibrium conditions:

1. Zero Profit Cutoff (assuming that the least productive firm that produces does not export):

$$\frac{w_L L + w_H H}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \gamma_s^{\sigma-1}[w_L^{1/2-z(\gamma_s)+z^2(\gamma_s)} w_H^{1/2+z(\gamma_s)-z^2(\gamma_s)} \tau_o^{z(\gamma_s)}]^{1-\sigma} - z(\gamma_s) f^o - f^s = 0. \tag{10}$$

   Firms with productivity γ_s are just able to break even.

2. Indifference between exporting and serving the domestic market only:

$$\frac{w_L L + w_H H}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} (1+\tau^{1-\sigma})\gamma_x^{\sigma-1}[w_L^{1/2-z_x(\gamma_x)+z_x^2(\gamma_x)} w_H^{1/2+z_x(\gamma_x)-z_x^2(\gamma_x)} \tau_o^{z_x(\gamma_x)}]^{1-\sigma} - z_x(\gamma_x) f^o -$$

$$-f^x = \frac{w_L L + w_H H}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \gamma_x^{\sigma-1}[w_L^{1/2-z_d(\gamma_x)+z_d^2(\gamma_x)} w_H^{1/2+z_d(\gamma_x)-z_d^2(\gamma_x)} \tau_o^{z_d(\gamma_x)}]^{1-\sigma} - z_d(\gamma_x) f^o \tag{11}$$

   Firms with productivity γ_x are indifferent between just serving the domestic market (in which case they obtain profits from selling domestically; offshore $z_d(\gamma_x)$ intermediates at fixed cost $z_d(\gamma_x) f^o$; pay the domestic fixed cost f^s) and exporting (in which case they obtain additional profits from selling in the foreign market; offshore $z_x(\gamma_x)$ intermediates at fixed cost $z_x(\gamma_x) f^o$; pay both the domestic and exporting fixed costs).

3. Free-entry condition:

$$\frac{w_L L + w_H H}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\int_{\gamma_s}^{\infty} ak^a \gamma^{\sigma-a-2}[w_L^{1/2-z(\gamma)+z^2(\gamma)} w_H^{1/2+z(\gamma)-z^2(\gamma)} \tau_o^{z(\gamma)}]^{1-\sigma} d\gamma +$$

$$+\frac{w_L L + w_H H}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\tau^{1-\sigma}\int_{\gamma_x}^{\infty} ak^a \gamma^{\sigma-a-2}[w_L^{1/2-z(\gamma)+z^2(\gamma)} w_H^{1/2+z(\gamma)-z^2(\gamma)} \tau_o^{z(\gamma)}]^{1-\sigma} d\gamma +$$

$$-f_s k^a \gamma_s^{-a} - f^x k^a \gamma_x^{-a} - f^o \int_{\gamma_s}^{\infty} z(\gamma) ak^a \gamma^{-a-1} d\gamma = f^e, \tag{12}$$

where a and k are the shape and location parameters of the Pareto distribution, respectively. Firms make zero expected profits before picking their productivity level γ in return for the sunk entry cost f^e. The first two integrals are expected profits from serving the domestic market and from exporting, the third and fourth terms are the expected fixed costs for selling domestically and exporting, respectively. The last integral is the expected fixed cost of offshoring.

