Offshoring, Exports and Employment: Theory and Evidence from Korean Firms*

Jae Yoon Lee
Korea Institute for Industrial Economics and Trade (KIET)
jlee177@kiet.re.kr

Devashish Mitra
Syracuse University
DMitra@Maxwell.Syr.Edu

Priya Ranjan
University of California-Irvine
PRanjan@UCI.Edu

January, 2017

Abstract

We extend the small-country trade model with firm heterogeneity (Demidova and Rodriguez-Clare, 2013) to incorporate offshoring (along with final goods trade). We derive the firm-level employment implications of output and input trade (and trade cost reductions) to provide a guide for our empirical work using Korean firm-level data for the period 2006-11. We find that input and output trade cost reductions increase both the volume of firm-level exports and imports as well as the number of firms exporting and the number importing. The impact of input trade cost reductions on firm employment changes from negative to positive as we move from the subsample of firms in industries where inputs are, on average, substitutable with respect to each other to the subsample in complementary input industries. On the whole, greater imports and being an importer are associated with greater employment, indicating that, on average, imported inputs are complementary to domestically produced ones. The magnitude of this effect is greater for exporting firms and increases with input complementarity. These results are fairly robust to specification, including difference-in-difference estimation with propensity score matching to address simultaneity problems.

Keywords: Employment; Offshoring: Elasticity of Substitution; Trade Costs; Exports; Firm Heterogeneity

JEL Classification Codes: F10, F14, F16, F66

* We thank Bill Horrace, Yoonseok Lee and Mary Lovely for comments on an earlier version. The standard disclaimer applies.

1 Introduction

In large parts of the industrialized world, manufacturing employment has been declining. Increased automation of manufacturing production and globalization are thought to be the main causes of this trend. While greater openness to international trade is only one facet of globalization, it is deemed to be the one most closely related to a decline in manufacturing employment in industrialized countries. Turning to a late industrializer, namely Korea, we also find a decline in manufacturing employment. Between 1991 and 2012, manufacturing employment has declined from 5.2 million to 4.2 million, while its manufacturing share of employment has fallen from 28 percent to 17 percent (Source: OECD). Over the same period the merchandise trade to GDP ratio has more than doubled. In this paper, we study the impact of greater trade openness on employment at the firm level in Korean manufacturing. In particular, we want to look at how firm-level employment is related to input and output trade.

It needs to be realized at the outset that there could be considerable heterogeneity in how firms react to greater possibilities for input and output trade. For example, these possibilities can provide some firms with the opportunity to import inputs, which could either be substitutes for or complements to inputs produced by workers in-house, depending on which firm employment could go up or down in response to greater input imports. Also, greater export and import possibilities will benefit the relatively productive firms that will be able to compete with foreign firms in the world market. On the other hand, these greater trading possibilities could hurt the less productive firms who will not be able to survive foreign competiton or might in response shrink their output and employment.

To study various possible employment outcomes related to trade, we extend the small country trade model with heterogeneous firms developed by Demidova and Rodriguez-Clare (2013), itself an extension of the well-known Melitz (2003) model. In the Demidova-Rodriguez-Clare model we incorporate offshoring (along with final goods trade). Our theory predicts that a decrease in the trading cost of final goods will lead to losses in employment for non-exporting firms. This channel works though a decline in the average industry price, which is equivalent to greater effective competititon faced by domestic firms. Our model also predicts that in addition to such an effect, exporting firms also experience an opposing effect: an increase in their labor demand due to an increase in exports (as exporting costs are now lower). However, our main focus in this paper is to study the impact of offshoring or importing inputs on firm level employment. Based on our theory, with an offshoring cost reduction we should expect non-offshoring firms (whether exporting or not) to suffer losses in employment because of the greater effective competition primarily driven by the lower prices charged by each offshoring firm (due to the cost reduction brought about by offshoring).[1] Offshoring firms experience another effect on their labor demand which depends on two elasticity parameters: the elasticity of substitution between inputs and the

[1] This is analogous to the "selection effect" mentioned above.

elasticity of substitution between varieties of output. When the input elasticity of substitution dominates, we have a case of high relative substitutability between inputs, effectively leading to a high degree of substitutability between domestic in-house labor and imported inputs, in which case a decline in offshoring costs should clearly lead to a decline in domestic firm-level employment for offshoring firms through a dominant substitution effect. The opposite case is that of high input complementarity where inputs produced by in-house labor and imported inputs are complements. In this case there is an overall positive productivity effect on employment arising from an offshoring cost reduction. Among the offshoring firms, those that export will experience a positive exporting effect: a lower cost of production will help expand exports and in turn employment.

Our theoretical model acts as a useful guide for empirically investigating the firm-level employment effects of offshoring and final goods trade, especially when it comes to the effects that are heterogeneous across firms. However, there are important aspects of the real world that our theoretical model does not capture, but which might show up in the results of our empirical investigation. Firstly, we do not allow for a pro-competitive effect of offshoring on the market for the import-competing intermediate input (domestic substitute of the foreign input). When the offshoring cost (trading cost of the offshored input) goes down, a larger fraction of firms would offshore, which could depress the price of the import-competing intermediate input through a fall in its demand. Thus, it is quite possible that then there would be a positive productivity effect not only for offshoring firms but also other firms. Secondly, we also take the intrinsic productivity of each firm as a given throughout after a firm draws it from a given distribution. The only change we see is in effective productivity (a decline in unit cost) that results from greater offshoring due to a fall in the trading cost of the offshored input. There is no other productivity effect of trade in our model, in the form of learning, R&D etc. There is, however, overwhelming evidence showing a positive productivity effect of import competition which makes firms more efficient.[2]

We perform our empirical investigation using firm-level data from Korea. The firm-level Korean panel data are drawn from the Survey of Business Activity (SBA) for the years 2006-2011. Our empirical work also uses data on trade costs for final goods as well as separately for intermediate goods or inputs. We use tariffs from the World Integrated Trade Solution (WITS), which need aggregation and concording to the Korean 3-digit classification. Transport costs are constructed at the 3-digit level by adjusting the US transport costs (for disaggregate categories) for different distances between Korea and its various major trading partners, which is followed by import-weighted aggregation to more aggregate categories, and then a process of concordance. The trade costs are the sum of import tariffs and transport costs. From the final goods trade costs, we create input trade costs using the input-output table for Korea, along with some additional concordance. In addition, we need measures of output and input substitution, which are derived from the elasticities of substitution in Broda and Weinstein (2006), again requiring further aggregation and concording as well as transformation using the

[2] See for instance Harrison (1994), Krishna and Mitra (1998), Pavcnik (2002), Amiti and Konings (2007), Topalova and Khandelwal (2010) etc.

input-output matrix. An attractive feature of our firm-level dataset is the presence of data on exports and imports at the firm-level, which we use in our analysis.

Our empirical analysis yields several results, most of them consistent with our theory and/or our economic intuition. We first verify that firm level trading is related to trade costs in the expected direction. We find that input and output trade cost reductions increase both the volume of firm-level exports and imports as well as the probabilities of firms exporting and importing. Turning to the relationship between employment and trade costs, we find that the correlation between input trade costs and firm employment changes from positive to negative as we move from the subsample of firms in industries where inputs are on average substitutable (where imported or outside inputs and inputs produced by workers in-house are mutually substitutable) to the subsample of firms in complementary input industries. Next we study the relationship between employment and firm level trading activities. Here we find that, on the whole, greater imports are associated with greater domestic firm-level employment, indicating that, on average, imported and domestic inputs produced in-house are complementary to each other. Effectively then, imported inputs are complementary to domestic labor. Consistent with our theoretical predictions, the magnitude of the positive employment effect of input imports is greater for exporting firms and for firms in industries where inputs are relatively more complementary.

Import status and employment are both ultimately functions of the firm's intrinsic productivity, i.e., larger firms (firms with higher output and employment levels) are the ones that are likely to offshore (import inputs). To address this problem of simultaneity, we use an approach of difference-in-difference with propensity score matching, similar to the one used by Girma, Greenaway, and Kneller (2003). Across all our difference-in-difference specifications (with propensity score matching) importing (of inputs) leads to higher domestic firm-level employment. There is also some evidence that imports have a bigger positive impact on employment for exporting firms. As with our other regressions, here as well the employment increasing impact of importing inputs from abroad is greater when input complementarity is higher.

In many ways, the paper closest to ours is the one by Groizard, Ranjan and Rodriguez-Lopez (2015). Using establishment level data from Californian manufacturing industries from 1992 to 2004, they find that, consistent with the prediction of trade models with heterogeneous firms, a decline in trade costs (input as well as output) is associated with job destruction (creation) in the least (most) productive establishments, with firm death most likely in the case of the least productive establishments. Interestingly, the effects of input trade costs on job creation or destruction at the establishment level are greater in magnitude than those of output trade costs. Note that the Groizard et al paper, unlike ours, does not look at the interaction between importing and exporting or the role of input substitutability or complementarity in the determination of firm-level employment. Also, unlike us, they do not possess information on imports and exports at the firm level and, therefore, are not able to investigate the impact of heterogenous trade flows at the firm level on firm employment. They are restricted to studying the impact of trade costs, the data on which are at the 3-digit industry level.

The earliest related work which looks at the heterogeneous impact of trade on firm or plant-level employment is Levinsohn (1999), who finds that in Chile, during their period of trade reforms (1979-86), there were substantial inter-plant differences in the rates of job creation and destruction based on plant size, with the smallest plants three times more likely to destroy jobs through firm death but experiencing smaller magnitudes of job contraction or destruction compared to the largest plants. The latter results are along the lines of the findings of Biscourp and Kramarz (2007), who use French firm-level manufacturing data from 1986 and 1992.

There are empirical studies that, similar to ours, try to separate the effects of input and final-good trade costs but on other firm-level outcomes. The main outcome variables to have been studied in that literature are plant-level productivity (Amiti and Konings, 2007 and Topolova and Khandelwal, 2011), the range of goods produced at the firm-level (Goldberg, Khandelwal and Pavcnik, 2010), and wages (Amiti and Davis, 2012). There is considerable evidence from these studies that reductions in trade costs, especially in input trade costs, can result in increases in firm/plant productivity and the product variety at the level of the firm. In addition, reductions in input tariffs increase wages in import-using firms (relative to others), while output tariff reductions lower wages in import-competing firms and raise wages in exporting firms. While these outcome variables are quite different, one could easily see how the impact of trade and trade costs on them could constitute additional channels through which employment could be affected.

2 The Model

We extend the small country trade model of Demidova and Rodriguez-Clare (2013) to incorporate offshoring (along with final goods trade). Here the country of interest is called Home which trades with rest of the world.

