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International Trade and Employment: Theory and Evidence from Korean Firms *

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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 costs and test them using Korean firm-level data for the period 2006-2016. A key theoretical result is that the impact of a change in offshoring cost on employment depends crucially on the net substitutability between inputs where net substitutability is the difference between the elasticities of input substitution and output substitution. Empirically we find that a decrease in the input trade cost reduces employment and the impact is stronger the greater the net substitutability between inputs. Our 2SLS results with firm-level imports (in place of trade costs) are consistent with our results with trade costs.

Keywords: Offshoring, Employment, South Korea, Trade Costs, Net Input Substitutability
JEL Codes: *F12, F14, F16*

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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 declined from 5.2 million to 4.2 million, while its manufacturing share of employment fell 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 examine how firm-level employment is related to trade, primarily input imports.

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-level 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 greater competition 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 (imports of inputs), along with final goods trade. As mentioned above, 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 firms (whether offshoring or not) to suffer losses in employment because of the greater effective competition primarily driven by the lower prices charged by each offshoring firm. Offshoring, as opposed to non-offshoring, firms experience another effect on their labor demand, the size and direction of which depends on the difference between two elasticity parameters: the elasticity of substitution between inputs and the elasticity of substitution between varieties of output. The difference, which we call the net input substitutability amplifies the negative effect of offshoring on employment or moderates the positive effect. Our model also predicts that a decrease in the cost of exporting final goods will lead to losses in employment for non-exporting firms. In addition to such an effect, exporting firms also experience an opposing effect: an increase in their "derived" labor demand from an increase in exports.

Our theoretical model serves 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. 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 2006-2016. Our empirical work also uses data on trade costs separately for final good exports and final good imports. The latter is used, in conjunction with Korea's input-output table, for the computation of the trade costs for imports of intermediate goods or inputs.[1] In addition, for our analysis, we need measures of output and input substitution, which are derived from the elasticities of substitution in Broda and Weinstein (2006). 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 key source of identification is the considerable variation in trade costs across industries and over time. Variations in these trade costs are driven by variations in their two components, namely tariffs and international transport costs, the latter most likely driven by technological improvements. In addition, we observe considerable variation in the net input substitutability across industries which helps us identify its role in determining the relationship between offshoring and employment.

Our empirical analysis yields several results, most of them consistent with our theory and/or our economic intuition. To be sure that the impact of trade cost reductions on employment are working through the right channels, 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 cost and firm employment is positive and statistically significant in the sample of industries with high net input substitutability. The impact is less clear cut for industries with low net input substitutability. This result is consistent with what we find when we interact the net input substi-

[1] We use effectively applied tariffs from the World Integrated Trade Solution (WITS), and transport costs are constructed using data on distances between Korea and its various major trading partners. The export trade costs are the sum of export tariffs (import tariffs of partner countries) and transport costs, while the import trade costs are the sum of import tariffs and transport costs.

tutability with input trade costs using the full sample. Here we find that a decrease in input trade costs on average reduces firm employment and the relationship is stronger for industries with positive net input substitutability and weaker for industries with negative net input substitutability.

Next, in order to additionally capture effects of firm-specific idiosyncratic trade costs as well as other global shocks (e.g. technology change in China as well as the lagged effect of China's WTO accession) that impact firm-level imports, we study the relationship between employment and firm-level trading activities. OLS regressions in this case are subject to an omitted variable bias. For example, a firm specific productivity shock would increase both imports and employment. To alleviate the omitted variable bias we use an instrument for imports. Our instrument for imports is the interaction between Chinese exports to its four major partners other than South Korea and the Korean firm's initial share in South Korea's industry-level imports. The idea is that an increase in Chinese exports to other countries captures the lower cost of importing these goods from China for Korean firms independent of any domestic firm specific productivity shock that would make importing more attractive for them. Given that the initial year of imports used to construct the firm's initial share is not included in the regression sample, these weighted exports are clearly exogenous to Korean firm imports. They also satisfy the exclusion restriction because the Chinese exports to other countries should not affect the employment of Korean firms through a channel other than the imports of Korean firms.[2]

The results from the IV regression suggest a stronger negative relationship (or, alternatively, a weaker positive relationship) between employment and imports for industries with a positive net input substitutability and a weaker negative relationship (or, alternatively, a stronger positive relationship) for industries with a negative net input substitutability. Therefore, the results from the IV regressions using firm-level imports are broadly consistent with the results from the regressions using the relationship between input trade costs and employment. The results are robust to controlling for total factor productivity. While our main sample is unbalanced, restricting our analysis to a balanced sample confirms the robustness of our key results.

A detailed analytical survey of the literature on the impact of offshoring on various labor-market outcomes is Hummels, Munch and Xiang (2018), from now on HMX. The existing literature on the impact of offshoring on specifically employment is fairly small, and considerable details of those papers are

[2]To ascertain that the exclusion restriction holds, we run some checks as described in detail in the results section. We also try versions of this instrumental variable where we restrict ourselves to China's exports of intermediate goods or parts and components. Our results remain qualitatively unchanged.

provided in HMX. While one set of papers uses worker-level data, there is another set of papers that use employer-employee matched datasets. In the first category, the papers look at how offshoring, measured at the industry level, affects the likelihood of job separations. The papers falling in this category include Egger, Pfaffermayr and Weber (2007) for Austria, Geisheker (2008) for Germany and Munch (2010) for Denmark. The main common result of these three papers is that offshoring reduces the probability of remaining in one's existing job, especially when it is low-skilled.

In the second category of papers are Hummels, Jorgenson, Munch and Xiang (2014), referred from now on as HJMX, using Danish matched data, Kramarz (2008) using French data, and Mion and Zhu (2013) using Belgian data. Though their main focus is on wage effects, HJMX, in addition to finding that a doubling of offshoring reduces earnings of low-skilled workers on average by 4.2%, find that a part of this wage reduction is due to "time spent in unemployment." In the case of high-skilled workers, their income loss arising from job loss is more than offset by wage gains. Kramarz, in general, finds a negative relationship between offshoring and employment. Mion and Zhu (2013) study the implications of import competition from China and offshoring to China for industry employment and skill upgrading. Using industry level data, they find that import competition from China leads to reduced employment growth but increased skill upgrading in low-tech manufacturing industries. Using firm-level data, they find that offshoring to China of both finished and intermediate goods leads to an increase in the share of non-production workers.

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 heterogeneous 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.

Among other related works, the earliest related paper 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.

The key contribution of our paper lies in highlighting the role of industry level net input substitutability (as measured by the difference between the input elasticity of substitution and the output elasticity of substitution) in determining the impact of trade and trade cost on employment theoretically and finding empirical support for it.[3] This introduces important nuances in the impact of trade policy on domestic employment, that policymakers need to take into account.

The remainder of the paper is organized as follows. In the next section we present the theoretical model. Section 3 discusses the data used in the paper. Section 4 provides empirical results and section 5 provides concluding remarks.

[3]It is worth mentioning that a lot of world trade is taking place via global supply chains where different stages in the production process are carried out in different countries. In the process, inputs cross international borders several times, some value being added at each stage, before ending up in the country of final use. Studying the labor market implications of global supply chains would be an interesting exercise for the future. In the present paper we implicitly assume that there are only two stages in the production of a good and at most one upstream stage can be carried out in a foreign country and the resulting intermediate good is imported by the Korean firms.

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 (i.e., one unit of labor endowment per individual). 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 homogeneous 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 homogeneous good is produced, which we assume to be the case. Therefore, the income of each person 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:

$$z_i^x(\omega) = A \left(p_i^x(\omega)\right)^{-\sigma_i}. \tag{3}$$

where p_i^x is the price faced by consumers in the export market and A is the demand shifter which is exogenous given our small country assumption. However, there is a fixed cost of exporting, f_i^x, and an iceberg trading cost $\tau_i^x t_x$, which has a general component τ_i^x and a firm specific component t_x.[4] As a result, not all firms will export.

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.[5] 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.

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

[4] The firm-specific component captures special relationships a specific firm may or may not have with certain export markets. In the empirical exercise, τ_i^x will be proxied by tariffs facing Korean exporters and the transportation cost.

[5] This assumption is appropriate for our empirical work on South Korea, which is a small country in trade.

$$Y(\psi) = \left[\alpha L(\psi)^{\frac{\rho-1}{\rho}} + (1-\alpha)M(\psi)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}, \tag{4}$$

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.[6] We assume that one unit of labor is required to produce one unit of $L(\psi)$. There is a fixed cost of operation, f, for every producing firm.

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

$$p_o(\psi) = \lambda t_o p_M^*, \tag{5}$$

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

$$c_s(\psi) \equiv \left[\alpha^\rho + (1-\alpha)^\rho p_s(\psi)^{1-\rho}\right]^{\frac{1}{1-\rho}} \tag{6}$$

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.