4. Relative factor market clearing condition:

$$\frac{\displaystyle\int_{\gamma_s}^{\gamma_x} \frac{\left(\frac{w_L}{w_H}\right)^{(1-\sigma)(z^2(\gamma)-z(\gamma))} \tau_o^{z(\gamma)(1-\sigma)}\gamma^{\sigma-a-2}}{\left(1/2 - z(\gamma) + z^2(\gamma)\right)^{-1}} d\gamma + (1+\tau^{2-\sigma})\int_{\gamma_x}^{\infty} \frac{\left(\frac{w_L}{w_H}\right)^{(1-\sigma)(z^2(\gamma)-z(\gamma))} \tau_o^{z(\gamma)(1-\sigma)}\gamma^{\sigma-a-2}}{\left(1/2 - z(\gamma) + z^2(\gamma)\right)^{-1}} d\gamma}{\displaystyle\int_{\gamma_s}^{\gamma_x} \frac{\left(\frac{w_L}{w_H}\right)^{(1-\sigma)(z^2(\gamma)-z(\gamma))} \tau_o^{z(\gamma)(1-\sigma)}\gamma^{\sigma-a-2} d\gamma}{\left(1/2 + z(\gamma) - z^2(\gamma)\right)^{-1}} + (1+\tau^{2-\sigma})\int_{\gamma_x}^{\infty} \frac{\left(\frac{w_L}{w_H}\right)^{(1-\sigma)(z^2(\gamma)-z(\gamma))} \tau_o^{z(\gamma)(1-\sigma)}\gamma^{\sigma-a-2}}{\left(1/2 + z(\gamma) - z^2(\gamma)\right)^{-1}} d\gamma} = \frac{w_L L}{w_H H} \tag{13}$$

The first integral in numerator and denominator captures the factor demand of domestic firms that only serve the local market and foreign non-exporting offshorers, which can be combined due to symmetry. The second integral is the factor demand of domestic exporting firms and foreign exporting offshorers.

These four equilibrium conditions, the normalization P=1, and the conditions for profit maximization together determine γ_s, γ_x, w_L, w_H, I and $z(\gamma)$.[5]

Comparative statics

Calibration

To solve the model, we rely on numerical simulations. First, we calibrate a number of parameters using standard values in the literature. Following Costinot and Rodríguez-Clare (2014), we set the Pareto shape parameter a equal to 5. For the elasticity of substitution between varieties σ, we choose a value of 3.5 (Broda and Weinstein, 2006). We set k, the lower bound of the Pareto distribution, equal to 0.1, which just determines the units in which productivity is measured. We set the initial levels of variable export costs τ and variable offshoring costs τ^o equal to 1.8 (consistent with Anderson and van Wincoop, 2004; Melitz and Redding, 2015).

With a Pareto productivity distribution, scaling f^e, f^s, f^x and f^o up or down by the same proportion leaves the productivity cutoffs and the mass of entrants unchanged, and merely scales average firm size up or down by the same proportion. Therefore we normalize f^s to 0.01. Similarly, with a Pareto productivity distribution, the sunk entry cost f^e affects the absolute levels of the productivity cutoffs but not their relative levels for different values of trade costs. As a result, the relative comparisons below are invariant to the choice of f^e, and hence we normalize $f^e = 0.01$. We set the offshoring fixed cost f^o equal to 0.03 in order to match the French manufacturing importer share from labor-abundant countries (defined as countries with less than 95 percent of the French level of secondary schooling) in 1996 of 0.1 and we choose an export fixed cost f^x of 0.007 to match the French exporter share to these

[5] The equilibrium mass of firms M can be obtained by substituting all other equilibrium outomes into a factor-market equilibrium condition.

countries of around 0.1.[6] Finally, we set *H*/*L* equal to two, so that the domestic economy is skill abundant.

We now discuss a number of comparative statics exercises, consisting of changes in the variable offshoring cost, the fixed offshoring cost, the variable export cost, and the fixed export cost.

A change in variable offshoring costs

We first consider a reduction in variable offshoring costs τ^o, starting at an initial level of 1.8. The upper panels of Figure 1 plot the skill premium (w_H / w_L), the share of exporters and the share of importers against the variable offshoring cost τ^o. The lower panels plot the skill intensity of the marginal intermediate that is offshored, $z(\gamma)$ and the firm-level skill ratio $H / L(\gamma)$ against productivity γ for different levels of variable offshoring costs τ^o. Reductions in variable offshoring costs lead to large increases in the share of firms that import. Reducing offshoring costs by 15 percentage points – from 1.8 to 1.65 – increases the fraction of importers from 0.1 to 0.2, which is close to the actual increase in the share of importers during the period 1996 to 2007 (from 0.1 to 0.19).