2.1 Preferences and Demand

The total size of the workforce in Home is $\mathbb{L}$, which is also the number of individuals in the economy. Individuals' preferences are defined over a number of differentiated, non-numeraire goods and a homogeneous, numeraire good. In particular, the utility function for the representative consumer is given by

$$\mathbb{U} = H + \sum_{i=1}^{N} \frac{\eta}{\eta - 1} Z_i^{\frac{\eta-1}{\eta}}, \tag{1}$$

where H denotes the consumption of the homogeneous good, $Z_i = \left(\int_{\omega \in \Omega_i} z_i^c(\omega)^{\frac{\sigma_i - 1}{\sigma_i}} d\omega \right)^{\frac{\sigma_i}{\sigma_i - 1}}$ is the CES consumption aggregator of a continuum of differentiated varieties within the ith differentiated goods sector, and η is the elasticity of demand for Z_i (where η governs the substitutability between homogenous and differentiated goods). Within Z_i, $z_i^c(\omega)$ denotes the consumption of variety ω, Ω_i is the set of differentiated varieties available for purchase, and $\sigma_i > 1$ is the elasticity of substitution between varieties. We assume that $\sigma_i > \eta$ so that differentiated-good varieties (within a differentiated good or sector) are better substitutes for each other than for the homogeneous good.

For differentiated goods, the representative individual's demand for variety ω of the ith differentiated good sector is given by $z_i^c(\omega) = \frac{p_i(\omega)^{-\sigma_i}}{P_i^{1-\sigma_i}} P_i Z_i$, where $p_i(\omega)$ is the price of variety ω, $P_i = \left[\int_{\omega \in \Omega_i} p_i(\omega)^{1-\sigma_i} d\omega\right]^{\frac{1}{1-\sigma_i}}$ is the price of the CES aggregator Z_i, and hence, $P_i Z_i$ is the household expenditure on differentiated goods produced by sector i. Given the quasi-linear and additively separable utility in (1), it follows that $Z_i = P_i^{-\eta}$, and therefore, the aggregate demand for variety ω of the ith sector is given by

$$z_i^d(\omega) = p_i(\omega)^{-\sigma_i} P_i^{\sigma_i - \eta} \mathbb{L}. \tag{2}$$

The homogeneous good, H, is produced by perfectly competitive firms using domestic labor only. One unit of domestic labor produces one unit of the homogeneous good. This fixes the domestic wage at 1 as long as some homogenous good is produced, which we assume to be the case. Therefore, the income of each household simply equals 1. We assume that the parameters are such that $\sum_{i=1}^{N} P_i Z_i = \sum_{i=1}^{N} P_i^{1-\eta} < 1$ for all i, so that a typical individual has enough income to buy all differentiated goods.

The firms in Home face the following export demand for their products:

$$z_i^x(\omega) = A p_i^x(\omega)^{-\sigma_i}.$$

where p_i^x is the price faced by consumers in the export market. However, there is a fixed cost of exporting, f_i^x, and an iceberg trading cost, which has a general component τ_i^x and a firm specific component t_x. As a result, not all firms will export. Note that the above demand function captures the idea that the income and price index in the rest of the world are taken as given by Home firms.

As in Demidova and Rodriguez-Clare (2013) we assume there is a fixed number of firms producing varieties of the ith good in the rest of the world denoted by N_i^f. Note that this is the implication of the small country assumption, which means the small country, Home is not able to affect the number of firms in the rest of the world and takes that number as given. However, only a subset of firms in the rest of the world will find it worthwhile to export to Home. These exporting firms from the rest of the world also face a fixed cost of exporting, f_i^f, and an iceberg trading cost, τ_i^f. As a result, only a subset of these firms are able to export to Home. In the rest of the paper, we are going to make the following symmetry assumption: $\tau_i^x = \tau_i^f = \tau_i$.

2.2 Production Structure

From now on, in order to avoid clutter we drop the subscript i from our notation. In other words, we are focusing on firms in a given differentiated goods sector (out of several of them). Suppose that after incurring an entry cost of f_E a firm draws a triplet $\psi = (\varphi, t_x, t_o)$ where φ is the exogenous productivity of the firm, $t_x \in [1, \overline{t_x}]$ is the firm-specific component of the variable cost of exporting, and $t_o \in [1, \overline{t_o}]$ is the firm specific component of the variable cost of offshoring. ψ is drawn from a distribution $G(\psi)$ with the p.d.f. $g(\psi)$. The production function of a Home firm with triplet ψ and whose productivity is φ is $z(\psi) = \varphi Y(\psi)$, with

$$Y(\psi) = \left[\alpha L(\psi)^{\frac{\rho-1}{\rho}} + (1-\alpha) M(\psi)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}, \tag{3}$$

where $L(\psi)$ is a composite of inputs produced *within* the firm, $M(\psi)$ is a composite of inputs procured from *outside* the firm, and $\rho \geq 0$ is the elasticity of substitution between the two types of inputs.[3] We assume that one unit of labor is required to produce one unit of $L(\psi)$.

The composite input $M(\psi)$ can be either procured domestically or it can be offshored. Let $p_s(\psi)$ denote the price paid by a firm with offshoring status s for a unit of composite input $M(\psi)$, for $s \in \{n, o\}$, where n denotes "not offshoring" and o denotes "offshoring". If $M(\psi)$ is procured domestically, then $p_n(\psi) = p_n$ for all ψ, that is, we are implicitly assuming that p_n units of the numeraire good translate into one unit of input $M(\psi)$. If the production of $M(\psi)$ is offshored, a firm has to pay a fixed cost of offshoring, f_o, and a variable cost, $p_o(\psi)$, per unit of input $M(\psi)$. Let p_M^* denote the price of input M in the foreign country, and let $\lambda > 1$ denote the iceberg cost of offshoring common to all firms and recall that t_o is the firm specific variable cost of offshoring. It follows that

$$p_o(\psi) = \lambda t_o p_M^*, \tag{4}$$

so that a decline in λ makes offshoring more attractive. Note that domestic firms have incentives to offshore only if $p_o(\psi) < p_n(\psi) = p_n$.

Given our production function and (3), the marginal cost of a firm with triplet ψ and offshoring status s is given by $\frac{c_s(\psi)}{\varphi}$, where

$$c_s(\psi) \equiv \left[\alpha^\rho + (1-\alpha)^\rho p_s(\psi)^{1-\rho}\right]^{\frac{1}{1-\rho}} \tag{5}$$

is the price of a unit of $Y(\psi)$ for a firm with status $s \in \{n, o\}$. Whenever a firm offshores it must be the case that $p_o(\psi) < p_n$, therefore, $c_o(\psi) < c_n(\psi) = c_n$ as well.

There is a fixed cost of operation, f, for every producing firm. In addition to offshoring, firms can export as well. There is a fixed cost of exporting f_x, an iceberg shipping cost of final goods, with a component common to all firms, given by $\tau > 1$, and a firm specific component, t_x mentioned earlier, so that the overall variable shipping cost is τt_x. Note that the general component of the variable shipping cost is symmetric (equal) for exports and imports of final goods, so that a reduction in τ would imply a reduction in this cost in both directions.

2.3 Equilibrium

With CES preferences, the price set by a Home firm with productivity φ in the home market is

$$p(\psi) = \left(\frac{\sigma}{\sigma-1}\right) \frac{c_s(\psi)}{\varphi}, \text{ for } s \in \{n, o\} \tag{6}$$

[3] ρ, like some of the other parameters such as σ, can vary across the various differentiated goods sectors.

The price that a firm charges in the foreign market, if it exports, is given as follows.

$$p^x(\psi) = \left(\frac{\sigma}{\sigma-1}\right)\frac{\tau t_x c_s(\psi)}{\varphi}, \text{ for } s \in \{n, o\} \tag{7}$$

Given the above description of the model, there are 4 possible types of firms: Those which sell only domestically and do not offshore, those which export but do not offshore, those which offshore but do not export and those which do both offshoring and exporting.

A firm with triple $(\varphi, t_x,\, t_o)$ chooses the mode that maximizes its net profit. The net profit is given by

$$\pi(\psi;\tau,\lambda) = \left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_s(\psi)}{\varphi}\right)^{1-\sigma}\left(\frac{P^{\sigma-\eta}\mathbb{L}+(\tau t_x)^{1-\sigma} AI_x}{\sigma}\right) - f - f_o I_o - f_x I_x \tag{8}$$

where I_o is the indicator variable for an offshoring firm and I_x is the indicator variable for an exporting firm.

Denote the productivity of the marginal surviving firm by $\widehat{\varphi}$. If this firm doesn't export or offshore then

$$\left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_n}{\widehat{\varphi}}\right)^{1-\sigma}\frac{P^{\sigma-\eta}\mathbb{L}}{\sigma} - f = 0 \tag{9}$$

The above gives the value of $\widehat{\varphi}$ for given P. It is shown in the appendix that the sufficient conditions for the marginal surviving firm to neither export nor offshore are

$$\left(\left(\frac{c_o(\psi)|_{t_o=1}}{c_n}\right)^{1-\sigma} - 1\right) f < f_o; \left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_o(\psi)|_{t_o=1}}{\widehat{\varphi}}\right)^{1-\sigma}\left(\frac{\tau^{1-\sigma}A}{\sigma}\right) < f_x.$$

The former requires the offshoring fixed cost to be high relative to the fixed cost of operation f while the latter requires the fixed cost of exporting to be high relative to the size of the Foreign market captured by A. The term $c_o(\psi)|_{t_o=1}$ refers to the cost of producing input Y for an offshoring firm with the lowest possible variable offshoring cost.

Next, substituting out $P^{\sigma-\eta}$ in (8) using (9), the net profits can be written as

$$\pi(\psi,\widehat{\varphi};\tau,\lambda) = \left(\frac{\widehat{\varphi}c_s(\psi)}{\varphi c_n}\right)^{1-\sigma} f + \left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_s(\psi)}{\varphi}\right)^{1-\sigma}\left(\frac{(\tau t_x)^{1-\sigma} A}{\sigma}\right) I_x - f - f_o I_o - f_x I_x \tag{10}$$

That is, profits are a function of $\widehat{\varphi}$ and triple ψ. Therefore, if we know $\widehat{\varphi}$ we can determine the profits of each firm and also whether they offshore and/or export.

$\widehat{\varphi}$ is determined by the free entry condition

$$\Pi \equiv \int_{\widehat{\varphi}}^{\infty}\int_{t_o}\int_{t_x}\pi(\psi,\widehat{\varphi};\tau,\lambda)g(\psi)dt_x dt_o d\varphi = f_e \tag{11}$$

In the above ψ is the triplet (φ, t_x, t_o), t_o denotes $t_o \in [1, \overline{t_o}]$ and t_x denotes $t_x \in [1,\, \overline{t_x}]$. The proof of existence is given in the appendix.

Once we have $\widehat{\varphi}$, we can determine the mode of globalization of each firm given its ψ. A firm chooses the mode that maximizes its net profits from the alternatives listed in (10). In general, among active firms, those with low

t_x are more likely to export, while those with low t_o are more likely to offshore. As well, higher productivity firms are more likely to engage in offshoring and exporting due to the fixed costs associated with these activities.

Next, we derive the following lemma (proof in appendix) which is useful in comparative statics below.

Lemma: $\frac{d\widehat{\varphi}}{d\tau} < 0$; $\frac{d\widehat{\varphi}}{d\lambda} < 0$.

That is, decreases in the costs of trading final goods or offshoring both increase the survival productivity cutoff. The result with respect to τ is, what has been called in some parts of the literature, the "selection effect" in the Melitz model and its various extensions, and the result with respect to λ is its analog for offshoring. Intuitively, a decrease in the cost of offshoring reduces the cost of production of offshoring firms. Thus there is a reduction in the sectoral price index P, which in turn has a profit reducing effect. As a result the break-even firm (which is purely domestic both in sales and input use) will be one with a higher productivity.