In addition to offshoring, firms can export as well. As mentioned earlier, exporting involves a fixed cost as well as an iceberg trading cost which has a general component τ_i^x. Firms exporting to Korea also face a variable trading cost of τ_i^f. In our empirical exercise we use tariffs and transportation costs to capture variable trading costs. While transportation costs are likely to be roughly symmetric between Korea and its trading partner, tariffs may not be. Therefore, we will use 3 different measures of output

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

trade costs: transportation costs which would affect both Korean exporters and firms exporting to Korea; Korean tariffs which would affect foreign firms exporting to Korea; tariffs facing Korean firms in their export markets. The transport cost will be an element of both τ_i^x and τ_i^f while the Korean tariffs will be a part of τ_i^f and the tariffs facing Korean firms in their export markets will be a part of τ_i^x.

Given our small open economy assumption, we show in the theoretical appendix that τ_i^f affects only the masses of domestic and foreign firms operating in the Home market in each industry. The survival productivity cutoff (and, therefore, the employment levels of firms that survive) in the open economy depends only on τ_i^x. Therefore, we perform comparative static exercises with respect to τ_i^x and it should be kept in mind that if the variation in τ_i^x is coming from transportation costs, it will affect τ_i^f as well which will have implications for the masses of firms. Recall that there is a firm specific exporting cost, t_x, giving a total variable exporting cost for a firm of $\tau_i^x t_x$. To unclutter the notation, we will use τ in the comparative static exercises below to refer to τ_i^x.

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

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

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

$$p^x(\psi) = \left(\frac{\sigma}{\sigma-1}\right)\frac{\tau t_x c_s(\psi)}{\varphi}, \text{ for } s \in \{n, o\} \tag{8}$$

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. The table below summarizes the various costs faced by these 4 types of firms as well as foreign firms exporting to Korea.

Firm type	Production cost		Exporting cost	
	fixed cost	composite input cost	fixed cost	variable cost
Purely domestic	f	p_n		
Exporting and non-offshoring	f	p_n	f^x	τt_x
Offshoring and non-exporting	$f + f_o$	$\lambda t_o p_M^*$		
Offshoring and exporting	$f + f_o$	$\lambda t_o p_M^*$	f^x	τt_x
Foreign firms			f^f	τ^f

Having introduced the key elements of the theoretical model in the text, we derive the equilibrium in the appendix. Given the Melitz structure of the model, we obtain a survival productivity cutoff, $\widehat{\varphi}$, such that firms drawing productivity below this cutoff cannot cover the fixed cost of operations and hence they exit immediately. 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 among the alternatives. 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.

We also derive the following lemma (proved in the appendix) which is useful for comparative statics.

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

The lemma above says that decreases in the costs of trading final goods (relevant for Korean exporters) or offshoring both increase the survival productivity cutoff. Intuitively, a reduction in the exporting trade cost makes exporting more profitable which increases the expected profit for potential entrants, thus leading to greater entry. While there will be a greater number of entering firms in the new equilibrium, a smaller proportion of them will survive (will be active), which means there is an increase in the survival threshold productivity, reducing expected profits net of fixed costs of entry back to zero.[7]

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.

Below we provide the key results based on comparative statics with respect to trading costs.

2.3 Trading costs and employment: some empirical implications

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

$$L_s(\psi) = L_s^d(\psi) + I_x L_s^x(\psi) \tag{9}$$

[7] While the threshold productivity goes up for sure, whether the number of active firms goes up or not depends on the nature of the unconditional productivity distribution.

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

$$L_s^d(\psi) = \alpha^\rho\,(\sigma-1)\,c_s(\psi)^{\rho-\sigma}\left(\frac{\varphi c_n}{\widehat{\varphi}}\right)^{\sigma-1} f;\; L_s^x(\psi) = \alpha^\rho\left(\frac{\sigma-1}{\sigma}\right)^{\sigma} c_s(\psi)^{\rho-\sigma}\,(\tau t_x)^{1-\sigma}\,\varphi^{\sigma-1}A, \text{ for } s \in \{n,o\}. \tag{10}$$

Denote the labor demand for the 4 possible types of firms by $L_{nd}(\psi)$, $L_{nx}(\psi)$, $L_{od}(\psi)$, and $L_{ox}(\psi)$, where *nd* denotes no offshore, no export, *nx* denotes no offshore, export, *od* denotes offshore, no export, and finally *ox* denotes offshore, export.

2.3.1 Output trading cost, τ and employment

Using (10) derive the following expressions for the change in labor demand resulting from a change in the output trading cost.

$$\frac{d\ln(L_{sd}(\psi))}{d\tau} = -\frac{(\sigma-1)}{\widehat{\varphi}}\frac{d\widehat{\varphi}}{d\tau};\; s \in \{n,o\} \tag{11}$$

$$\frac{d\ln(L_{sx}(\psi))}{d\tau} = -\epsilon_d\frac{(\sigma-1)}{\widehat{\varphi}}\frac{d\widehat{\varphi}}{d\tau} - (1-\epsilon_d)\frac{(\sigma-1)}{\tau};\; s \in \{n,o\} \tag{12}$$

where ϵ_d is the share of labor used for domestic production. Since $\frac{d\widehat{\varphi}}{d\tau} < 0$, we expect $\frac{d\ln(L_{sd}(\psi))}{d\tau} > 0$. That is, non-exporting firms experience a decrease in employment following a decrease in output trading cost. The sign of $\frac{d\ln(L_{sx}(\psi))}{d\tau}$ is ambiguous because an increase in exports expands employment as captured by the second term but an increase in $\widehat{\varphi}$ reduces employment as captured by the first term. Note that in (12) the value of ϵ_d will be different for offshoring and non-offshoring firms. Therefore, we expect a decrease in the output trading cost to reduce labor demand in non-exporting firms but the impact is ambiguous on exporting firms.

To capture the above comparative statics, we use the following equation to estimate the impact of the output trade cost on the labor demand of different types of firms.

$$\ln(L_{ijt}) = \gamma_0 + \gamma_1\tau_{jt} + \gamma_2\tau_{jt}EXP_{ijt} + \gamma_3\tau_{jt}EXP_{ijt}IMP_{ijt} \tag{13}$$

where i denotes firm, j denotes industry, t denotes year, EXP captures the export status of the firm and IMP captures the import or offshoring status. Verify from above that

$$\frac{d\ln(L_{ijt})}{d\tau_{jt}} = \gamma_1 + \gamma_2 EXP_{ijt} + \gamma_3 EXP_{ijt}IMP_{ijt} \tag{14}$$

Since $\frac{d\ln(L_{sd}(\psi))}{d\tau} > 0$ in (11), we expect $\gamma_1 > 0$ which captures the impact of trade costs on on non-exporting firms. From (12) we know that the impact on exporting firms is ambiguous. The impact on exporting firms that offshore differs from the impact on exporting firms that do not offshore because they have different ϵ_d, the share of labor used to meet domestic production. Parameters γ_2 and γ_3 capture the effects on these two types of firms. We expect $\gamma_2 < 0$ so that $\gamma_1 + \gamma_2$, capturing the impact of changes in trade costs on exporting firms that do not offshore, has an ambiguous sign. Finally, the impact of changes in trade costs for exporting firms that do offshore is captured by $\gamma_1 + \gamma_2 + \gamma_3$, which differs from the impact on exporting firms that do not offshore by γ_3 which can be positive or negative.

To summarize, $\gamma_1 > 0$ captures the impact of changes in trade costs on non-exporting firms, $\gamma_1 + \gamma_2$ ($\lesseqgtr 0$) captures the impact on exporting firms that do not offshore and $\gamma_1 + \gamma_2 + \gamma_3(\lesseqgtr 0)$ captures the impact on exporting firms that do offshore.

2.3.2 Input trading cost, λ and employment

Using the same steps as above, derive the following expressions for the change in labor demand resulting from a change in offshoring cost.

$$\frac{d\ln(L_{nk}(\psi))}{d\lambda} = -I_k \frac{(\sigma-1)}{\widehat{\varphi}} \frac{d\widehat{\varphi}}{d\lambda} > 0; \tag{15}$$

$$\frac{d\ln(L_{ok}(\psi))}{d\lambda} = -I_k \frac{(\sigma-1)}{\widehat{\varphi}} \frac{d\widehat{\varphi}}{d\lambda} + (\rho-\sigma)\frac{d\ln(c_o(\psi))}{d\lambda}; \tag{16}$$

where $k = d, x$; $I_d = 1$; $I_x = \epsilon_d$. The inequality in (15) follows from the fact that $\frac{d\widehat{\varphi}}{d\lambda} < 0$. That is, non-offshoring firms, whether they export or not, experience a decrease in labor demand as the offshoring cost decreases. For offshoring firms, we have two terms in the expressions in (16). The first term again captures the fact that these firms also experience a decrease in labor demand because $\frac{d\widehat{\varphi}}{d\lambda} < 0$. The second term, however, has an ambiguous sign. Verify from (6) that $\frac{d\ln(c_o(\psi))}{d\lambda} > 0$. Therefore, the sign of the second term is same as the sign of $(\rho - \sigma)$.