At the same time, the same reduction in offshoring costs also induces a small increase in the share of firms that export, from around 0.11 to around 0.13. This is due to the complementary effects between importing and exporting: the reduction in importing costs increases offshoring, which has positive effects on firm-level sales through lower unit costs. This, in turn, induces more firms to pay the export fixed cost and start exporting.

We now discuss the change in the relative demand for skills induced by the reduction in offshoring costs. From the lower left panel, we see that the marginal intermediate input offshored $z(\gamma)$ is increasing in γ. With high offshoring costs ($\tau^o = 1.8$) the least productive

[6] The firm-level dataset for French manufacturing firms from 1996-2007, where these numbers are taken from, is described in detail in Carluccio et al. (2015).

importer has a productivity of around 0.15 and the marginal intermediate offshored has a $z(\gamma)$ of around 0.05 for the most productive firms, so that the remaining set of intermediates $z \in (0.05,1]$ is produced domestically. By contrast, without variable offshoring costs ($\tau^o = 1$) the least productive firm that imports is close to the lower bound of the productivity distribution (0.1) and the marginal intermediate imported by the most productive firms is z=0.5, so that only the intermediates $z \in (0.5,1]$ are produced domestically for these firms. As can be seen from the top left panel, this change in offshoring decisions has large effects on relative factor prices: a reduction in offshoring costs from 1.8 to 1.65 increases the skill premium by around 5 percentage points and a full elimination of variable offshoring costs leads to an increase by 30 percentage points. Observe that the presence of fixed offshoring costs prevents full factor price equalization even in the absence of any variable offshoring costs.

In the lower right panel, we can see the combined effect of changes in factor prices and changes in offshoring costs on firm-level relative demand for skill $H / L(\gamma)$. When offshoring costs are high ($\tau^o = 1.8$), the skill premium is low and most firms produce all intermediates domestically. Consequently, the skill ratio of non-offshorers is relatively high because skilled labor is cheap and the skill ratio of offshorers is only slightly larger than the one of non-offshorers. By contrast, when offshoring costs are low ($\tau^o = 1$), the demand for skilled labor is very high and thus the skill premium is large. This implies that non-offshorers are very labor-intensive, since they substitute away from skilled labor. Differently, offshorers are very skill-intensive since they have offshored most of the labor-intensive inputs and specialize in producing skill-intensive inputs.