2.4 Trading costs and firm level trade

While our main interest in the paper lies in studying the impact of trading on employment, since we have rich data on firm level trading activities, we first derive some implications on the relationship between trade costs and firm level trade. It is shown in the appendix that a decrease in the output trading cost, τ, increases exports at both the intensive and extensive margins. That is, existing exporting firms export more and more firms are likely to export. Similarly, a decrease in the input trading cost λ also increases exports by making firms more competitive in the export market. It also increases the probability of a firm exporting.

Looking at firm level imports, it is shown in the appendix that a decrease in the input trading cost, λ, has both direct and indirect effects on firm level imports. The indirect effect operates through changes in $\widehat{\varphi}$ which works to reduce imports, however, the direct effect increases imports at both the intensive and extensive margins. A decrease in the output trading cost, τ, also affects imports. It affects the imports of exporting firms because if exports expand these firms need more inputs, including imported inputs, to service export demand. In addition, a decrease in τ affects all firms indirectly through an increase in $\widehat{\varphi}$. That is, a decrease in τ would indirectly reduce firm level imports.

2.5 Trading costs and employment

Since our main aim is in deriving the implications of changes in the costs of offshoring and trading final goods on employment, we present the expressions for employment derived in the appendix. Denoting the employment for domestic production by $L_s^d(\psi)$, for exports by $L_s^x(\psi)$, and total employment by $L_s(\psi)$, we obtain

$$L_s(\psi) = L_s^d(\psi) + I_x L_s^x(\psi)$$

where I_x is an identity function which takes the value 1 if the firm exports, and zero otherwise and

$$L_s^d(\psi) = \alpha^\rho \, (\sigma - 1) \, c_s(\psi)^{\rho-\sigma} \left(\frac{\varphi c_n}{\widehat{\varphi}}\right)^{\sigma-1} f; L_s^x(\psi) = \alpha^\rho \left(\frac{\sigma-1}{\sigma}\right)^\sigma c_s(\psi)^{\rho-\sigma} \, (\tau t_x)^{1-\sigma} \, \varphi^{\sigma-1} A, \text{ for } s \in \{n, o\}. \tag{12}$$

2.5.1 Ouput trading cost, τ, and employment

From (12) obtain

$$\frac{dL_s^d(\psi)}{d\tau} = -\frac{(\sigma-1)\, L_s^d(\psi)}{\widehat{\varphi}} \frac{d\widehat{\varphi}}{d\tau} > 0; \frac{dL_s^x(\psi)}{d\tau} = -\frac{(\sigma-1)\, L_s^x(\psi)}{\tau} < 0.$$

That is, there are job losses due to decreased domestic sales arising from the fall in the trading costs of final goods and job gains due to increased exporting. Combining the above results we get the following prediction for different types of firms.

$$\frac{dL_s(\psi)}{d\tau} = -\frac{(\sigma-1)\, L_s^d(\psi)}{\hat{\varphi}} \frac{d\hat{\varphi}}{d\tau} - I_x \frac{(\sigma-1)\, L_s^x(\psi)}{\tau}. \tag{13}$$

Therefore, for non-exporting firms ($I_x = 0$) there will be job losses due to a decline in the trade costs of final goods, but for exporting firms ($I_x = 1$) the impact would be ambiguous.

2.5.2 Input trading cost, λ, and employment

From (12) obtain

$$\frac{dL_s^d(\psi)}{d\lambda} = -\frac{(\sigma-1)\, L_s^d(\psi)}{\hat{\varphi}} \frac{d\hat{\varphi}}{d\lambda} + \frac{(\rho-\sigma)\, L_s^d(\psi)}{c_s(\psi)} \frac{dc_s(\psi)}{d\lambda} \tag{14}$$

When $s = n$, then $\frac{dL_s^d(\psi)}{d\lambda} > 0$ because $\frac{dc_n}{d\lambda} = 0$ and $\frac{d\widehat{\varphi}}{d\lambda} < 0$. Therefore, the impact on the labor demand of non-exporting firms depends on their offshoring status. If they do not offshore, then their labor demand decreases. When $s = o$, $\frac{dc_o(\psi)}{d\lambda} > 0$, and therefore, the sign of the second term above is same as the sign of $\rho - \sigma$. The second term in the expression above captures two effects. First, a decrease in λ implies that offshoring firms find offshored inputs to be cheaper, and hence they further substitute offshored inputs for domestic labor which leads to a decrease in the demand for domestic labor. The strength of this effect depends on ρ, the elasticity of substitution between domestic labor and offshored inputs. The larger the ρ the stronger this effect. We can call this the *substitution effect* of offshoring. Second, since offshoring firms become more productive (their marginal cost of production decreases), the demand for their products increases. This leads to an increase in labor demand. The strength of this latter effect depends on the elasticity of demand for the firm (same as the elasticity of substitution between varieties, σ). We can call this the *productivity effect* of offshoring. The net *substitution-productivity effect* depends on $\rho - \sigma$. If $\rho > \sigma$, then the substitution effect dominates and hence a decrease in the cost of offshoring reduces the demand for labor through the *substitution-productivity effect*, while if $\rho < \sigma$, then the *substitution-productivity effect* leads to an increase in the demand for labor.

For exporting firms we have the following additional effects.

$$\frac{dL_s^x(\psi)}{d\lambda} = (\rho - \sigma)\,\frac{L_s^x(\psi)}{c_s(\psi)}\,\frac{dc_s(\psi)}{d\lambda} \tag{15}$$

Note that the above expression is exactly the same as the second term in (14) except that $L_s^d(\psi)$ has been replaced by $L_s^x(\psi)$. Therefore, for exporting firms that do not offshore, there is no additional effect on labor demand: $\frac{dL_s^x(\psi)}{d\lambda} = 0$ when $s = n$. For exporting firms that offshore, the sign of the above expression depends on the *substitution-productivity effect:* $\frac{dL_s^x(\psi)}{d\lambda} < (>) 0$ if $\rho < (> \sigma)$.

Combining the above, we have the following results for the 4 types of firms in our model.

$$\frac{dL_s(\psi)}{d\lambda} = -L_s^d(\psi)\left(\frac{(\sigma-1)}{\hat{\varphi}}\frac{d\hat{\varphi}}{d\lambda} - \frac{(\rho-\sigma)}{c_o(\psi)}\frac{dc_o(\psi)}{d\lambda}I_o\right) + L_s^x(\psi)\frac{(\rho-\sigma)}{c_o(\psi)}\frac{dc_o(\psi)}{d\lambda}I_oI_x, \tag{16}$$

where I_o is an indicator function taking the value 1 if the firm offshores and 0 otherwise.

The above is going to guide us towards coming up with an estimating equation for our empirical exercise.

2.6 Empirical Implications

There are a number of empirical implications of our theoretical model pertaining to the relationship between trade and employment.

1. When there is a decrease in τ (the trading cost of final goods):

i. non-exporting firms suffer losses in employment due to the above-mentioned *selection effect* (increase in $\widehat{\varphi}$ through a reduction in P)

ii. exporting firms experience two opposing effects: decrease in their labor demand due to decrease in domestic sales, and increase in their labor demand due to increase in exports.

2. When there is a decrease in λ (offshoring cost, which is the trading cost of the offshorable input):

i. non-offshoring firms (whether exporting or not) suffer losses in employment due to an increase in $\widehat{\varphi}$, through a reduction in P.

ii. offshoring firms that are non-exporting experience the *substitution-productivity effect* related to their domestic sales, while offshoring firms that export experience this effect relating to their export sales as well. This effect leads to an increase in labor demand if $\rho < \sigma$ and a decrease in labor demand, otherwise. Note that the *substitution-productivity effect* for offshoring firms that export is produced by an interaction between exporting and offshoring.

Recall that our model is one with a multi-industry setting where different industries have different σ and ρ and that we suppressed the industry subscripts to minimize clutter in our notation. We, therefore, have some further implications of our theoretical analysis for empirical work.

3. In industries where $\rho > \sigma$ the *substitution-productivity effect* causes a decrease in employment in response to offshoring. Therefore, in these industries, a decrease in offshoring cost would reduce employment unambiguously

for all firms. In industries where $\rho < \sigma$, the *substitution-productivity effect* causes an increase in employment in response to offshoring. Therefore, the overall impact of a decrease in offshoring cost on the employment of offshoring firms is ambiguous in these industries.

While the above predictions were derived from the theoretical model, it is important to note that there might be important aspects of the real world that our theoretical model does not capture. Recall that we assumed the domestic price of the composite input produced outside the firm boundary to be constant at p_n. An implication is that non-offshoring firms always lose from a decrease in the offshoring cost. However, it is conceivable that p_n could change in response to a decrease in λ. When λ decreases, a larger fraction of firms offshore, which reduces the demand for the domestically produced composite input. This can reduce p_n if the supply curve for domestically produced input is upward sloping due to say a limited amount of a specific factor required to produce the input domestically. Alternatively, if the domestic suppliers of these inputs have monopoly power in the domestic market, the increased competition from offshored inputs could erode their monopoly power and consequently reduce p_n. A reduction in p_n will benefit non-offshoring firms. If p_n decreases in response to a decrease in λ, then $\frac{dc_n}{d\lambda} > 0$, and hence, non-offshoring firms experience a *substitution-productivity effect* similar to the one described earlier for offshoring firms.

In our model we also take the intrinsic productivity of each firm as a given after it has drawn its productivity from a given distribution. The only change we see is in effective productivity that results from greater offshoring due to a fall in the trading cost of the offshored input. There is no other productivity effect of trade in our model, in the form of learning, R&D etc. There is empirical evidence showing a positive productivity effect of import competition which makes firms more efficient. This comes not only from the imports of inputs but also from the imports of competing foreign products. This is especially seen in the recent empirical work on trade liberalization and productivity, where the effects of output and input tariff liberalization are separated (Amiti and Konings, 2007 and Khandelwal and Topalova, 2010).

3 Data Description

3.1 Firm-level Variables

The firm-level Korean panel data are drawn from the Survey of Business Activity (SBA) for the years 2006-2011. Conducted by Statistics Korea, this survey covers all business entities with a capital stock greater than US$300,000 and employment greater than 50 regular workers. Restricting ourselves to the manufacturing sector, our sample consists of 8,094 firms and 33,098 observations. Our firm-level imports, exports, sales, capital stock and employment data come from the SBA.

3.2 Trade Cost

The sectoral trade cost is an important determinant of offshoring, imports and exports. To match with our firm-level data, the trade cost is constructed at the 3-digit level of the Korean Standard Industrial Classification (KSIC, revision 9). The specifics of the construction of the output and input trade costs are provided in the following subsections.

3.2.1 Output Trade Cost

We use the standard definition of output trade cost in the literature, which is the sum of the tariff and transport cost as a percentage of the value of imports. The import weighted sectoral tariff is arrived at by constructing a import-weighted average of all the 6-digit HS MFN import tariffs from the World Bank's World Integrated Trade Solution(WITS) within each 3-digit industry. We then use our own concordance between HS and KSIC to arrive at the KSIC 3-digit trade costs.