The second term in the expressions for offshoring firms in (16) 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 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 call this the *scale effect* of offshoring. The net 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, while if $\rho < \sigma$, then the *scale effect* dominates leading to an increase in the demand for labor. In the remainder of the paper we refer to $\rho - \sigma$ as the parameter capturing the *net input substitutability*.

The impact of a change in the offshoring cost on employment across different types of firms can be captured by the following estimating equation:

$$\ln(L_{ijt}) = \beta_0 + \beta_1\lambda_{jt} + \beta_2\lambda_{jt}EXP_{ijt} + \beta_3\lambda_{jt}EXP_{ijt}IMP_{ijt} + \beta_4\lambda_{jt}(\rho_j - \sigma_j)IMP_{ijt} + \varepsilon_{ijt}. \tag{17}$$

The triple interaction term, $\lambda_{jt}EXP_{ijt}IMP_{ijt}$ arises from the fact that ϵ_d of an offshoring firm that exports is different from that of a non-offshoring firm that exports. The above yields

$$\frac{d\ln(L_{ijt})}{d\lambda_{jt}} = \beta_1 + \beta_2 EXP_{ijt} + \beta_3 EXP_{ijt}IMP_{ijt} + \beta_4(\rho_j - \sigma_j)IMP_{ijt} \tag{18}$$

Note from (15) that $\frac{d\ln(L_{nd}(\psi))}{d\lambda} > 0$, therefore, we expect $\beta_1 > 0$. That is, purely domestic firms suffer an employment loss from a reduction in offshoring cost. Next note from the expression for $\frac{d\ln(L_{nx}(\psi))}{d\lambda}$ in (15) that since ϵ_d, the share of labor in domestic production, is less than 1, the following must be true: $\beta_2 < 0$ such that $\beta_1(= \frac{d\ln(L_{nd}(\psi))}{d\lambda}) > \beta_1 + \beta_2(= \frac{d\ln(L_{nx}(\psi))}{d\lambda}) > 0$. That is, an exporting firm that does not offshore also suffers an employment loss, but the impact is smaller because its export market is unaffected.

For offshoring firms the discussion of the *substitution* and *scale* effects earlier suggests that $\beta_4 > 0$. That is, a decrease in the offshoring cost reduces (increases) employment in industries where the *net substitutability* $(= \rho_j - \sigma_j)$ is positive (negative). So, for offshoring firms that do not export we have $\frac{d\ln(L_{od}(\psi))}{d\lambda} = \beta_1 + \beta_4(\rho_j - \sigma_j)$ from (18). For offshoring firms that export as well, we have $\frac{d\ln(L_{ox}(\psi))}{d\lambda} = \beta_1 + \beta_2 + \beta_3 + \beta_4(\rho_j - \sigma_j)$. $\beta_1 + \beta_2 + \beta_3$ captures the first term in the expression for $\frac{d\ln(L_{ox}(\psi))}{d\lambda}$ in (16). Even though the first term in the expression for $\frac{d\ln(L_{ox}(\psi))}{d\lambda}$ in (16) looks identical to the expression for $\frac{d\ln(L_{nx}(\psi))}{d\lambda}$ in (15), which suggests that it can be captured by $\beta_1 + \beta_2$, however, there is no reason for ϵ_d to be the same for these two types of firms. Therefore, we introduce β_3 to capture any differences in ϵ_d across these two types of firms. Again, since $\epsilon_d < 1$, it must be the case that $\beta_2 + \beta_3 < 0$ but

$\beta_1 + \beta_2 + \beta_3 > 0$ because the first term in the expression for $\frac{d\ln(L_{ox}(\psi))}{d\lambda}$ is positive.

Note that the above estimating equation requires an industry level estimate of the net input substitution parameter: $(\rho_j - \sigma_j)$. We have reliable estimates of σ_j but our constructed measure of ρ_j has some limitations, and therefore, we also try an alternate estimation where we assume ρ_j to be the same across industries. In that case the estimating equation becomes

$$\ln(L_{ijt}) = \beta_0 + \beta_1\lambda_{jt} + \beta_2\lambda_{jt}EXP_{ijt} + \beta_3\lambda_{jt}EXP_{ijt}IMP_{ijt} + \beta_4\lambda_{jt}(-\sigma_j)IMP_{ijt} + \beta_5\lambda_{jt}IMP_{ijt} + \varepsilon_{ijt}. \quad (19)$$

where β_5 absorbs the effect of ρ_j.

Since our offshoring cost measures are at the industry level and we have access to the firm-level trade data, we also estimate the impact of importing directly on employment. The underlying assumption is that imports are going to respond to changes in offshoring cost. We expect a change in either the general offshoring cost, λ, or the firm specific offshoring cost, t_o, to increase imports. The *substitution effect*, the strength of which depends on the input elasticity of substitution parameter, ρ, will reduce domestic employment, however, the *scale effect*, the strength of which depends on σ, will cause both imports and domestic employment to increase. To capture these effects, we use the following estimating equation.

$$\ln(L_{ijt}) = \beta_0 + \beta_1 import + \beta_2 import * EXP_{ijt} + \beta_3(\rho_j - \sigma_j)import_{ijt} + \varepsilon_{ijt}. \quad (20)$$

Of particular interest here is the sign of β_3 which we expect to be negative. That is, increased imports are more likely to be associated with lower domestic employment in industries where $\rho_j - \sigma_j > 0$ due to the *substitution effect* dominating the *scale effect* and the opposite should be true when $\rho_j - \sigma_j < 0$.

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 2006-2016. 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 our sample to the manufacturing sector, our sample consists of 9,504 firms and 63,529 observations.[8] Our firm-level

[8]The original sample is not balanced, but we perform robustness checks with a balanced sample. All our main results are quite robust to using a balanced sample. This novel dataset has also been used by Choi and Pyun (2018), Chun et al. (2017),

imports, exports, sales, capital stock and employment data come from the SBA.

We are going to use firm-level imports as our measure of offshoring. It is conceivable that firm-level imports could contain some goods which are sold with no value added by the firm. As shown by HJMX, this is particularly true for service firms, however, for manufacturing firms these imports constitute a tiny fraction (median value of 2.9%). Therefore, the bulk of imports of manufacturing firms are inputs. Another concern regarding imported inputs is whether they are a substitute for labor inside the firm as in our theoretical model. HJMX define two measures of offshoring, a broad measure of offshoring which includes all imported inputs and a narrow measure of offshoring which includes inputs belonging to the same industry as that of producing firms. It is conjectured that a firm is more likely to be able to produce the latter category of inputs within the firm boundary. Due to data limitations we are unable to create a narrow measure of offshoring, however, given the finding of HJMX that the narrow measure of offshoring accounts for 87% of the manufacturing firms' imports at HS2 level of aggregation, the results obtained using our broad measure of offshoring should be similar to that obtained using the narrow measure of offshoring. However, this shortcoming is offset to a certain extent by some robustness checks with our instrumental variable (a) constructed using only intermediate inputs according to the UN BEC categories, and, alternatively, (b) constructed only using parts and components as per Ng and Yeats (1999) (details described later).

3.2 Trade Cost

The sectoral trade cost is an important determinant of offshoring, imports and exports. Our trade cost measures are calculated at the Korean Standard Industrial Classification (KSIC, revision 9) two-digit level to match our firm-level data. The KSIC classification available to us for each firm from Statistics Korea does not go beyond the two-digit level to protect the confidentiality of firms that figure in the survey (SBA).[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. Since the tariffs that Korean firms face in their

Cho and Lee (2020).

[9]It is worth pointing out that the 2-digit and 3-digit tariffs are highly correlated. The correlation coefficient is 0.66.

export market could be different from the Korea's tariffs on their imports, we construct two separate measures of output trade cost. Both our trade cost measures share a common, symmetric industry-level transportation cost. However, when it comes to the tariff component of the trade cost, one of them, namely the Import Trade Cost or MTC uses Korean import tariffs, while the other one, which we call the Export Trade Cost or XTC, uses tariffs faced by Korean exporters in trading partner countries. In addition, MTC is useful in constructing our Input Trade Cost or ITC (as explained in the next subsection), while XTC will be used in the regressions as a proxy for the output trade cost, τ faced in exporting in the theoretical exercise.

To construct MTC, our first step is to construct an import-weighted average HS six-digit product tariff for each year, which is arrived at by computing an import-weighted average of all the Effectively Applied (AHS) import tariff rates on imports from all the different partner countries within that six-digit HS level, obtained from the World Bank's World Integrated Trade Solution (WITS). We, then, use our own concordance table between HS and KSIC, followed by computing a simple average of the above HS six-digit averages within a KSIC two-digit level to arrive at the tariff portion of our two-digit MTC for each year.

To construct export tariffs faced by Korean exporters in each industry, we first compute a weighted average of import tariff rates imposed by Korea's trading partners within a HS six-digit product, with Korea's exports at that six-digit level to those various countries (same as imports of those various partner countries from Korea) as weights. As in the case of MTC, we, then, use our own concordance table between HS and KSIC, followed by computing a simple average of the above HS six-digit averages within a KSIC two-digit level to arrive at the tariff portion of XTC for each year. The data used to construct our export tariff rate are also from the World Bank's World Integrated Trade Solution (WITS).