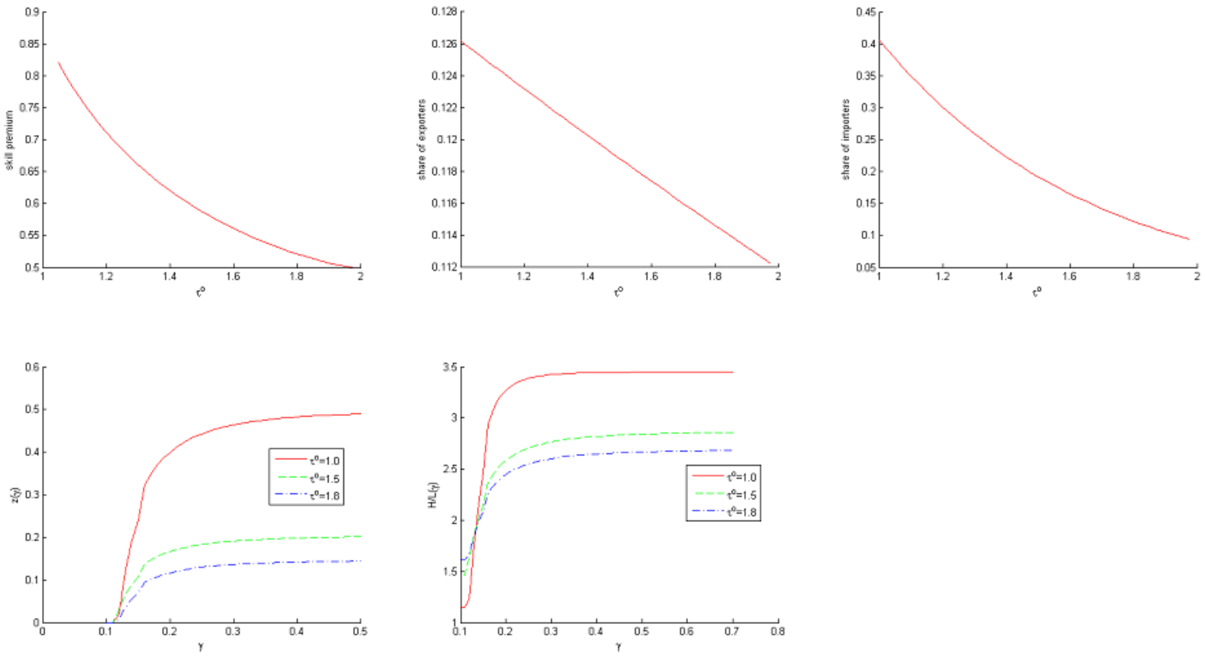

Figure 1: A change in variable offshoring costs.

The upper left panel plots the skill premium against variable offshoring costs, the upper middle panel plots the fraction of exporters against variable offshoring costs and the upper right panel plots the fraction of importers against variable offshoring costs. The lower left panel plots the marginal imported intermediate as a function of firm productivity γ for different levels of variable offshoring costs. The lower right panel plots the firm-level skill ratio as a function of firm productvity γ for differen levels of variable offshoring costs.

A change in fixed offshoring costs

Next, we study a reduction in the fixed offshoring cost f^o, starting at a level of 0.03. In general, results are similar to reductions in variable offshoring costs. From the upper right panel of Figure 2, which plots the fraction of importers against f^o, we see that reductions in fixed offshoring costs imply large increases in the fraction of importers. With zero fixed importing costs, all firms import at least some intermediates. The upper middle panel plots the fraction of exporters against fixed offshoring costs. Reductions in fixed offshoring costs also increase the fraction of exporters somewhat due to complementarities between exporting and importing. A reduction in fixed offshoring costs increases imports and this reduces firms' variable costs and increases sales, making it worthwile for some firms to pay the additional exporting fixed cost.

The upper left panel plots the implied effect of importing on the skill premium. As fixed offshoring costs are reduced, the skill premium increases because firms offshore more and more skill-intensive intermediates. These effects are, however, quantitatively smaller than those of reductions in variable offshoring costs. The lower left panel plots the marginal intermediate offshored as a function of firm productivity γ for different levels of fixed offshoring costs. When fixed offshoring costs are relatively high ($f^o = 0.02$), most firms do not offshore and the marginal input offshored by the most productive firms is very labor-intensive (*z*=0.05). Differently, when there are no fixed offshoring costs ($f^o = 0$), all firms offshore and the marginal good offshored is the same for all firms. Consequently, reductions in fixed offshoring costs affect mostly the extensive margin of offshoring (the measure of firms importing intermediates) rathern than the intensive margin (the amount and range of intermediates imported by each firm).

Finally, the lower right panel of Figure 2 depicts the firm-level skill ratio as a function of productivity for high and low offshoring costs. When offshoring costs are high ($f^o = 0.02$), domestic firms are more skill intensive than firms in the absence of offshoring costs ($f^o = 0$). This reflects the change in the skill premium induced by changes in offshoring fixed costs. By contrast, sufficiently productive offshorers are more skill intensive with high offshoring fixed cost than offshorers in the absence of offshoring fixed costs. This reflects the fact that their marginal offshored input is more skill intensive when factor price differences across the two countries are larger, which is the case when fixed offshoring costs are higher.