Since transport cost information between Korea and each of its partners is not available, we use as proxies the distance-adjusted transformations of the U.S. costs of shipping from the same countries.[4] The product level ad valorem transport cost can be defined as the ratio of import charge to the customs import value, where import charge is the cost of all freight, insurance and other charges in the process of export. The customs import value is the total value of imports at the border excluding duties and import charges.[5] Bernard, Jensen, and Schott (2006) calculated U.S. sectoral transport cost using the same data source. They found the import weighted average for the entire manufacturing sector to be 5.6% during the period 1977-81, 4.4% during 1982-86, and

[4] The data on industry transport costs are based on product-level transport costs which are available from "U.S. Imports of Merchandise" (obtained from Peter Schott's webpage). Collected by the US census bureau, this dataset contains direct transport cost information for each product from various countries of origin to the US. To use the U.S. transport cost data for the construction of Korean transport costs, we perform the following steps. First, we construct Korea's transport cost at the HS 6-digit level with each of its major trading partners, namely China, Japan, Southeast Asia, EU27, and North America (NAFTA). Since transport cost information between Korea and each of these partners is not available, we use as proxies the distance-adjusted transformations of the U.S. costs of shipping from the same countries. However, for these transformations to result in valid proxies it is important to make sure that the US import structure is close to Korea's, which we actually find to be the case. For example, there is a 98 percent overlap between the products imported by Korea and the US from China, while in the case of imports from the EU this overlap is 94 percent. There is also very significant overlap in products imported from other parts of the world. Finally, industry-level import weighted transport costs are computed after averaging product level costs weighted by imports. When we compute weights to be applied to product-level transport costs of imports from the EU, we use the total amount of imports from all EU27 member countries. Similarly, the imports from all three NAFTA countries are used as weights for arriving at Korea-US transport costs.

[5] Conventionally, matched partner c.i.f. to f.o.b. ratio from UN COMTRADE database is used as a commodity level transport cost measure. However, as Hummels and Lugovskyy (2006) pointed out, this indirect transport cost measure is not usable at the commodity level due to severe measurement error. They found only 10% of the ad valorem shipping costs (at the 2-digit level) to be in the 0-100% range.

4.1% during 1987-1991. Our simple average for the Korean case for the manufacturing sector for the period 2006-2010 turns out to be 2.6%, while the import-weighted average is 1.8%. Considering that our data are more recent and given Korea's proximity to China, we should expect this smaller average.

3.2.2 Input Trade Cost

Following Amiti and Konnings (2007), input trade cost is generated by taking the weighted average of the output trade cost with the weights from the Korean input-output table for the year 2005. The input trade cost computed using this method is highly correlated with the output trade cost, with correlation coefficient being 0.89 for 2008 and 0.87 overall. This makes it difficult to identify separately the impact of the input and output trade costs when both trade costs are simultaneously included in the same regression. For this reason, we also construct an alternative input trade cost measure by excluding diagonal elements of the input-output table from our computations. The correlation coefficient between the output trade cost and the alternative input trade cost measure is much lower, 0.61 for 2008 and 0.57 overall.

3.2.3 Input Elasticity of Substitution

Input substitutability significantly affects the overall effect of offshoring on firm level domestic labor demand. The data on output elasticity of substitution are from Broda and Weinstein (2006) and are the estimates of the elasticity of substitution betwen product varieties for the U.S. during the period 1990-2001.[6] This output elasticity of substitution estimate for each product (SITC rev.3) is first converted to HS code (6 digit) and is then assigned to KSIC industries using a concordance table we have created. Then using the level of imports as weights, our 3-digit industry level output elasticity of substitution measure is created. Finally, the input elasticity of substitution measure is obtained by using input-output tables in the same way these weights were used for constructing the input trade cost.

Table 1 provides all the summary statistics of the main variables used in this paper.

4 Empirical Results

While our main interest in the paper lies in studying the relationship of trade and trade costs with employment, we begin our empirical exercise by looking at the relationship between trade costs and firm level trade since, using our access to firm-level trade, we want to confirm that the impacts of changes in trade costs on employment are indeed taking place through changes in firm-level trade flows.

[6] The estimates are publicly available at David Weinstein's website.

4.1 Relationship between trade costs and firm level trade

We first look at the impact of trade costs on firm exports. As discussed in the theoretical section, our model predicts that a decrease in τ or λ increases exports at both the intensive and extensive margins. Table 2 shows the impact of industry level trade costs on firm level exports. All columns in Table 2 show results from the estimation of regressions with random firm effects along with year fixed effects. While OTC denotes output trade cost (our proxy for τ), ITC denotes input trade cost (our proxy for λ). In columns (1) and (2), we see a negative and significant impact of input and output trade costs respectively on the intensive margin of exports. A one percentage point reduction in the input trade cost (which is on average more than a 10 percent reduction) leads to a 3.8 percent increase in the intensive margin of exports (in firm-level exports), while a one percentage point reduction in the output trade cost (which is again on average more than a 10 percent reduction) leads to a 2.7 percent increase in the intensive margin of exports.

At the level of disaggregation at which we are performing our study and at which the input-output table for Korea is constructed, the diagonal elements of the input-output table are large in magnitude. In other words, the input of a 3-digit industry into itself is large, which results in a very high correlation between the input and output tariffs, in turn making it difficult to identify their effects separately when thrown into the right-hand side of a regression simultaneously. Therefore, we construct a modified input trade cost variable based on the off-diagonal elements of the input-output matrix applied to industry-level output trade costs. This is the input trade cost measure, denoted by $ITC2$ used in all our regressions in which both input and output trade costs are thrown in simultaneously. Column (3) shows the results of such a regression, where again we have random firm effects and year fixed effects. Here a one percentage point decrease (on average a 10 percent decrease) in the input trade cost leads to a 2 percent increase in the intensive export margin. The impact of the output trade cost here is also the same in terms of both sign and magnitude.

From columns (4) through (6), where we look at the extensive margin using linear probability models again with random firm effects and year fixed effects, we see that the impact of a percentage point decrease in the input trade cost is to increase the probability of exporting by 0.004-0.007, while a percentage point decrease in the output trade cost leads to an increase in this probability by 0.003-0.004. Thus, we can conclude from the results presented in Table 2 that input and output trade cost reductions increase both the volume of exports of exporting firms as well as the probability of firms exporting.

Note that we have assumed symmetry in the output trade costs across exports and imports. That is, our measure of output trade cost is based on industry tariffs in Korea and the transport cost between Korea and its trading partners. We are assuming that this output trade cost is faced by both Korean exporters and firms exporting to Korea. A partial justification for this assumption is that an important component of our measure of trade cost is transport cost. Transport costs are really symmetric even empirically, so a reduction in them either over time within the same industry or as we move from one industry to another over time will mean that the costs of both importing competing products as well as of exporting go down. Another justification is based on the reciprocity of tariff reductions arising from negotiations at the WTO. Therefore, a reduction in the output trade costs will result in an increase in the intensive and extensive margins of exports.

We next turn our attention to the impact of trading costs on firm level imports. As discussed in the theoretical section, a decrease in the trading cost (both input and output trading cost) has a direct positive effect on imports but there is an indirect negative effect rendering the theoretical impact ambiguous. Table 3 reports results of the impact of trading costs on firm level imports. Once again, all columns in Table 3 show results from regressions with random firm effects along with year fixed effects. In columns (1) and (2), we see a negative and significant impact of input and output trade costs respectively on the intensive margin of imports. A one percentage point reduction in the input trade cost (more than a 10 percent reduction) leads to a 1.4 percent increase in the intensive margin of imports (in firm-level imports of inputs), while a one percentage point reduction in the output trade cost (again on average more than a 10 percent reduction) leads to a 0.8 percent increase in the intensive margin of imports.

Column (3) shows the results of a regression where our modified input trade cost ($ITC2$) and the output trade cost variables are thrown in simultaneously into the right-hand side. Here a one percentage point decrease (on average a 10 percent decrease) in the input trade cost leads to a 1 percent increase in the intensive import margin. A one percentage point decrease in the output trade cost leads to a 0.5 percent increase in the intensive import margin. From columns (4) through (6), where we look at the extensive margin using linear probability models again with random firm effects and year fixed effects, we see that the impact of a percentage point decrease in the input trade cost is to increase the probability of importing by 0.003-0.004, while a percentage point decrease in the output trade cost leads to an increase in the probability of importing by 0.001-0.002. Therefore, the results in Table 3 show that the impact of a decrease in the trading cost (both input and output trading cost) is to increase imports both at the intensive and extensive margins. Empirically, the direct effect seems to outweigh the countervailing indirect effect of a decrease in trading costs on firm level imports.

While some of the results on the impact of trading costs on firm level trade may be obvious, it is worth highlighting the link between exports and imports. We found evidence that a decrease in the input trading cost increases exports by making firms more competitive in the export market. Similarly, a reduction in the output trading cost increases imports because a boost to firm exports gives a boost to their demand for imported inputs as well.

Now we turn our attention to the relationship between employment and trading costs.

4.2 Relationship between trade costs and employment

To empirically study the relationship between trade costs and firm employment, we first try the following simple specification:

$$\ln(L_{ijt}) = \alpha_i^L + \alpha_j^L + \alpha_t^L + \beta_1^L TC_{jt} + \mathbf{Z}_{ijt}\Gamma^L + \varepsilon_{ijt}^L,$$

where TC_{jt} is the output trade cost (OTC) or the input trade cost (ITC) discussed earlier. Recall from the theoretical section that the impact of the input trade cost on employment depends crucially on the *substitution-productivity* effect. Our theoretical model predicts that a decrease in the input trade cost, λ, is likely to reduce employment if $\rho - \sigma > 0$ and increase employment in the opposite case via the *substitution-productivity* effect.[7] To capture the *substitution-productivity* effect in this simple framework, we split the sample into the case where intermediate inputs are on average complements of each other and the case where they are substitutes**.** There are two ways we do these splits: on the basis of the median of the degree of input substitutability minus the degree of substitutability between varieties of the final product (here on called output substitutability) and, alternatively, based solely on the median degree of input substitutability. We use here the Broda-Weinstein elasticity of substitution. We expect a decline in the input trade cost to reduce employment in the high $\rho - \sigma$ industries and the opposite in the low $\rho - \sigma$ industries. That is, we expect $\beta_1^L > 0$ in the former industries and $\beta_1^L < 0$ in the latter industries.

The results are presented in Table 4. All these regressions are random firm effects regressions with year fixed effects. We perform the regressions in table 4 by splitting the sample two ways: on the basis of the median of the degree of input substitutability minus the degree of substitutability between varieties of the final product (here on called output substitutability) in table 4a and, alternatively, based solely on the median degree of input substitutability in table 4b. Columns 1 and 2 in tables 4a and 4b use ITC as the measure of input trade cost. Fairly consistent with our theory, the coefficient of ITC (estimate of β_1^L) switches sign from positive to negative as we move from the substitutable input subsample to the complementary input subsample. Also, the estimate of β_1^L is statistically significant in each case. The coefficient estimates imply that for a one percentage point decline in the input trade cost (which is more than a 10 percent reduction), employment decreases by 0.2-0.4% in the substitutable input case but increases by 1.3-2.2% in the complementary inputs case. Columns 3 and 4 in both the panels of table 4 use OTC instead of ITC and the results are qualitatively similar to those obtained for ITC. Finally, columns 5 and 6 show the results when $ITC2$ (our modified input trade cost measure) and OTC are thrown in simultaneously as was done earlier while studying the relationship between firm level trade and trade costs. Again, the results are qualitatively similar.