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 all the same trading partners.[10] 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

[10] The data on industry transport costs are based on product-country-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 first construct Korea's transport cost at the HS 6-digit level with each of its trading partners, using as proxies the distance-adjusted transformations of the U.S. costs of shipping from the same countries. Finally, KSIC two-digit transport costs for Korea are created through a trade-weighted averaging first across countries and then across products within a KSIC two-digit industry. Note all EU27 member countries together are treated as a single consolidated trading partner of Korea. The same is the case with the treatment of the three NAFTA countries.

process of export. The customs import value is the total value of imports at the border excluding duties and import charges.[11] 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 4.1% during 1987-1991. Our simple average for the Korean case for the manufacturing sector for the period 2006-2016 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 (ITC) is generated by taking the weighted average of the import trade cost (MTC) with the weights from the Korean input-output table for the year 2005. The calculation of ITC is as follows.

$$ITC_{kt} = \sum_{j} MTC_{jt} \cdot s_{kj}$$

where s_{kj} are cost shares of industry j in the production of a good in industry k in the year 2005.

3.2.3 Output and Input Elasticities of Substitution

As shown in the above theory sections, the net input substitutability $(\rho - \sigma)$ 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 between product varieties (within each product category) for Korea specifically during the period 1990-2001.[12] 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 two-digit industry level output elasticity of substitution measure (σ_j) for each industry j is created. Finally, the input elasticity of substitution measure (ρ_k) is obtained by using

[11] 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.

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

input-output tables in the same way these weights were used for constructing the input trade cost.

$$\rho_k = \sum_j \sigma_j \cdot s_{kj}$$

Here is a possible justification for our measure of input elasticity of substitution. Let's, for the purpose of a simple example, suppose that different varieties of aluminum and steel are all the inputs used in producing a particular final product. The output elasticity of substitution for steel measures the degree of substitutability between different varieties of steel, while, similarly, the output elasticity of substitution for aluminum measures the degree of substitutability between different varieties of aluminum. As the input share of aluminum gets closer to zero (or, alternatively, to one), the input elasticity of substitution, measuring the substitutability between all the different varieties of inputs used in this product would converge to the output elasticity of substitution for steel (or, alternatively, for aluminum). The input-output coefficients will give us the relative importance of steel and aluminum in the production of this final output, and we, accordingly, use those weights to get a weighted-average measure of the input elasticity of substitution. Since some varieties of inputs will be produced in-house and some outside (and we are not making any assumptions on the differences in the characteristics of the two kinds of inputs), we believe the average elasticity of substitution between input varieties will capture the elasticity of substitution between in-house inputs and other inputs. However, we acknowledge that this is a highly imperfect measure of the input elasticity of substitution. But, then, this is the best we can do with the available data. Nevertheless, we perform a robustness check to compensate for the imperfect nature of our measure. Table A10 in the online appendix provides our estimates of ρ, σ, and $\rho - \sigma$ for each industry in our sample and we observe that $\rho - \sigma$ varies from a low of -23.66 to a high of 1.11.

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. To conserve space, we report the results from this exercise in an online appendix (Table A1). We summarize here those results, since they throw light on the mechanism through which trade costs affect employment (see the next subsection for those effects), and, as seen later, these results will be useful in understanding the identification of the employment effects of firm-level imports.

As expected, we find a reduction in input trade costs to lead to increases in imports both at the extensive and intensive margins. That is, the quantity of imports as well as the probability of importing increases. The same is true of exports and the export trade cost. More interestingly, a decrease in the input trading cost increases exports by making firms more competitive in the export market. Similarly, a reduction in the export trading cost increases imports because a boost to firm exports gives a boost to their demand for imported inputs as well.

Next we turn to our key empirical results on the relationship between trading and employment.

4.1 Relationship between trade costs and employment

4.1.1 Identification

While our theoretical model helps us with identifying the effects we are interested in, our identification empirically targets firm-level employment changes taking place along with considerable changes we see in input trade costs and output trade costs in our sample. Figure 1 plots our measures of trade costs as well as their components over the sample period 2006-2016. There is over time variation in all measures, with Korean import tariffs being the most volatile and transportation costs being the least volatile.

When we focus on industry-level trade costs, the variation over time can be much greater, and this is what helps us a great deal with our identification. We see in Figure 2 that within each of our industries there are considerable changes in import and export tariffs and transport costs between the final and the initial years of our sample period.[13] Note that our input trade cost for each industry is a weighted average of the sum of import tariffs and transport costs of different industries, with the weights being the shares of inputs into a particular industry from various industries and obtained from the input-output matrix. Thus, the considerable changes in import tariffs and transport costs translate into considerable changes in input trade costs. In addition, as seen in Figure 2, changes in trade costs vary considerably across industries. In the case of import trade costs, the reduction over the entire period ranges from less than half a point for manufacture of electronic components to a reduction of over 16 points in beverages.

[13] We are looking at the period 2006-15 in place of 2006-16 in Figure 2, since there was a sudden increase in applied tariffs in the year 2016 and that was not part of the overall trend in 2006-16.

For export trade costs, the variation is from slightly over half a point increase (pharmaceuticals) to over a 4-point reduction (food products). In addition, we observe considerable variation in the net input substitutability across industries (ranges from -23.66 to 1.11) which helps us identify its role in determining the relationship between offshoring and employment.[14]

The summary statistics in Table 1 shows variation overall in employment and trade costs. This is seen by the difference between the minimum and maximum values of these variables. For the various trade costs we also see that the standard deviation is considerable relative to the sample mean. Therefore, our identification is going to come from the inter-industry and over time variations in trade costs and employment.

4.1.2 Split-sample analysis

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

$$\ln(employment)_{ijt} = \beta_0 + \beta_1 ITC_{jt} + \Gamma \mathbb{Z}_{it} + \varepsilon_{ijt} \tag{21}$$

where $\ln(employment)_{ijt}$ is the (log) employment for firm i in industry j in year t, ITC_{jt} represents input trade cost defined as above, $\mathbb{Z}_{ijt}$ includes firm and year fixed effects and elements of output trade cost.

Recall from the theoretical section that the impact of the input trade cost on employment depends crucially on the *net input substitutability* which we capture empirically through $\rho - \sigma$. Our theoretical model predicts that a decrease in the input trade cost, λ, is likely to reduce employment if $\rho - \sigma > 0$, but the impact is ambiguous in the opposite case. To capture the impact of net input substitutability ($\rho - \sigma$) in this simple framework, we split the sample into a high net substitutability group and a low net substitutability group. We do these splits in two ways: on the basis of $\rho - \sigma$, and, alternatively, based solely on the degree of output substitutability (σ). The latter alternative partitioning is done since the input substitutability measure (ρ) has limitations. If we assume an average ρ to apply to all firms, then effectively we can perform our partitioning based on σ alone.

The results are presented in Table 2. Panel A provides results for the split based on the sign of ($\rho - \sigma$). In Panel B we split them based on σ alone and whether σ is above the median or below the median.[15]

[14] For 12 industries in our sample $\rho - \sigma > 0$ and for the other 11 $\rho - \sigma < 0$.

[15] Since the distribution of σ is highly skewed with most observations lying in the group of σs below the mean, our split here is based on whether σ is above the median or below it.When we split the sample based on whether σ is above or below the

All these regressions include firm and year fixed effects and robust standard errors are clustered at the industry-by-year level. Consistent with our theory, the coefficient of ITC (estimate of β_1) is positive and statistically significant in column 1 (when the net substitutability is high) in both panels. In column 2 (when the net substitutability is low), the sign of the estimate of β_1 is negative in panel A and positive in panel B, but statistically insignificant in both cases. The coefficient estimates in column 1 imply that for a one percentage point decline in the input trade cost (which is more than a 10 percent reduction), employment decreases by 1.3% when the net input substitutability is high.

Columns 3 and 4 in both panels of Table 2 use *Transportation Cost*, *Import Tariff* and *Export Tariff* simultaneously in place of ITC and the results are less clear cut with these variables. While the coefficient estimates of all three variables are statistically insignificant when net substitutability of inputs is low (column 4), in the high substitutability case (column 3) the coefficient estimates of transportation cost and export tariff are significant, with the former positive in sign and the latter negative. Transportation cost is a symmetric variable in both directions, so it is difficult to say whether its role in export costs or import costs empirically dominates. Also, export tariffs, in our theory, affect exporting and non-exporting firms differently. The negative sign of the coefficient of the export tariff is consistent with our theoretical prediction for exporting firms. But then theory does not predict any differences in the substitutable and complementary input cases. Therefore, we move to columns 5 and 6 where ITC is once again our right-hand side variable of focus and the other three variables are thrown in simultaneously, mainly as controls. Here, once again, the coefficient of ITC is positive and significant in both panels in column (5) when the net input substitutability is high. For a one percentage point decline in the input trade cost (which is more than a 10 percent reduction), employment decreases by 2.2-2.4%. In the low net input substitutability case presented in column (6), the sign of ITC is positive in both panels but the coefficient is statistically significant only in Panel B. Recall that for the case of low net input substitutability, our theoretical prediction on the relationship between employment and input trade cost is ambiguous. Therefore, finding a positive and significant coefficient of ITC in column 6 of panel B is not inconsistent with our theoretical prediction.

mean we get qualitatively similar results.