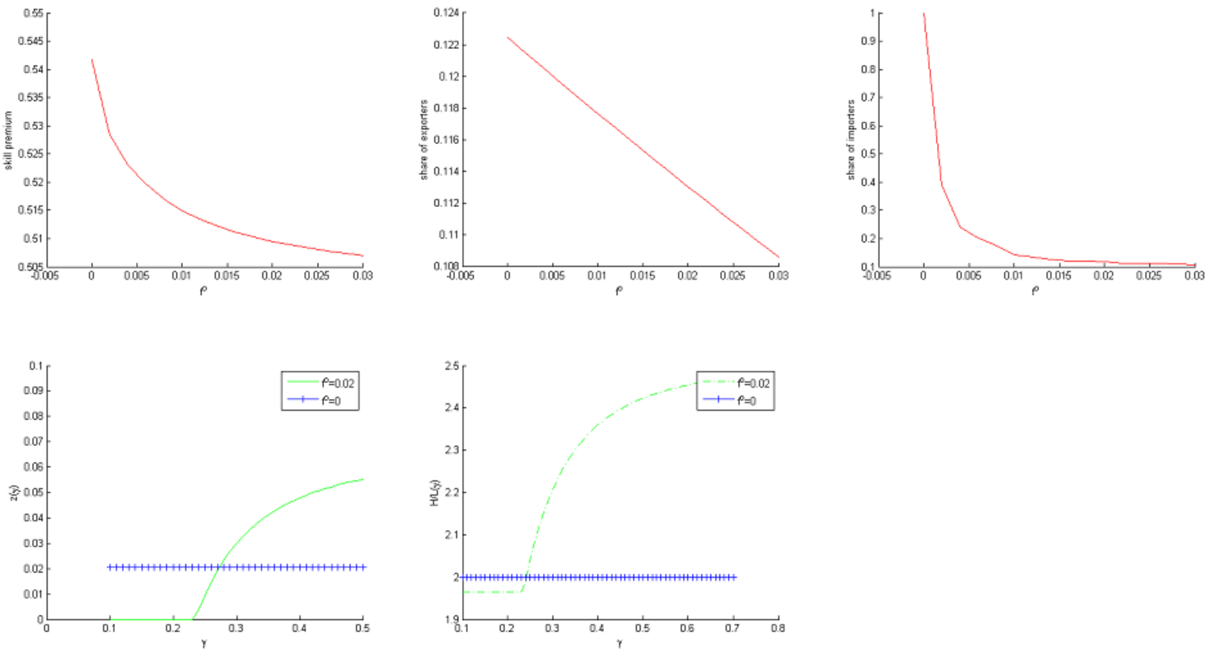

Figure 2: A change in variable offshoring costs.

The upper left panel plots the skill premium against fixed offshoring costs, the upper middle panel plots the fraction of exporters against fixed offshoring costs and the upper right panel plots the fraction of importers against fixed offshoring costs. The lower left panel plots the marginal imported intermediate as a function of firm productivity γ for different levels of fixed offshoring costs. The lower right panel plots the firm-level skill ratio as a function of firm productvity γ for different levels of fixed offshoring costs.

A change in variable export costs

As our next experiment, we consider a reduction in variable export costs, τ, starting from an initial level of 1.8. The upper middle panel of Figure 3 plots the share of exporters against variable trade costs on final varieties and shows that reductions in iceberg trade costs on these goods lead to large increases in the fraction of exporters. As the upper right panel – which plots the share of importers against variable trade costs on exports – shows, reductions in export costs also imply a moderate increase in the share of importers. This fact again reflects complementarities between exporting and importing. Reductions in variable export costs make exporting profitable for more firms and also increase the intensive margin of exporting. The increased revenue from exports makes it worthwhile to pay the fixed costs of importing additional and more skill-intensive intermediates. As the upper left panel shows, the reduced variable export cost have a positive – albeit small – impact on the skill premium, which comes from changes in the extensive margin of importing.