[7] Strictly speaking, in our model the *substitution-productivity* effect applies only to offshoring firms. However, in practice, non-offshoring firms can also be similarly affected through the competitive pressure of the trade cost decline on the market for domestically produced intermediate inputs (produced outside the final goods firm).

Intuitively, as the input trade costs fall and the imported inputs become cheaper, if the imported inputs are substitutes of in-house inputs (produced using domestic labor), then this fall in the price of inputs results in a decrease in firm employment. If the imported inputs are complements to in-house labor, then this fall in their price will lead to an increase in the firm-level demand for domestic labor. It is important to note that this could also mean that a fall in the trade cost could put greater competitive pressure even on the market for domestically produced intermediate inputs (produced outside the final goods firm), thereby also making them cheaper. This would also lead to the same result for non-offshoring firms. As mentioned above, the sign also switches in the same way for the coefficient of the output trade cost, OTC. However, we should not read much into the sign of the output trade cost coefficient as it might just be a combination of various possible effects.[8]

4.3 Relationship between firm level trade and employment

While the results from the simple regression above show the relationship between trade costs and employment which are consistent with the theoretical results, below we attempt to run regressions which are more closely tied with the theoretical predictions of the model. Based on the empirical implications derived in the theoretical section, we first run regressions that follow directly from our comparative statics with respect to τ and λ. Defining $EXP_{ijt} \in \{0,1\}$ and $IMP_{ijt} \in \{0,1\}$ as the exporting and importing dummies respectively, we first run the following two regressions.

$$\ln(L_{ijt}) = \alpha_i^L + \alpha_j^L + \alpha_t^L + \beta_1^L EXP_{ijt} + \beta_2^L \tau_{jt} + \beta_3^L EXP_{ijt}\tau_{jt} + \mathbf{Z}_{ijt}\Gamma^L + \varepsilon_{ijt}^L. \tag{17}$$

$$\ln(L_{ijt}) = \widetilde{\alpha}_i^L + \widetilde{\alpha}_j^L + \widetilde{\alpha}_t^L + \widetilde{\beta}_1^L EXP_{ijt} + \widetilde{\beta}_2^L \lambda_{jt} + \widetilde{\beta}_3^L (\rho_j - \sigma_j) IMP_{ijt}\lambda_{jt} + \widetilde{\beta}_4^L (\rho_j - \sigma_j) EXP_{ijt} IMP_{ijt}\lambda_{jt} + \mathbf{Z}_{ijt}\Gamma^L + \widetilde{\varepsilon}_{ijt}^L. \tag{18}$$

Theory predicts that $\beta_1^L > 0$, $\beta_2^L > 0$ and $\beta_3^L < 0$. $\beta_1^L > 0$ because exporting firms should have higher employment to meet export demand. $\beta_2^L > 0$ because a decrease in τ should reduce employment for non-exporting firms, while $\beta_3^L < 0$ captures the fact that the impact of a decrease in τ on exporting firms, given by $\beta_2^L + \beta_3^L$, is ambiguous.

[8] On the one hand, purely domestic firms face greater competition from foreign firms and also there is the so-called "selection effect," where the marginal firm that continues to operate is a higher-productivity firm after the output trade cost falls. This leads to higher average productivity and lower average marginal cost and average price (across the surviving firms), which reduces firm-level labor demand. Exporting firms increase their employment through a bigger foreign market but decrease their employment through the selection effect in the domestic market. On top of all this, there could be the positive productivity impact of falling trade costs, for which there is considerable support in the existing literature. Finally, as we have discussed earlier, a large part of the inputs is produced within a sector as seen in the large diagonal elements of the input-output matrix. Thus the the output trade costs might be capturing some of the input cost effects.

Similarly in the regression equation with offshoring costs, $\widetilde{\beta}_1^L > 0$ again captures the higher employment of exporting firms to meet export demand. $\widetilde{\beta}_2^L > 0$ captures the impact of a change in the offshoring cost on non-trading firms. For firms that export but do not offshore, the impact of a change in offshoring cost will still be simply $\widetilde{\beta}_2^L > 0$ since their costs do not change in either the domestic market or export market. $\widetilde{\beta}_2^L + \widetilde{\beta}_3^L(\rho_{jt} - \sigma_{jt})$ captures the impact on offshoring firms that do not export, and $\widetilde{\beta}_2^L + \left(\widetilde{\beta}_3^L + \widetilde{\beta}_4^L\right)(\rho_j - \sigma_j)$ captures the impact on offshoring firms that export as well. We expect $\widetilde{\beta}_3^L > 0$ and $\widetilde{\beta}_4^L > 0$.[9] We do not present these results since they are inconclusive.[10] This might have something to do with the fact that while our dependent variable is at the firm level, the trade cost variables are at the industry level, thereby providing inadequate variation for the detailed identification across different types of firms (exporting, offshoring, non-offshoring etc.) to take place.

Since we have firm level data on imports and exports, and have seen earlier that firm level exports and imports are responsive to trade costs in the expected way, we present the results of the regressions described below which use firm level trade data instead of using the industry level trade cost data. An additional motivation for using firm level trade data is that trade could increase even in the absence of any changes in our trade cost measures based on tariffs and transportation costs. This can happen because improvements in communication technology can reduce the cost of managing global supply chains and coordinating production over distances. Given firm heterogeneity, these changes could affect firms differently, something that we capture in our theoretical model by introducing firm specific exporting and importing costs, t_x and t_o, respectively.

As noted earlier, when $\rho - \sigma > 0$, we expect a decrease in the offshoring cost to reduce domestic employment for offshoring firms due to the *substitution-productivity* effect, and hence we expect firm imports of inputs and their domestic employment to move in opposite directions. Similarly, when $\rho - \sigma < 0$ we expect domestic employment of firms to increase in response to a decrease in offshoring cost, therefore, firm imports and their domestic employment should move in the same direction. While we have talked about these effects in the context of changes in the general component of offshoring cost, λ, they remain valid in response to a decrease in the firm-specific offshoring cost t_o. Given this, we estimate the following relationship.

$$\begin{aligned} \ln(L_{ijt}) &= \alpha_i^{L'} + \alpha_j^{L'} + \alpha_t^{L'} + \beta_1^{L'} EXP_{ijt} + \beta_2^{L'} \ln(1 + imports_{ijt}) + \beta_3^{L'}(\rho_j - \sigma_j)\ln(1 + imports_{ijt}) \\ &\quad + \beta_4^{L'}(\rho_j - \sigma_j) EXP_{ijt} \ln(1 + imports_{ijt}) + \mathbf{Z}_{ijt}\Gamma^{L'} + \varepsilon_{ijt}^{L'} \end{aligned} \tag{19}$$

$\beta_1^{L'} > 0$ will again capture the higher employment of exporting firms compared to non-exporting firms. We

[9] In industries where $(\rho_{jt} - \sigma_{jt}) > 0$ a decrease in λ will cause employment to decrease due to the substitution-productivity effect. Therefore, we expect $\widetilde{\beta}_3^L(\rho_{jt} - \sigma_{jt}) > 0$. In industries where $(\rho_{jt} - \sigma_{jt}) < 0$, a decrease in λ will cause employment to increase due to the substitution-productivity effect. That is, we expect $\widetilde{\beta}_3^L(\rho_{jt} - \sigma_{jt}) < 0$ in this case. Therefore, we expect $\widetilde{\beta}_3^L > 0$. Using the same reasoning we expect $\widetilde{\beta}_4^L > 0$ as well.

[10] The results are available upon request. We find the estimates of β_1^L and $\widetilde{\beta}_1^L$ to be positive and significant but the the estimates of other coefficients of interest are statistically insignificant.

add one to the level of imports before taking logs to keep the zero-import observations in the regression. $\beta_2^{L'}$ captures the relationship between imports (offshoring) and employment for firms in the industry where the *substitution-productivity* rought zero ($\rho_j \approx \sigma_j$). For firms that do not export, the relationship between imports and employment is captured by $\beta_2^{L'} + \beta_3^{L'}(\rho_j - \sigma_j)$. We expect $\beta_3^{L'} < 0$ because when $\rho_j > \sigma_j$ imports are negatively related with firm level employment while when $\rho_j < \sigma_j$ the two are positively related. For importing firms that export as well, the relationship is captured by $\beta_2^{L'} + \left(\beta_3^{L'} + \beta_4^{L'}\right)(\rho_j - \sigma_j)$. We expect $\beta_4^{L'} < 0$. The qualitative relationship between offshoring cost and employment for offshoring firms is same irrespective of their exporting status, however, the quantitative impact is stronger for exporting firms because the latter experience the *substitution-productivity* effect both for their domestic sales and export sales. We capture this additional effect for exporting firms through the $\beta_4^{L'}(\rho_j - \sigma_j)$ term.

Table 5 provides estimates of equation (19). These regressions are run as plain OLS and with random firm effects and year fixed effects, with and without industry effects. The results in table 5 seem to be somewhat but not totally consistent with our theoretical predictions. The estimate of $\beta_1^{L'}$ is positive and significant confirming that exporting firms have larger employment. The estimate of $\beta_2^{L'}$ is positive and significant suggesting that for industries with $\rho_j = \sigma_j$, imports of inputs increase firm-level employment. The estimate of $\beta_3^{L'}$ is negative and significant when the industry fixed effect is not included but becomes insignificant upon the inclusion of industry fixed effects. Our theoretical prediction for $\beta_3^{L'}$ is negative. The estimate of $\beta_4^{L'}$is negative and significant in the OLS estimation but becomes insignificant in the random effects estimation. Our theoretical prediction for $\beta_4^{L'}$ is negative as well.

On the whole, the results here show that greater imports are associated with greater employment. This indicates that on average the imported inputs are complementary to domestic labor. However, there is some evidence, that this complementarity goes down with $(\rho - \sigma)$ as predicted by our theoretical model. We also find some evidence, albeit weak, that, consistent with our theoretical predictions the magnitude of this effect is greater for exporting firms. Finally, exporting is associated with higher labor demand in a robust fashion.

In order to capture these same qualitative results (as in Table 5), in Table 6 we present some simpler alternative specifications (not derived from theory) to make sure that our empirical results are robust to relaxing the structure imposed in our main estimating regression. We also want to see the impact of firm level trade on employment without the inclusion of our constructed measures of ρ and σ. We present here only the RE results, since RE is our preferred specification and no additional insights can be gained from the OLS results. Columns 1 and 4 include only imports as the explanatory variable with and without industry fixed effects. In both cases imports are positively related with firm level employment. Columns 2 and 4 add exporting status as well as its interaction with imports as additional explanatory variables. Exporting firms clearly have higher employment and the impact of increase in imports on employment is larger for exporting firms as suggested by the coefficient of $EXP \ln(1 + imports)$ term. Finally, in columns 3 and 6 we include the interaction of imports with $(\rho - \sigma)$. The negative and statistically significant coefficient of $(\rho - \sigma)ln(1 + imports)$ is consistent with the *substitution-productivity* effect derived in the theoretical model. That is, imports increase employment less in industries with substitutable inputs and more in industries with complementary inputs.