4.1.3 Full-sample analysis

We next estimate regressions which allow the impact of trade costs on employment to vary across firms depending on their trading status and across industries depending on the net input substitutability. Our main sample is unbalanced. However, we also provide results for a balanced sample, which is a subset of our dataset.[16]

We first estimate equation (13) which captures the relationship between export trade cost and employment. We run the following specification.

$$\ln(employment)_{ijt} = \gamma_0 + \gamma_1 XTC_{jt} + \gamma_2 XTC_{jt} \times EXP_{ijt} + \gamma_3 XTC_{jt} \times EXP_{ijt} \times IMP_{ijt} + \Gamma \mathbb{Z}_{ijt} + \varepsilon_{ijt} \quad (22)$$

where XTC is the export trade cost, IMP_{ijt} (EXP_{ijt}) equals one if firm i is an importer (exporter) of industry j in year t (and zero otherwise), $\mathbb{Z}_{ijt}$ contains firm fixed effects, year fixed effects, and the intercept IMP_{ijt} and EXP_{ijt} dummies. Recall our theoretical prediction that a decrease in export trading cost should reduce employment at non-exporting firms ($\gamma_1 > 0$) while exporting firms experience an increase in employment on their exporting operations ($\gamma_2 < 0$), the overall impact on their employment is ambiguous: $\gamma_1 + \gamma_2$ ($\lesseqgtr 0$) as is the impact on exporting firms that offshore as well: $\gamma_1 + \gamma_2 + \gamma_3$ ($\lesseqgtr 0$).

The results from the estimation of (22) are presented in Table 3, column (1) for the whole sample and column (5) for the balanced sample. Again, robust standard errors are clustered at the industry-by-year level. The estimates in column (1) suggest that a decrease in export trade costs reduces employment at non-exporting firms ($\gamma_1 = .009$), increases employment at exporting firms that do not offshore ($\gamma_1 + \gamma_2 = -.005$) and has no effect on exporting firms that import as well ($\gamma_1 + \gamma_2 + \gamma_3 \approx 0$). While these results are roughly consistent with the theoretical predictions, only the estimate of γ_2 is statistically significant. The results for the balanced sample in column (5) are very similar.

Next we turn to the impact of input trade costs on employment. Based on the estimating equation (17) derived in the theoretical section we run the following specification.

$$\begin{aligned} \ln(employment)_{ijt} &= \beta_0 + \beta_1 ITC_{jt} + \beta_2 ITC_{jt} \times EXP_{ijt} + \beta_3 ITC_{jt} \times EXP_{ijt} \times IMP_{ijt} \\ &\quad + \beta_4 (\rho_j - \sigma_j) ITC_{jt} \times IMP_{ijt} + \Gamma \mathbb{Z}_{ijt} + \varepsilon_{ijt} \end{aligned} \quad (23)$$

[16] While our theoretical model allows for entry and exit, the comparative static exercise looks at the effects on existing firms (of course, factoring in the induced entry and exit on existing firms). Our unbalanced panel will affect results additionally through compositional changes in the sample as a result of induced entry and exit, not captured in our theory. Therefore, we provide results for the balanced panel as well.

Columns (2) and (6) in Table 3 provide results of a simpler specification where $\beta_2 = \beta_3 = 0$ to see if the net input substitutability matters as was the case in Table 2. Results reported in column (2) imply that a reduction in ITC reduces employment ($\beta_1 > 0$) and the effect is stronger for importing firms in industries with high degrees of net input substitutability ($\beta_4 > 0$). The results in column (6) for the balanced sample are very similar.

Columns (3) and (7) provide estimates of (23). Recall that in the theoretical section we derived the following predictions: $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_1 + \beta_2 > 0$, $\beta_1 + \beta_2 + \beta_3 > 0$ and $\beta_2 + \beta_3 < 0$, and finally $\beta_4 > 0$. Our results in columns (3) and (7) are consistent with all of these predictions. It is worth emphasizing our support for the key prediction: $\beta_4 > 0$. The estimate of β_4 is positive and significant in columns (3) and (7) confirming the presence of the net input substitutability channel in determining the impact of input trade cost on employment.

Finally, we estimate the following grand specification which combines equations (22) and (23) and simultaneously includes input trade cost and export trade cost.

$$\begin{aligned} \ln(employment)_{ijt} \;=\;& \beta_0 + \beta_1 ITC_{jt} + \beta_2 ITC_{jt} \times EXP_{ijt} + \beta_3 ITC_{jt} \times EXP_{ijt} \times IMP_{ijt} \\ & + \beta_4(\rho_j - \sigma_j) ITC_{jt} \times IMP_{ijt} + \gamma_1 XTC_{jt} + \gamma_2 XTC_{jt} \times EXP_{ijt} \\ & + \gamma_3 XTC_{jt} \times EXP_{ijt} \times IMP_{ijt} + \Gamma \mathbb{Z}_{ijt} + \varepsilon_{ijt} \end{aligned} \tag{24}$$

The results from the estimation of the above equation are presented in columns (4) and (8) of Table 3. Based on the estimates in column (4) we can say the following for the impact of a reduction in the offshoring cost on 4 different types of firms: (i) it reduces the employment of firms that neither offshore nor export ($\beta_1 > 0$); (ii) it reduces the employment of firms that export but do not offshore $\beta_1 + \beta_2 > 0$) but the impact is smaller than for non-trading firms ($\beta_2 < 0$); (iii) it reduces the employment for offshoring firms that do not export in industries where $(\rho - \sigma) > -3.9$ ($\beta_1 + \beta_4(\rho - \sigma) > 0$ if $\rho - \sigma > -3.9$) and increases it otherwise; iv) finally for firms that offshore and export, it reduces employment in industries where $(\rho - \sigma) > -4.8$ ($\beta_1 + \beta_2 + \beta_3 + \beta_4(\rho - \sigma) > 0$ if $\rho - \sigma > -4.8$) and increases it otherwise. In our sample, there are only 2 out of 23 industries where $\rho - \sigma < -3.9$ or $\rho - \sigma < -4.8$.[17] Therefore, for 21 industries the relationship between input trade costs and employment is positive based on the estimates in column (4). The results are similar for the balanced sample presented in column (8).

[17]Those 2 industries have $\rho - \sigma$ of -14.53 and -23.66. For the remaining 21 industries, $\rho - \sigma \geq -1.6$. See table A9 in the online appendix.

Note that both IMP and EXP dummies have positive signs throughout. This shows that, under frictionless trade ($ITC = 0, XTC = 0$), both importing and exporting firms have higher employment than totally domestic firms (that neither import nor export). This is also true for trade under frictions when $\rho \geq \sigma$.

Robustness Exercises Our sample spans the financial crisis (although we have just two years of data before the crisis). It is important to note that both trade and employment did take a hit during the crisis years, which could affect our results. Our time fixed effects are expected to take care of, to a certain extent, such concerns. At the same time, the global financial crisis is expected to provide additional variation in our variables, which could be useful. However, theoretically, there is nothing we can say about how the effect running through net substitutability will change as a result of the crisis. Therefore, in Table A2 in the online appendix we provide results for post-crisis years 2010-16. The results remain robust, and are similar to those presented for the full sample in Table 3.

While the results presented in Table 3 used weighted trade costs, we also present a set of results where two-digit trade costs are arrived at by taking an unweighted average of trade costs of the various products within each two-digit industry, in place of the weighted average taken earlier. Those results are presented in columns 1-4 of Table A3 of our online appendix. Our results are qualitatively similar to those presented in Table 3. Another robustness check, where in addition to the controls presented in Table 3, we also control for the import tariffs is provided in the last 2 columns of Table A3 of the online appendix. This is an additional measure of output trade cost since our main measure of output trade cost in these regressions is the export trade cost which affects exporters. The results are robust to the inclusion of import tariffs. As a further robustness check, we have added capital and TFP as additional controls to the regressions in Table 3. The results presented in Table A4 in the online appendix are robust to these additional controls.

Since our measure of ρ has limitations, to reassure ourselves and the readers, we run a specification where we assume a common input elasticity of substitution across all industries. In this case, in our regression $(\rho - \sigma) \times IMP \times ITC$ gets replaced by the combination of $IMP \times ITC$ and $(-\sigma) \times IMP \times ITC$ since ρ is a constant. This specification is certainly valid for a firm at the sample average of the input elasticity of substitution, even though unknown. The results with this robustness check are shown in Table A5 in the online appendix. The results are qualitatively similar.