The lower left panel of Figure 3 depicts the marginal offshored input as a function of productivity for high ($\tau = 1.8$) and low ($\tau = 1.2$) offshoring costs. A reduction in variable exporting costs leads additional firms to start importing (shifts the function $z(\gamma)$ to the left) and thereby reduces the relative price of unskilled labor, which reduces incentives to offshore relatively labor-intensive inputs– so that the marginal offshored input becomes less skill intensive (shifts the function $z(\gamma)$ down). The lower right panel shows that both non-offshoring and offshoring firms become less skill intensive domestically when final trade costs decline, as they substitute away from skilled labor, which becomes more expensive.

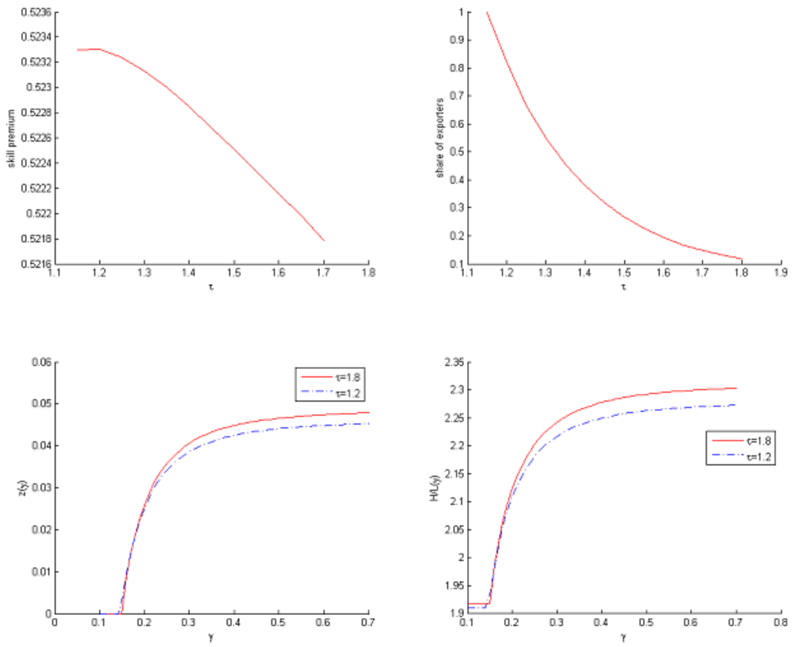

Figure 3: A change in varaible export costs.

The upper left panel plots the skill premium against variable export costs, the upper middle panel plots the fraction of exporters against variable export costs and the upper right panel plots the fraction of importers against variable export costs. The lower left panel plots the marginal imported intermediate as a function of firm productivity γ for different levels of variable export costs. The lower right panel plots the firm-level skill ratio as a function of firm productvity γ for different levels of variable export costs

A change in fixed export costs

Finally, we briefly discuss changes in fixed exporting costs. The results are quantitatively and qualitatively similar to changes in variable export costs and are therefore not presented separately. Higher fixed costs of exporting imply a lower fraction of exporters and also a somewhat lower fraction of importers, which highlights again complementarities between exporting and importing. There is also a small positive effect on the skill premium, as new importers demand additional skilled labor. Lower fixed exporting costs induce an increase in the extensive margin of importing and a fall in the marginal intermediate imported $z(\gamma)$, which reflects the lower benefits from importing given that lower export costs are associated with slightly smaller factor price differences between countries.

3 Concluding Remarks

The results presented above are interesting in that they force us to think harder about the effects of policy changes. For example, consider a decrease in the barriers to export faced by the final-good industry in our model, which is neither skill- nor labor-intensive. Standard Heckscher-Ohlin theory suggests this would have no distribution effects on workers with different skill levels. Our model instead allows for such effects because more exports raise the production scale of firms, thus leading them to import more labor-intensive goods even if the barriers to these imports did not change in this comparative-statics exercise.