4.4 Results from the difference-in-difference estimation with propensity score matching

In the previous sub-section we captured the impact of importing/offshoring on employment. A potential problem with the above approach is that imports and import status are endogenous. Import status, imports and employment might be simultaneously determined as both are ultimately functions of the firm's intrinsic productivity. Thus larger firms (firms with higher output and employment levels) are the ones that are likely to offshore (import inputs). To solve this simultaneity or endogeneity problem we run a difference-in-difference regression with propensity score matching. Our method here is similar to the one used by Girma, Greenaway, and Kneller (2003).

First, we restrict the target sample to firms that are observed for the entire sample period, 2006-2011. Then, we define an import starter as a firm that became an importer in 2007, 2008, 2009 or 2010. The treatment group here consists of these firms, since our focus in this paper is on importing of inputs (or offshoring). We excluded complicated cases, namely firms that discontinued importing after they first entered the import market. Our control group consists of firms that did not import at all over our full six year sample period.

Matching of firms in the treatment group with those in the control group was performed on a cross-section by cross-section (year by year) basis. That is, for each year (2007, 2008, 2009 and 2010), the following probit model is estimated.

$$P(Import\ Starter_{it} = 1) = F(lnTFP_{i,t-1}, lnL_{i,t-1}, (Sales/WageBill)_{i,t-1}, EXP_{i,t-1}) \qquad (20)$$

where TFP is the total factor productivity, L is employment, and EXP is the export status. For each year for which we run the probit for propensity score matching, our sample for the probit regression consists of firms that start importing that year and those that do not import at all that year. For each import starting firm that year, a firm from the control group that is the closest in terms of the probability of starting importing that year is selected. After matched firms are identified for each year, all observations on matched firms across all years are pooled to create our final matched sample panel dataset.

To make sure our matching has been successful we perform a test of balancing hypothesis, which consists of t-tests of equality of means of the matching variables between the control and treatment groups. We also checked that for the matching variables the standardized bias, mean difference between treatment and control group adjusted by the square root of average sample variance, was small enough after matching. A rule of thumb is that it should ideally be less than 5% (in absolute value) after matching (Caliendo and Kopeinig, 2008).

We present the results for the matching performance in our propensity score matching in Table 7. We see that, for the initial year, the standardized bias prior to matching is very high - in the range of 25-80%. After matching this bias goes down to below 10 percent in all cases and below 5 percent in three out of four cases. While before matching we could easily reject the null hypothesis that the mean of each variable in the treatment group is the same as that in the control group, after matching we cannot reject this null for any of the variables.

To find out the impact of importing on the firm's total employment (or export volume), a difference-in-difference regression was run on the matched panel dataset as per the following estimating equation.

$$\ln L_{it} = \phi + \delta_1 IMP_{i,t-1} + f_i + D_t + \xi_{it} \tag{21}$$

where $IMP_{i,t-1}$ is a dummy variable which for firm i takes the value 1 if it is importing in year $t-1$ (and is 0 otherwise). Given the way our matched data set has been created, this variable takes the value 0 for a treatment firm until it starts importing, and from then on the variable takes the value 1 indicating the post import starting periods for firms in the treatment group. Since the impact of importing of inputs on employment might show up with a small lag and because we want to minimize the endogeneity problem, our right-hand side variable of interest is lagged by a year and δ_1 represents the one-year lagged average change in the outcome, y_{it}, attributable to the firm starting to import. We also experimented with alternatively using contemporaneous variables. However, since our results qualitatively did not change we do not present them here.

Table 8 presents results of the regression equation (21). Columns 1 and 4 present OLS and RE estimates of equation (21). The results show that importing of inputs leads to higher domestic employment. The coefficient of the lagged importing indicator is statistically significant at the 1 percent level in the OLS regression in column (1) and at 10% in column (3). The coefficient on lagged import in column (1) suggests that importing increases employment by 34%, while the RE estimate in column (3), focusing on the within variation, suggests a much smaller increase in employment of 2.3%.

Similar to equation (19) which was based on the theoretical model, we also run the following regression.

$$\begin{aligned} \ln L_{it} &= \phi' + \delta_1' EXP_{ijt-1} + \delta_2' IMP_{i,t-1} + \delta_3'(\rho_j - \sigma_j) IMP_{i,t-1} \\ &\quad + \delta_4'(\rho_j - \sigma_j) IMP_{i,t-1} EXP_{ijt-1} + f_i' + D_t' + \xi_{it}' \end{aligned} \tag{22}$$

Columns (2) and (4) in Table 8 present estimates of equation (22). Focusing on the RE specification in column (4) note that a firm that becomes an importer experiences a 2.2% increase in employment. Once again, this effect becomes smaller as $\rho - \sigma$ rises, as captured by the negative sign of the coefficient of $IMP(\rho - \sigma)$, which is consistent with our theoretical predictions. But the triple interaction term $IMP(\rho - \sigma)EXP$ is positive and significant in the RE specification, which is inconsistent with our theory. As before, there is very strong evidence from these regressions that exporters employ more workers than other firms.

Thus we find from our difference-in-difference estimation that, on average, importing inputs raises firm-level employment. This effect is stronger when the complementarity between imported inputs and domestically produced inputs is relatively high.

5 Conclusions

In this paper, we extend the small country trade model with firm heterogeneity, developed by Demidova and Rodriguez-Clare (2013), where we incorporate offshoring (along with final goods trade). Our theoretical model acts as a useful guide for empirically investigating the firm-level employment effects of input and final goods trade, especially when it comes to the effects that are heterogeneous across firms.

We perform our empirical investigation using firm-level data from Korea for the years 2006-2011, and data on trade costs for final goods as well as separately for intermediate goods or inputs, combining data from different sources and transforming, aggregating and concording according to our needs, specific to the country we study, namely Korea. There was also similar effort involved in the creation of our measures of input and output substitution.

Our empirical analysis yields several results, some of them fairly consistent with our theory and/or our economic intuition. As expected from theory, the correlation between input trade cost and firm employment changes from positive to negative as we move from the subsample of firms in industries where inputs are on average substitutable (foreign inputs and inputs domestically produced by in-house labor are substitutable) to the subsample of firms in complementary input industries.

We find that, on the whole, greater imports are associated with greater employment, indicating that on average the imported inputs are complementary to firm-level employment. Consistent with our theoretical predictions, this effect is magnified for exporting firms and in firms in industries where inputs are relatively more complementary to each other.

We use the approach of difference-in-difference with propensity score matching to address the simultaneity of imports, import status and employment. Across all our difference-in-difference specifications (with propensity score matching) importing (of inputs) leads to higher domestic firm-level employment. Moreover, as found with our other regressions, here as well the employment increasing impact of importing inputs from abroad is greater when input complementarity is higher.

References

[1] Amiti, M. and D. R. Davis (2012): "Trade, Firms, and Wages: Theory and Evidence", Review of Economic Studies, 79(1), 1-36.

[2] Amiti, M. and J. Konings (2007): "Trade Liberalization, Intermediate Inputs, and Productivity : Evidence from Indonesia," *American Economic Review*, 97(5), 1611-1638.

[3] Bernard, A. B., J. B. Jensen and P. K. Schott (2006): "Trade Costs, Firms and Productivity," *Journal of Monetary Economics*, 53, 917-937.

[4] Biscourp, P. and F. Kramarz (2007): "Employment, Skill Structure and International Trade: Firm-Level Evidence for France." *Journal of International Economics*, 72(1), 22-51.

[5] Broda, C. and D. E. Weinstein (2006): "Globalization and the Gains from Variety," *The Quarterly Journal of Economics*, 121(2), 541-585.

[6] Caliendo, M. and S. Kopeinig (2008): "Some Practical Guidance for the Implementation of Propensity Score Matching," *Journal of Economic Surveys*, 22(1), 31-72.

[7] Demidova, S. and A. Rodriguez-Clare (2013): "The Simple Analytics of the Melitz Model in a Small Economy," *Journal of International Economics*, 90(2), 266-272.

[8] Feenstra, R. C., J. Romalis and P. K. Schott (2002): "U.S. Imports, Exports, and Tariff Data, 1989-2001," NBER Working Papers 9387, National Bureau of Economic Research, Inc.

[9] Girma, S., D. Greenaway and R. Kneller (2003): "Export Market Exit and Performance Dynamics: A Causality Analysis of Matched Firms," *Economics Letters*, 80, 181-187.

[10] Goldberg, P. K., A. K. Khandelwal, N. Pavcnik, and P. Topalova (2010): "Imported Intermediate Inputs and Domestic Product Growth : Evidence from India," *Quarterly Journal of Economics*, 125(4), 1727-1767.

[11] Groizard, J.L., P. Ranjan and A. Rodriguez-Lopez (2015): "Trade Costs and Job Flows: Evidence from Establishment-Level Data," *Economic Inquiry*, 53(1), 173-204.

[12] Hummels, D. and V. Lugovskyy (2006): "Are Matched Partner Trade Statistics a Usable Measure of Transportation Costs?," *Review of International Economics*, 14(1), 69-86.

[13] Levinsohn, J. (1999): "Employment Responses to International Liberalization in Chile," *Journal of International Economics* , 47(2), 321-344.

[14] Melitz, M. J. (2003): "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 71(6), 1695-1725.

[15] Pavcnik, N. (2002): "Trade liberalization, exit, and productivity improvement: Evidence from Chilean plants," *Review of Economic Studies* 69 (1), 245–76.

[16] Rauch J. E. (1999): "Network versus Markets in International Trade," *Journal of International Economics*, 48, 7-35.

[17] Topalova, P. and A. Khandelwal (2011): "Trade Liberalization and Firm Productivity: The Case of India," *Review of Economics and Statistics*, 93(3), 995-1009.

6 Appendix

6.1 Condition for the marginal surviving firm to neither export nor offshore

For the marginal firm to not export, it must be the case that

$$\left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_n}{\widehat{\varphi}}\right)^{1-\sigma}\left(\frac{\tau^{1-\sigma}A}{\sigma}\right) < f_x$$

That is, even if the firm gets the lowest possible draw of exporting variable cost t_x which is 1, it still cannot cover the fixed cost of exporting, and hence it doesn't export.

In order for this firm to not offshore it must be the case that

$$\left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_o(\psi)|_{t_o=1}}{\widehat{\varphi}}\right)^{1-\sigma}\frac{P^{\sigma-\eta}\mathbb{L}}{\sigma} < f+f_o.$$

That is, even if the firm gets the most favorable draw of t_o which is 1, it still doesn't find it worthwhile to offshore. Since (9) is satisfied for this firm, the above can be written as

$$\left(\frac{c_n}{c_o(\psi)|_{t_o=1}}\right)^{\sigma-1} f < f+f_o. \tag{23}$$

So, if the above condition is satisfied, then the marginal existing firm doesn't offshore.