To sum up, a decrease in input trade costs, on average, reduces firm employment, however, the relationship is stronger for offshoring (importing) firms in industries with positive net input substitutability ($(\rho - \sigma) > 0$) relative to offshoring firms in industries with negative net input substitutability ($(\rho - \sigma) < 0$)). In other words, the *net input substitutability effect* either magnifies the positive effect of input trade costs on firm employment or moderates it and, in some cases, turns the relationship into a negative one. Our results on the impact of export trading cost on employment are less robust.

Next we study the relationship between firm level trade and employment.

4.2 Relationship between firm-level trade and employment

Since our trade cost measures are only at the two-digit industry level, we further explore the predictions of the theoretical model with firm-level data on imports to directly study the relationship between imports and employment. As pointed out by Hummels et al. (2018), firm-level importing data show large differences in offshoring activity across firms and, compared to the IO table, provide greater scope for the identification of the effects of offshoring on labor-market outcomes. Recall that in our theoretical model we have firm-level trade costs as well, and firm-level trade data captures the impact of firm-level trading costs which could not be captured using the industry level trade costs in the results provided earlier. In addition, there have been big changes outside Korea (which are exogenous to Korea), e.g. technological changes in China and the lagged impact of China's entry into the WTO unfolding over time. These changes can impact imports by Korean firms even in the absence of changes in the industry level trade costs. The regressions of employment on imports at the firm level can also capture the effects of trade cost changes at a more disaggregate industry level as well as those idiosyncratic to the firm.

4.2.1 *Results on the employment-imports relationship*

Based on the estimating equation (20) derived in the theoretical section, we run the following specification.

$$\begin{aligned} ln(Employment)_{ijt} &= \beta_0 + \beta_1 \ln(1 + imports)_{it} + \beta_2 \left[\ln(1 + imports)_{it}\right] \times EXP_{ijt} \\ &+ \beta_3 \left[\ln(1 + imports)_{it}\right] \times (\rho_j - \sigma_j) + \Gamma \mathbb{Z}_{ijt} + \varepsilon_{ijt} \end{aligned} \tag{25}$$

$\mathbb{Z}_{ijt}$ includes year fixed effects, export dummies (EXP_{ijt}), and firm fixed effects. Since we are using log of imports as a regressor, to include all firms (importing and non-importing), we add 1 to the value of imports, and hence we use $\ln(1 + imports)$ as the key regressor of interest.

β_1 captures the relationship between imports (offshoring) and employment for non-exporting firms in the industry where the *net input substitutability* roughly equals zero ($\rho_j \approx \sigma_j$). $\beta_1 + \beta_2$ captures the same relationship for exporting firms. Of particular interest here is the sign of β_3 which we expect to be negative as discussed in the theory section. That is, increased imports should be associated with lower employment in industries where $\rho_j - \sigma_j > 0$ due to the net input substitutability effect and the opposite should be true when $\rho_j - \sigma_j < 0$.

The results from the estimation of equation (25) are presented in Table 4. Let us first discuss the OLS results presented in columns (1) and (3) for the full sample and (5) and (7) for the balanced sample. The estimate of β_1 in column (1) implies that for non-exporting firms in the industry where the net input substitutability roughly equals zero ($\rho_j \approx \sigma_j$) there is a positive relationship between imports and employment. The positive estimate of β_2 suggests that exporting firms have a stronger positive relationship between imports and employment. More interestingly, the estimate of β_3 is negative and significant, which is consistent with the net input substitutability effect. Relative to firms in industries with $(\rho - \sigma) \leq 0$, firms in industries with $(\rho - \sigma) > 0$ experience a reduction in employment. In column (3), we control for firm productivity using the logarithm of total factor productivity (TFP), which is one way of correcting for an important part of the simultaneity problem. Controlling for firm productivity partially alleviates the endogeneity problem because a firm specific productivity shock could increase both imports and employment.[18] The results are qualitatively similar to the ones in column (1). The coefficient estimates reported in column (3) imply that the impact of imports on employment for non-exporting firms is $.0033 - .0003\,(\rho - \sigma)$ $(= \beta_1 + \beta_3\,(\rho - \sigma))$ and for exporting firms it is $.0049 - .0003\,(\rho - \sigma)$ $(= \beta_1 + \beta_2 + \beta_3\,(\rho - \sigma))$. Since the largest value of $\rho - \sigma$ in our sample is 1.11, the relationship between imports and employment is positive. That is, greater importing is associated with greater employment for all industries and the effect is smaller for industries with high $\rho - \sigma$. Similar results are obtained in columns (5) and (7) for the balanced sample.[19]

[18] The TFP used as a control is obtained from production function estimation. An important issue in the estimation of production functions is the correlation between unobservable productivity shocks and input levels. Firms respond to positive (negative) productivity shocks by simultaneously expanding (reducing) output and inputs. To address this issue, we follow the Levinsohn and Petrin (2003) procedure with the Ackerberg, Caves and Frazer (2015) correction in estimating the productivity of firms. The estimator uses intermediate inputs as proxies for productivity shocks. The elasticities of output with respect to labor, capital and materials are 0.3425, 0.4216 and 0.2016 respectively, resulting in a returns to scale of 0.97 (which is very close to a constant-returns-to-scale production function). Note that these estimated TFPs are highly correlated with those generated by the Olley-Pakes method with the Ackerberg-Caves-Frazer correction (correlation coefficient of 0.866).

[19] As a further robustness check we controlled for capital in addition to TFP and the results are similar.

Clearly, the relationship between imports and employment suffers from an endogeneity problem. While we are interested in seeing how a change in imports induced by a change in the trading cost affects employment, there are other factors such as a firm specific productivity shock or demand shock which could simultaneously raise both employment and imports without a change in the trading cost. We will address this endogeneity problem using an instrumental variable approach, which we describe in the next few paragraphs.

We need to look at the part of a firm's imports that are exogenous and are not driven by any firm-level shocks, that also directly impact the firm's employment. We construct an instrument using Chinese exports in different industries to other major economies in Asia interacting with individual firm's initial share of industry imports. We use China's exports to Japan, India, Vietnam, and Taiwan to construct our industry-level, Chinese productivity-driven export shocks.[20] These four top Asian importers of Chinese products together have import structure similar to Korea's. Hence, our instrument delivers accurate first-stage predictions. We have run robustness checks by further restricting the country set to either only Japan or expanding it by including other trading partners such as Malaysia and Indonesia, and our results stay robust.

Since China's exports to Korea have risen rapidly (and Korea is China's 4th largest exporting destination as of 2017) and intermediate goods make up a large share of China's exported products, using China's exports to construct our instrument for intermediate input is appropriate and relevant in our case. The firm-level instrument is defined as follows:

$$\ln MIV_{it} = ln\left(\frac{M_{i0}}{M_{j0}} \times Exports_{jt}^{China \to Other}\right)$$

where MIV_{it} is the instrument for firm-i's import in year t, $\frac{M_{i0}}{M_{j0}}$ is the firm i's import share in industry j at the beginning of the period, $Exports_{jt}^{China \to Other}$ represents China's exports to other economies in industry j in year t.[21] This measure captures China's export supply shocks as in Autor et al. (2013) and Acemoglu et al. (2016).

The idea is that if Chinese exports to these other countries expand in these industries, the common element in this growth as well as the growth in the imports by the Korean firms we study is driven

[20]Note that China's industry level exports are being used here, which may not be exactly what firms in those respective industries in other countries import. However, at the two-digit industry level, most of the inputs come from the same industry. As mentioned above, the diagonal elements of any input-output table, at this level of aggregation, are fairly large. Besides, our instrumental variable is arrived at by interacting with a firm's initial share in industry-level imports.

[21]M_{i0} is firm i's initial year imports, while M_{j0} is the total imports of all firms in industry j in the initial year.

by Chinese productivity growth, which is similar to the effect of a lower trade cost. Therefore, from the point of view of Korean firms, this can be viewed as the availability of cheaper inputs. In the terminology of our theoretical model, it would be a lowering of p_M^*, the price of the imported input. As Figure 1 shows, there is a strong positive correlation between Chinese exports and the firm-level imports in Korea. The instrument is strongly correlated with the import exposure at the firm level. The first stage results shown in Table A6 of the online appendix (corresponding to second-stages shown in the 2SLS regressions reported in Table 4) are strong, as the Weak IV F-stat is above the Stock-Yogo critical value by a wide margin. Furthermore, the first-stage result is shown in Figure 3 where each dot represents a firm by year in our sample, and the line is fitted by the OLS regression.

The instrument also satisfies the exclusion restriction because Chinese exports to other Asian countries should not affect Korean firm-level employment through any channel other than the imports of these firms from China. We conduct some robustness checks in this regard in our sub-section on robustness exercises below.

Note that our instrument is created by using import weights $\frac{M_{i0}}{M_{j0}}$ from the initial year of imports. Since many firms have zero imports in the initial years, if we were to simply use initial year imports as weights the instruments for these firms will always have a value of zero even for years when they have positive imports. Following HJMX, we include firms only from a year after they start importing, with weights constructed using the first year of their imports.