The implications of our results go beyond the above discussion and suggest an avenue for future research: quantitative exercises in the trade literature often require unrealistically high trade elasticities to produce some of the sizable effects observed in the data. See, for example, Yi (2003) for a discussion of the difficuties of trade models to explain sizable increase in volumes of trade given the not so large reductions in trade frictions observed over the second half of the 20th century. Introducing the complementarities we discuss in this paper might provide mechanisms that enhance the predictive power of standard trade models.

References

James E. Anderson and Eric van Wincoop, 2004 “Trade Costs, ”*Journal of Economic Literature*, 2(3), 691-751.

Pol Antràs, Teresa Fort and Felix Tintelnot (2014). “The Margins of Global Sourcing: Theory and Evidence from U.S. Firms,” manuscript.

Andrew B. Bernard, J. Bradford Jensen and Peter K. Schott, 2009. “Importers, Exporters and Multinationals: A Portrait of Firms in the U.S. that Trade Goods, in Timothy Dunne, J. Bradford Jensen, and Mark J. Roberts, editors” *Producer Dynamics: New Evidence from Micro Data*, University of Chicago Press.

Andrew B. Bernard, Stephen J. Redding and Peter K. Schott, 2007. “Comparative Advantage and Heterogeneous Firms, ”*Review of Economic Studies*, 74(1), 31-66.

Christian Broda and David E. Weinstein, 2006. “Globalization and the Gains From Variety,” *Quarterly Journal of Economics*, 121(2), 541-585.

Juan Carluccio, Alejandro Cuñat, Harald Fadinger and Christian Fons-Rosen, 2015 “Offshoring and Skill-Upgrading in French Manufacturing: A Heckscher-Ohlin-Melitz View ” *CEPR Discussion Paper* Nr. 10864.

Arnaud Costinot and Andrés Rodriguez-Clare 2014. “Trade Theory with Numbers: Quantifying the Consequences of Globalization, ”*Handbook of International Economics*, Elsevier.

Matthieu Crozet and Federico Trionfetti, 2013. “Firm-level Comparative Advantage, ”*Journal of International Economics*, 91(2), 321-328.

Jonathan Eaton Samuel Kortum, 2002. “Technology, Geography, and Trade, ”*Econometrica*, 70(5), 1741-1779.

Robert C. Feenstra and Gordon H. Hanson, 1997. “Foreign direct investment and relative wages: Evidence from Mexico’s maquiladoras, ”*Journal of International Economics*, 42(3-4), 371-393.

James Harrigan and Ariell Reshef, 2015. “Skill Biased Heterogeneous Firms, Trade Liberalization, and the Skill Premium, ”*Canadian Journal of Economics*, forthcoming.

Elhanan Helpman, 1984. “A Simple Theory of International Trade with Multinational Corporations, ”*Journal of Political Economy*, 92(3), 451-471.

Hiroyuki Kasahara and Beverly Lapham, 2013. “Productivity and the decision to import and export: Theory and evidence, ”*Journal of International Economics*, 89(2), 297-316.

Marc J. Melitz, 2003. “The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity, ”*Econometrica*, 71(6), 1695-1725.

Marc J. Melitz and Stephen J. Redding, 2015. “New Trade Models, New Welfare Implications, ”*American Economic Review*, 105(3): 1105-46.

Yue Ma, Heiwai Tang and Yifan Zhang, 2014. “Factor intensity, product switching, and productivity: Evidence from Chinese exporters, ”*Journal of International Economics*, 92, 349-362.

Kei-Mu Yi, 2003. “Can Vertical Specialization Explain the Growth of World Trade?, ”*Journal of Political Economy*, 111(1), 52-102.