Can this firm do both if either of them alone is not possible? This will not be possible if

$$\left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_o(\psi)|_{t_o=1}}{\widehat{\varphi}}\right)^{1-\sigma}\left(\frac{P^{\sigma-\eta}\mathbb{L}+\tau^{1-\sigma}A}{\sigma}\right) - f - f_o - f_x < 0$$

Substituting out $P^{\sigma-\eta}$ using (9) the above can be written as

$$\left(\frac{c_n}{c_o(\psi)|_{t_o=1}}\right)^{\sigma-1} f - f - f_o + \left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_o(\psi)|_{t_o=1}}{\widehat{\varphi}}\right)^{1-\sigma}\frac{\tau^{1-\sigma}A}{\sigma} - f_x < 0$$

In light of (23) a sufficient condition for the above is that

$$\left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_o(\psi)|_{t_o=1}}{\widehat{\varphi}}\right)^{1-\sigma}\left(\frac{\tau^{1-\sigma}A}{\sigma}\right) - f_x < 0$$

We know that the firm cannot export when it is not offshoring: $\left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_n}{\widehat{\varphi}}\right)^{1-\sigma}\left(\frac{\tau^{1-\sigma}A}{\sigma}\right) < f_x$. In order for this firm to not export when offshoring a sufficient condition is $\left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_o(\psi)|_{t_o=1}}{\widehat{\varphi}}\right)^{1-\sigma}\left(\frac{\tau^{1-\sigma}A}{\sigma}\right) < f_x$. Since if this condition is satisfied, the condition $\left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_n}{\widehat{\varphi}}\right)^{1-\sigma}\left(\frac{\tau^{1-\sigma}A}{\sigma}\right) < f_x$ is satisfied as well. Therefore, the condition needed for the marginal firm to neither export nor offshore is

$$\begin{aligned}\left(\frac{c_n}{c_o(\psi)|_{t_o=1}}\right)^{\sigma-1} f &< f+f_o;\\ \left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_o(\psi)|_{t_o=1}}{\widehat{\varphi}}\right)^{1-\sigma}\left(\frac{\tau^{1-\sigma}A}{\sigma}\right) &< f_x.\end{aligned}$$

Suppose A is proportional to the domestic market size: $A = \mu P^{\sigma-\eta}\mathbb{L}$, where μ is the proportionality factor. Now, the second condition above becomes

$$\left(\frac{c_n}{c_o(\psi)|_{t_o=1}}\right)^{\sigma-1} \mu\tau^{1-\sigma} f < f_x$$

That is, the common exporting costs (τ and f_x) should be sufficiently large so that even if the firm gets the best possible draw of firm specific trading cost, it still doesn't want to export.

6.2 Existence proof

We show that $\frac{d\Pi}{d\widehat{\varphi}} < 0$. Taking the derivative of (11) with respect to $\widehat{\varphi}$ obtain

$$\frac{d\Pi}{d\widehat{\varphi}} = -\int_{t_o}\int_{t_x} \pi(\psi|_{\widehat{\varphi}}, \widehat{\varphi}; \tau, \lambda) g(\psi) dt_x dt_o + \int_{\widehat{\varphi}}^{\infty}\int_{t_o}\int_{t_x} \frac{\partial\pi(\psi, \widehat{\varphi}; \tau, \lambda)}{\partial\widehat{\varphi}} g(\psi) dt_x dt_o d\varphi, \tag{24}$$

where $\psi|_{\widehat{\varphi}} = (\widehat{\varphi}, t_x, t_o)$. Next, note that $\pi(\psi|_{\widehat{\varphi}}, \widehat{\varphi}; \tau, \lambda) = 0$ for all t_x, t_o because a firm with productivity $\widehat{\varphi}$ neither offshores nor exports and the net profits are zero for this firm by construction. Moreover $\frac{\partial\pi(\psi,\widehat{\varphi};\tau,\lambda)}{\partial\widehat{\varphi}} < 0$ as can be easily verified from (10). Therefore, $\frac{d\Pi}{d\widehat{\varphi}} < 0$, and hence the equilibrium exists if the initial conditions are correct. We need $\Pi > f_e$ when $\widehat{\varphi} \to \varphi_{\min}$ and $\Pi < f_e$ when $\widehat{\varphi} \to \infty$.

6.3 Impact of changes in τ and λ on $\widehat{\varphi}$

The free entry condition (11) implies

$$\frac{d\Pi}{d\tau} \equiv \frac{\partial\Pi}{\partial\widehat{\varphi}}\frac{d\widehat{\varphi}}{d\tau} + \frac{\partial\Pi}{\partial\tau} = 0$$

From the expression for Π in (11)

$$\frac{\partial\Pi}{\partial\tau} \equiv \int_{\widehat{\varphi}}^{\infty}\int_{t_o}\int_{t_x} \frac{\partial\pi(\psi, \widehat{\varphi}; \tau, \lambda)}{\partial\tau} g(\psi) dt_x dt_o d\varphi < 0$$

The inequality above follows from the fact that $\frac{\partial\pi(\psi,\widehat{\varphi};\tau,\lambda)}{\partial\tau} \le 0$ (easily verified from (10)) for any ψ. Since (24) yields $\frac{\partial\Pi}{\partial\widehat{\varphi}} < 0$, we get

$$\frac{d\widehat{\varphi}}{d\tau} = -\frac{\partial\Pi}{\partial\tau}/\frac{\partial\Pi}{\partial\widehat{\varphi}} < 0$$

Similarly,

$$\frac{d\Pi}{d\lambda} \equiv \frac{\partial\Pi}{\partial\widehat{\varphi}}\frac{d\widehat{\varphi}}{d\lambda} + \frac{\partial\Pi}{\partial\lambda} = 0$$

Again, from the expression for Π in (11)

$$\frac{\partial\Pi}{\partial\lambda} \equiv \int_{\widehat{\varphi}}^{\infty}\int_{t_o}\int_{t_x} \frac{\partial\pi(\psi, \widehat{\varphi}; \tau, \lambda)}{\partial\lambda} g(\psi) dt_x dt_o d\varphi < 0$$

Once again, the inequality above follows from the fact that $\frac{\partial\pi(\psi,\widehat{\varphi};\tau,\lambda)}{\partial\lambda} \le 0$ for any ψ as is easily verified from (10). Therefore,

$$\frac{d\widehat{\varphi}}{d\lambda} = -\frac{\partial\Pi}{\partial\lambda}/\frac{\partial\Pi}{\partial\widehat{\varphi}} < 0$$

6.4 Impact of trade costs on firm level trade

Since the export demand for a firm is $z^x(\psi) = p^x(\psi)^{-\sigma} A = \left(\left(\frac{\sigma}{\sigma-1} \right) \frac{\tau t_x c_s(\psi)}{\varphi} \right)^{-\sigma} A$, clearly, $\frac{\partial z^x(\psi)}{\partial \tau} < 0$, that is, a decrease in the output trade cost increases exports. It also follows that the revenue from exporting is $z^x(\psi) p^x(\psi) = p^x(\psi)^{1-\sigma} A = \left(\left(\frac{\sigma}{\sigma-1} \right) \frac{\tau t_x c_s(\psi)}{\varphi} \right)^{1-\sigma} A$. Therefore, $\frac{\partial z^x(\psi) p^x(\psi}{\partial \tau} < 0$. That is, a lower output trade cost increases export revenue, and hence given the fixed cost of exporting, a firm is more likely to export.

It can also be verified that $\frac{\partial z^x(\psi)}{\partial \lambda} \leq 0$ because $\frac{\partial c_s(\psi)}{\partial \lambda} \geq 0$. Recall from the text that when $s = o$, $\frac{dc_o(\psi)}{d\lambda} > 0$ and when $s = n$, then $\frac{dc_n(\psi)}{d\lambda} = 0$. That is, a decrease in the offshoring cost also increases exports and increases the probability of a firm exporting.

Given the unit cost for Y in (5), Shephard's lemma implies the following expression for firm level imports or offshoring derived from the domestic sales of a firm.

$$M^d = \left((1-\alpha)^{\rho} c_s(\psi)^{\rho} / \varphi \right) p_o^{-\rho} p(\psi)^{-\sigma} P^{\sigma-\eta} \mathbb{L}$$

Since the price of offshored input is $p_o(\psi) = \lambda t_o p_M^*$, the above can be written as

$$M^d = \left((1-\alpha)^{\rho} c_s(\psi)^{\rho} / \varphi \right) \left(t_o p_M^* \right)^{1-\rho} \lambda^{-\rho} p(\psi)^{-\sigma} P^{\sigma-\eta} \mathbb{L}$$

Next, substituting out $p(\psi)$ and P in the above expression using equations (6) and (9) obtain

$$M^d = (1-\alpha)^{\rho} \left(t_o p_M^* \right)^{-\rho} \lambda^{-\rho} (\sigma - 1) \left(c_s(\psi)^{\rho-\sigma} \right) \left(\frac{\varphi c_n}{\widehat{\varphi}} \right)^{\sigma-1} f$$

Taking the log of the above obtain

$$\log M^d(\psi) = cons\tan t - \rho \log \lambda + (\rho - \sigma) \log (c_s(\psi)) + (\sigma - 1) (\log \varphi - \log \widehat{\varphi})$$

Verify that the direct effect of a change in λ on imports (ignoring the effect on $\widehat{\varphi}$) is as follows.

$$\frac{\partial \log M^d(\psi)}{\partial \lambda} = -\frac{\rho}{\lambda} + \frac{(\rho - \sigma)}{\lambda} \frac{(1-\alpha)^{\rho} \left(\lambda t_o p_M^* \right)^{1-\rho}}{\alpha^{\rho} + (1-\alpha)^{\rho} \left(\lambda t_o p_M^* \right)^{1-\rho}}$$

Verify from above that $\frac{\partial \log M^d(\psi)}{\partial \lambda} < 0$. That is, the direct effect of a decrease in λ is to increase imports at the firm level. It is straightforward to verify that a firm is more likely to offshore the lower the λ. The indirect effect working through $\widehat{\varphi}$ will go in the opposite direction because $\frac{d\widehat{\varphi}}{d\lambda} < 0$ as shown above.

The above expressions are for the domestic sales of a firm. For exporting firms, there will be an additional term corresponding to the export sales with a similar effect. That is, the imported inputs needed in export sales is given by

$$M^x = (1-\alpha)^{\rho} \left(\frac{\sigma}{\sigma - 1} \right)^{-\sigma} \left(t_o p_M^* \right)^{-\rho} \lambda^{-\rho} \left(c_s(\psi)^{\rho-\sigma} \right) (\tau t_x)^{1-\sigma} \varphi^{\sigma-1} A$$

Again, $\frac{\partial \log M^x(\psi)}{\partial \lambda} < 0$.

As well, for exporting firms, we also get $\frac{\partial \log M^x(\psi)}{\partial \tau} < 0$. That is, a decrease in output trading cost increases their exports and consequently increases their demand for imported inputs.

Note also that changes in τ affect all firms indirectly through their domestic sales because $\frac{d \log M^d(\psi)}{d\tau} > 0$ follows from $\frac{d\widehat{\varphi}}{d\tau} < 0$. That is, the import of all firms is adversely affected by a decrease in τ due to the effect of τ on $\widehat{\varphi}$.