While the OLS results in Table 4 imply a positive relationship between firm-level imports and employment, the IV (2SLS) regression results in columns (2) and (4) imply a negative relationship. Looking at column (4) which controls for TFP[22], the coefficient estimates imply that the impact of imports on employment for non-exporting firms is $-.0898 - .0005\,(\rho - \sigma)$ and for exporting firms it is $-.0536 - .0005\,(\rho - \sigma)$. Even at the smallest value of $\rho - \sigma$ in our sample of -23.66, the relationship between imports and employment is negative for both exporting and non-exporting firms. While the negative estimate of β_3 is a robust result in our 2SLS specification, the overall relationship between imports and employment is not as seen in the estimates in columns (6) and (8) for the balanced sample.[23][24]

We can interpret the differing OLS and IV results in terms of the IV estimates correcting for the

[22]Note that the TFP control in columns (4) and (8) of the 2SLS specification are to show robustness, as 2SLS by itself is expected to correct for endogeneity.

[23]For example, from the estimates in column (8) we find that the impact of imports on the employment of non-exporting firms is $.0031 - .0003\,(\rho - \sigma)$ which is positive for all $\rho - \sigma$ in our sample because the largest value of $\rho - \sigma$ is 1.11. The same is true for exporting firms as well.

[24]Again, using capital as an additional control yields similar results.

simultaneity bias in the OLS regressions. The set of results presented in Table 4 provides further and robust evidence on the key role of net input substitutability and validates our previous results using a high level of aggregation for trade costs.

4.2.2 *Robustness Exercises*

As was the case with trade costs regressions, in Table A7 we present results for the post-financial crisis sample and the results are similar to those for the full sample reported in Table 4.

Table 5 reports various robustness checks for our IV regressions.[25] Column (1) reports the baseline 2SLS results from column (2) of Table 4. We also run some robustness checks where $Exports_{jt}^{China \to Other}$ in our IV described earlier is now (a) constructed using only intermediate inputs according to the UN BEC categories (with corresponding 2SLS results presented in column (2)), and, alternatively, (b) constructed only using parts and components as per Ng and Yeats (1999) (2SLS results presented in column (3).[26] While Panel A uses the full sample, in panel B, to check for further robustness, we drop industries that had a relatively larger share of imports from high-income countries.[27] We find that our variable of interest, the estimate of β_3 remains negative and highly significant throughout, once again providing strong support for our main theoretical prediction.

The fact that Korea is a major supplier of inputs to Chinese factories might come in the way of the exclusion restriction of the instrument holding. To make sure that this is not a problem, we perform a few checks. First, we find that the correlation between our instrument and firm-level ln(1 + exports) is only 0.22. Also, when ln(1 + exports) is regressed on our instrument and firm and year fixed effects, our instrument is statistically insignificant with a $t-$ratio of 1.3. Finally, we run our main employment-on-imports specification dropping firms in industries with high export volumes from Korea to China (namely, Electronics, Semiconductors and Chemicals). As can be seen in Table A8 of our online appendix, the results are qualitatively unchanged. There still is strong evidence for the presence of net input substitutability effect, including in the IV regressions with this restricted sample.

Also, given that our measure of ρ has limitations, as was done in the case of trade costs regressions,

[25]The corresponding first-stage results are reported in Table A6 of our online appendix.

[26]The Broad Economic Categories (BEC) group products according to their main end use. We follow the UN classification system and break down products into capital goods, intermediate goods, and consumption goods. Alternatively, we also classify parts and components according to Ng and Yeats (1999) in measuring production fragmentation.

[27]The industries we drop are manufacture of chemicals and chemical products (except pharmaceuticals and medicinal chemicals), manufacture of pharmaceuticals, medicinal chemicals and botanical products, manufacture of other machinery and equipment, and manufacture of motor vehicles, trailers and semitrailers.

we perform a robustness exercise where we assume ρ to be constant across industries and allow only σ to vary in which case the term $[\ln(1+imports)_{it}]\,(\rho_j-\sigma_j)$ is replaced by $[\ln(1+imports)_{it}]\,(-\sigma_j)$ and $\ln(1+imports)_{it}$ since ρ is treated as a constant. Since $\ln(1+imports)_{it}$ is already included as a regressor, our estimating equation (25) becomes

$$\begin{aligned} ln(Employment)_{ijt} &= \beta_0+\beta_1\ln(1+imports)_{it}+\beta_2\,[\ln(1+imports)_{it}]\,EXP_{ijt} \\ &+ \beta_3\,[\ln(1+imports)_{it}]\,(-\sigma_j)+\Gamma\mathbb{Z}_{ijt}+\varepsilon_{ijt} \end{aligned} \tag{26}$$

The results from estimating the above equation are presented in Table A9 in the online appendix and the results are qualitatively similar to those in Tables 4 and 5. In particular, the estimate of β_3 is negative and significant.

To sum up, our regressions using the variation in trade costs across industries reported in Table 3 suggest that lower trade costs are associated with lower employment. Using firm-level data on imports we find from the OLS regressions in Table 4 that greater imports are associated with greater employment. However, the OLS coefficients are likely to be biased upwards because of omitted variables such as productivity shocks or demand shocks which can induce a positive relationship between imports and employment. Many of our 2SLS regressions with firm fixed effects suggest a negative relationship between imports and employment. All the OLS and the 2SLS regressions confirm the presence of the net input substitutability effect as was the case in Table 3. That is, the negative relationship between imports and employment is stronger in industries with a positive net input substitutability ($(\rho-\sigma)>0$) and weaker in industries with a negative net input substitutability ($(\rho-\sigma)<0$). The endogeneity of imports, along with arguments supporting the quality of our instrument (seen from the first stage results and the relevant F-statistic), implies that we trust our 2SLS results over our OLS ones.

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 2006-2016, 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 main sample is an unbalanced panel. But when we restrict our empirical analysis to a balanced panel to check for robustness, our results remain qualitatively unchanged.

Our empirical analysis yields several results, most of them fairly consistent with our theory. As expected from theory, the relationship between input trade cost and firm employment is positive and statistically significant in the sample of industries with high net input substitutability. The impact is less clear cut for industries with low net input substitutability. More generally, a decrease in input trade costs, on average, reduces firm employment, however, the relationship is stronger for offshoring (importing) firms in industries with positive net input substitutability relative to offshoring firms in industries with negative net input substitutability.

Looking at the relationship between imports and employment, we find from our OLS regressions that greater imports are associated with greater employment, however, the OLS estimates are likely to be upwardly biased. Using an instrumental variable approach to correct for the bias, we find that while the overall relationship is less clear cut, there is a consistent pattern across all regressions: the strong evidence for the presence of the net input substitutability effect. That is, the negative effect of imports on employment is accentuated or the positive effect is counteracted in industries with positive net input substitutability.

An important extension would be to analyze both theoretically and empirically how workers of different skill levels (low-skilled versus high-skilled) may be more or less substitutable with offshoring. That will require a different dataset that provides detailed information on skills. Given our dataset, we have had to make the assumption that labor is only of one kind.

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Tables and Figures

Table 1: Summary Statistics

	mean	sd	min	max
Firm-Level Measures				
ln(1+imports)	4.47	4.45	0.00	17.72
IMP	0.57	0.49	0.00	1.00
ln(1+exports)	5.69	4.54	0.00	18.37
EXP	0.66	0.47	0.00	1.00
ln(employment)	4.92	0.84	1.10	11.53
ln(wage bill)	8.63	1.03	0.00	16.27
ln(share of foreign capital)	0.06	0.18	0.00	0.69
ln(total sales)	10.63	1.29	0.00	18.88
ln(TFP)	1.28	0.34	0.22	6.74
Total Sales to Wage Ratio	9.49	48.96	0.00	12141.36
Industry-Level Measures				
MTC (import trade cost), weighted	10.73	8.38	1.01	50.85
ITC (input trade cost), weighted	9.83	4.86	1.71	23.30
XTC (export trade cost), weighted	11.59	6.07	3.10	61.80
MTC (import trade cost), unweighted	10.29	8.29	0.80	50.96
ITC (input trade cost), unweighted	8.56	4.02	1.42	21.66
XTC (export trade cost, τ_2), unweighted	11.75	5.61	3.08	58.30
$\rho - \sigma$	-0.64	3.75	-23.66	1.11
ρ	3.26	1.25	1.94	10.50
σ	3.90	4.52	1.49	29.01

Note: $N = 63529$. IMP and EXP are importing and exporting dummies. Manufacturing sample. KSIC from 11 to 33. XTC is included as a control in all regressions. MTC is used to construct ITC.