6.5 Expressions for Employment

Given the unit cost for Y in (5), Shephard's lemma implies that labor requirement per unit of output for a firm with productivity φ and offshoring status s is given by $\alpha^\rho c_s(\psi)^\rho/\varphi$, for $s \in \{n, o\}$. Therefore, $L_s(\psi) = (\alpha^\rho c_s(\psi)^\rho/\varphi)\, z(\psi)$. Next, we use (2) for $z(\psi)$ to get $L_s^d(\psi) = (\alpha^\rho c_s(\psi)^\rho/\varphi)\, p(\psi)^{-\sigma} P^{\sigma-\eta}\mathbb{L}$ as the labor requirement to meet domestic demand. Lastly, substitute out $p(\psi)$ and P using equations (6) and (9) to obtain

$$L_s^d(\psi) = \alpha^\rho\,(\sigma-1)\left(c_s(\psi)^{\rho-\sigma}\right)\left(\frac{\varphi c_n}{\widehat{\varphi}}\right)^{\sigma-1} f \text{ for } s \in \{n, o\}$$

For exporting firms, the export demand is $z^x(\psi) = p^x(\psi)^{-\sigma} A = \left(\left(\frac{\sigma}{\sigma-1}\right)\frac{\tau t_x c_s(\psi)}{\varphi}\right)^{-\sigma} A$, therefore, they need to ship $\tau t_x z^x(\psi)$, and hence we get the following labor requirement for exports

$$L_s^x(\psi) = \alpha^\rho \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} c_s(\psi)^{\rho-\sigma}\,(\tau t_x)^{1-\sigma}\,\varphi^{\sigma-1} A$$

Combining the above, we obtain the expression for employment presented in the text.

Table 1 < Summary Statistics >

Variable	Mean	Std. Deviation	Min	Max	Obs.
ln(import)	8.280	2.239	0	17.67	14,551
IMP	0.440	0.496	0	1	33,104
ln(export)	8.678	2.259	0	18.37	19,849
EXP	0.600	0.490	0	1	33,104
OTC	9.691	10.994	0.235	152.47	32,113
ITC	9.056	8.892	1.908	81.50	31,953
ITC2	8.784	8.304	2.320	60.30	31,953
ρ-σ	-0.429	12.4	-94.27	21.07	75
ln(market share)	-7.030	1.584	-16.08	-0.170	33,094

Note: EXP and IMP are indicator variables for exporting and importing firms.

Table 2 < Impact of Trade Cost on Exports >

	Intensive Margin : ln(export)			Extensive Margin : Prob(export>0)		
	(1)	(2)	(3)	(4)	(5)	(6)
ITC	-0.038*** (0.004)			-0.007*** (0.001)		
ITC2			-0.020*** (0.005)			-0.004*** (0.001)
OTC		-0.027*** (0.004)	-0.021*** (0.005)		-0.004*** (0.0004)	-0.003*** (0.0004)
ln(market share)$_0$	0.542*** (0.020)	0.538*** (0.020)	0.546*** (0.020)	0.055*** (0.003)	0.054*** (0.003)	0.055*** (0.003)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
# of Obs.	19304	19417	19304	31951	32103	31951
# of Firms	5399	5421	5399	7858	7883	7858
R^2	0.198	0.193	0.200	0.044	0.040	0.043

***, **, and * denote significance at the 1%, 5%, and 10% levels. Robust standard errors are reported in parentheses. ITC (ITC2) is the input trade cost which is a weighted average of output trade cost (OTC) with weights from input-output table including (excluding) the diagonal elements. Random effects estimations are performed on models (1)-(3). LPM with random effects estimations are performed on models (4)-(6)

Table 3 < Impact of Trade Cost on Imports >

	Intensive Margin : ln(import)			Extensive Margin : Prob(import>0)		
	(1)	(2)	(3)	(4)	(5)	(6)
ITC	-0.014*** (0.003)			-0.004*** (0.0005)		
ITC2			-0.011*** (0.003)			-0.003*** (0.001)
OTC		-0.008*** (0.003)	-0.005* (0.003)		-0.002*** (0.0004)	-0.001*** (0.0005)
ln(market share)$_0$	0.678*** (0.018)	0.675*** (0.018)	0.680*** (0.018)	0.066*** (0.003)	0.065*** (0.003)	0.066*** (0.003)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
# of Obs.	14226	14318	14226	31951	32103	31951
# of Firms	4499	4517	4499	7858	7883	7858
R^2	0.263	0.263	0.264	0.053	0.052	0.053

***, **, and * denote significance at the 1%, 5%, and 10% levels. Robust standard errors are reported in parentheses. ITC (ITC2) is the input trade cost which is a weighted average of output trade cost (OTC) with weights from input-output table including (excluding) the diagonal elements. Random effects estimations are performed on models (1)-(3). LPM with random effects estimations are performed on models (4)-(6)

Table 4a < Impact of Trade Costs on Firm-Level Employment >

Ln(employment)	(ρ-σ) Sub input	Comp input	(ρ-σ) Sub input	Comp input	(ρ-σ) Sub input	Comp input
	(1)	(2)	(3)	(4)	(5)	(6)
ITC	0.003***	-0.010***				
	(0.001)	(0.002)				
ITC2					0.002**	-0.022***
					(0.001)	(0.003)
OTC			0.001**	-0.004***	0.001***	-0.001
			(0.000)	(0.001)	(0.0004)	(0.001)
ln(market share)$_0$	0.250***	0.300***	0.167***	0.240***	0.250***	0.309***
	(0.009)	(0.010)	(0.006)	(0.008)	(0.009)	(0.010)
Year FE	Yes	Yes	Yes	Yes	YES	YES
# of Obs.	16409	15542	16562	15544	16409	15542
# of Firms	4262	4245	4307	4246	4262	4245
R^2	0.255	0.376	0.276	0.393	0.256	0.384

Table 4b < Impact of Trade Costs on Firm-Level Employment >

Ln(employment)	ρ Sub input	Comp input	ρ Sub input	Comp input	ρ Sub input	Comp input
	(1)	(2)	(3)	(4)	(5)	(6)
ITC	0.004***	-0.021***				
	(0.001)	(0.004)				
ITC2					0.002***	-0.013***
					(0.001)	(0.003)
OTC			0.001***	-0.012***	0.002***	-0.006***
			(0.000)	(0.002)	(0.0004)	(0.002)
ln(market share)$_0$	0.349***	0.247***	0.235***	0.192***	0.349***	0.245***
	(0.010)	(0.010)	(0.008)	(0.008)	(0.010)	(0.010)
Year FE	Yes	Yes	Yes	Yes	YES	YES
# of Obs.	17227	14724	17380	14726	17227	14724
# of Firms	4395	3982	4436	3983	4395	3982
R^2	0.410	0.273	0.431	0.290	0.410	0.265

***, **, and * denote significance at the 1%, 5%, and 10% levels. Robust standard errors are reported in parentheses. Random effects estimations are performed. . ρ: input elasticity of substitution, σ : output elasticity of substitution.

Table 5. Impact of Imports on Firm-Level Employment

ln(employment)	(1) RE	(2) RE	(3) OLS	(4) OLS
ln(Import+1)	0.007***	0.007***	0.035***	0.016***
	(0.001)	(0.001)	(0.001)	(0.001)
[ln(Import+1)]*(ρ-σ)	-0.0003*	-0.0001	-0.0004**	0.00003
	(0.0002)	(0.0001)	(0.0002)	(0.0001)
[ln(Import+1)]*(EXP)*(ρ-σ)	0.0001	-0.0001	-0.0005**	-0.0005***
	(0.0001)	(0.0001)	(0.0002)	(0.0001)
EXP	0.042***	0.038***	0.137***	0.054***
	(0.007)	(0.007)	(0.008)	(0.007)
ln(market share)$_0$	0.267***	0.349***	0.256***	0.450***
	(0.007)	(0.008)	(0.003)	(0.004)
Industry FE	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes
# of Obs.	32942	32942	32942	32942
# of Firms	8068	8068		
R^2	0.334	0.499	0.367	0.576

***, **, * denote significance at 1%, 5%, and 10%. Robust standard errors are reported in parentheses. ρ: input elasticity of substitution, σ : output elasticity of substitution.

Table 6. Impact of Imports on Firm-Level Employment: Some Alternative Specifications

ln(employment)	(1) RE	(2) RE	(3) RE	(4) RE	(5) RE	(6) RE
ln(Import+1)	0.008***	0.005***	0.005***	0.008***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
[ln(Import+1)]* (EXP)		0.002	0.002*		0.003**	0.003**
		(0.001)	(0.001)		(0.001)	(0.001)
[ln(Import+1)]* (ρ-σ)			-0.0002***			-0.0002***
			(0.0001)			(0.0001)
EXP		0.037***	0.038***		0.032***	0.032***
		(0.007)	(0.007)		(0.007)	(0.007)
ln(market share)$_0$	0.268***	0.267***	0.267***	0.350***	0.349***	0.349***
	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)
Industry FE	No	No	No	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
# of Obs.	33094	33094	32942	33094	33094	32942
# of Firms	8093	8093	8068	8093	8093	8068
R^2	0.328	0.331	0.335	0.496	0.499	0.500

***, **, * denote significance at 1%, 5%, and 10%. Robust standard errors are reported in parentheses. ρ: input elasticity of substitution, σ : output elasticity of substitution.

Table 7. Test of Balancing Hypothesis: 2007 matching performance

Variable	Sample	Mean		% Bias	t-test	
		Treatment	Control		T	P - value
ln(Employment)	Unmatched	5.397	4.683	79.9	11.81	0.000
	Matched	5.397	5.454	-6.3	-0.36	0.719
Sales/Wage Bill	Unmatched	10.112	7.480	33.7	4.77	0.000
	Matched	10.112	9.961	1.9	0.15	0.884
Export Dummy	Unmatched	0.578	0.289	60.8	6.82	0.000
	Matched	0.578	0.593	-3.1	-0.25	0.806
ln(TFP)	Unmatched	4.846	4.620	25.4	3.12	0.002
	Matched	4.846	4.876	-3.3	-0.25	0.800

Table 8 Difference-in-Difference Estimation: Impact of Importing on Employment

ln(employment)	Ordinary Least Squares		Random Effects	
	(1)	(2)	(3)	(4)
$IMP_{i,t-1}$	0.338***	0.285***	0.023*	0.022
	(0.038)	(0.041)	(0.014)	(0.015)
$IMP_{i,t-1} * (\rho-\sigma)_{i,t}$		-0.057*		-0.021*
		(0.033)		(0.011)
$IMP_{i,t-1} * (\rho-\sigma)_{i,t} * EXP_{i,t-1}$		0.042		0.020*
		(0.033)		(0.011)
$EXP_{i,t-1}$		0.288***		0.033**
		(0.036)		(0.014)
Year FE	Yes	Yes	Yes	Yes
# of Firms	590	590	590	590
# of Obs.	2,970	2,949	2,970	2,949
R^2	0.03	0.066	0.03	0.055

*** Significant at 1%, ** significant at 5%, and * significant at 10%. IMP : Import dummy (takes the value 1 if the firm is importing, 0 otherwise). ρ : input elasticity of substitution, σ : output elasticity of substitution.