Table 2: Trade Costs and Employment, Split Sample

	(Panel A: $\rho - \sigma$)					
	$\rho - \sigma > 0$: Sub Input; $\rho - \sigma <= 0$: Comp Input					
	(1) Sub Input	(2) Comp Input	(3) Sub Input	(4) Comp Input	(5) Sub Input	(6) Comp Input
ITC (input trade cost)	0.013***	-0.001			0.022***	0.005
	(0.002)	(0.002)			(0.003)	(0.003)
Transportation cost			0.008***	-0.006	-0.007**	-0.012**
			(0.002)	(0.004)	(0.003)	(0.006)
Import tariff			0.001	-0.001	-0.007***	-0.003
			(0.002)	(0.002)	(0.002)	(0.002)
Export tariff			-0.006***	0.002	-0.009***	0.002
			(0.002)	(0.002)	(0.002)	(0.002)
Observations	35328	26684	35328	26684	35328	26684
	(Panel B: σ)					
	$\sigma <$ median : Sub Input; $\sigma >=$ median: Comp Input					
	(1) Sub Input	(2) Comp Input	(3) Sub Input	(4) Comp Input	(5) Sub Input	(6) Comp Input
ITC (input trade cost)	0.012***	0.002			0.024***	0.004*
	(0.002)	(0.001)			(0.003)	(0.003)
Transportation cost			0.012***	-0.001	-0.001	-0.005
			(0.004)	(0.002)	(0.004)	(0.003)
Import tariff			0.000	-0.000	-0.008***	-0.002
			(0.002)	(0.001)	(0.002)	(0.002)
Export tariff			-0.005***	0.001	-0.007***	0.001
			(0.002)	(0.002)	(0.002)	(0.002)
Observations	29219	32620	29219	32620	29219	32620
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Note: Table reports split sample results of OLS regressions with firm and year fixed effects. The split samples are based on the value of $\rho - \sigma$ or σ. *Sub Input* refers to a high net substitutability group ($\rho - \sigma > 0$ or σ is below median) and *Comp Input* refers to a low net substitutability group ($\rho - \sigma \leq 0$ or σ is above or equal to median). Dependent variables are log of employment. The input trade cost, is the sum of import tariffs and transport costs. The export ouput trade cost, is the sum of export tariffs (import tariffs of partner countries) and transport costs. Robust standard errors in parentheses are clustered at the industry-by-year level. ρ is the input elasticity of substitution, σ is the Korean output elasticity of substitution from Broda and Weinstein (2006).
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3: Trade Costs and Employment, Full Specification

	Full Sample				Balanced Sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ITC (β_1)		0.0060***	0.0063***	0.0074***		0.0069***	0.0073***	0.0090***
		(0.0010)	(0.0011)	(0.0013)		(0.0012)	(0.0014)	(0.0017)
EXP $\times ITC$ (β_2)			-0.0013*	-0.0001			-0.0013	-0.0002
			(0.0008)	(0.0012)			(0.0010)	(0.0015)
EXP $\times$ IMP $\times$ ITC (β_3)			0.0009*	0.0018*			0.0009	0.0008
			(0.0005)	(0.0010)			(0.0006)	(0.0012)
IMP $\times(\rho-\sigma)\times$ ITC (β_4)		0.0017***	0.0017***	0.0019***		0.0011**	0.0012**	0.0013**
		(0.0004)	(0.0004)	(0.0004)		(0.0006)	(0.0006)	(0.0006)
XTC (γ_1)	0.0009			-0.0019**	0.0008			-0.0027**
	(0.0008)			(0.0010)	(0.0010)			(0.0013)
EXP $\times$ XTC (γ_2)	-0.0014**			-0.0014	-0.0013*			-0.0013
	(0.0006)			(0.0009)	(0.0008)			(0.0012)
EXP $\times$ IMP $\times$ XTC (γ_3)	0.0005			-0.0010	0.0006			-0.0000
	(0.0004)			(0.0008)	(0.0005)			(0.0009)
EXP=1	0.0413***	0.0261***	0.0361***	0.0412***	0.0392***	0.0257***	0.0367***	0.0410***
	(0.0073)	(0.0036)	(0.0079)	(0.0081)	(0.0099)	(0.0046)	(0.0108)	(0.0110)
IMP=1	0.0196***	0.0239***	0.0176***	0.0189***	0.0088	0.0143***	0.0077	0.0081
	(0.0047)	(0.0032)	(0.0049)	(0.0049)	(0.0059)	(0.0039)	(0.0062)	(0.0062)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	62390	62390	62390	62390	34694	34694	34694	34694

Note: Results in columns (1) to (4) are based on the full sample, and (5) to (8) are based on the balanced-panel sample. All tables include year fixed effects. ITC, the input trade cost, is the sum of import tariffs and transport costs. XTC, the export trade cost, is the sum of export tariffs (import tariffs of partner countries) and transport costs. ρ is the input elasticity of substitution, σ is the Korean output elasticity of substitution from Broda and Weinstein (2006). Robust standard errors in the parentheses are clustered at the industry-by-year level. * $p < .10$, ** $p < .05$, *** $p < .01$

Table 4: The Impact of Trade Costs (Proxied by Firm-Level Imports) on Employment, OLS and 2SLS

	Full Sample				Balanced Sample			
	(1) OLS	(2) 2SLS	(3) OLS	(4) 2SLS	(5) OLS	(6) 2SLS	(7) OLS	(8) 2SLS
ln(1+Imports) (β_1)	0.0035***	-0.0881	0.0033*	-0.0898	0.0035**	0.0034**	0.0031**	0.0031**
	(0.0010)	(0.0774)	(0.0015)	(0.0781)	(0.0015)	(0.0015)	(0.0015)	(0.0015)
EXP × ln(1+Imports) (β_2)	0.0019*	0.0453+	0.0016	0.0462+	0.0010	0.0010	0.0009	0.0009
	(0.0011)	(0.0333)	(0.0333)	(0.0337)	(0.0016)	(0.0016)	(0.0016)	(0.0016)
ln(1+Imports) $\times(\rho-\sigma)$ (β_3)	-0.0003***	-0.0005***	-0.0003***	-0.0005***	-0.00028**	-0.00031**	-0.00027**	-0.00030**
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
EXP=1	0.0082+	0.0224	0.0086	0.0192	0.0014	0.0018	0.0030	0.0034
	(0.0063)	(0.0428)	(0.0105)	(0.0420)	(0.0095)	(0.0095)	(0.0095)	(0.0095)
ln(TFP)			0.1502***	0.2398***			0.1340***	0.1345***
			(0.0258)	(0.0834)			(0.0173)	(0.0171)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	32798	32798	32798	32798	15741	15741	15741	15741

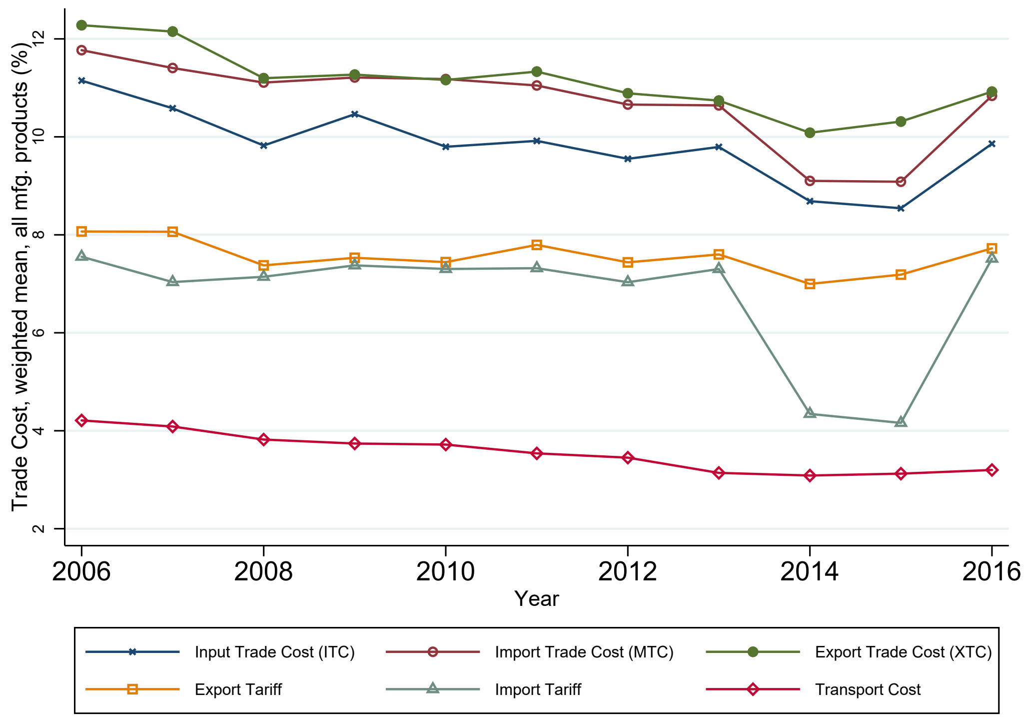
Note: Table reports results of OLS and IV regressions with firm and year fixed effects. Dependent variables are log of employment. Results in columns (1) to (4) are based on the full sample, and (5) to (8) are based on the balanced-panel sample. Robust standard errors in parentheses are clustered at the firm level. ρ is the input elasticity of substitution, σ is the Korean output elasticity of substitution from Broda and Weinstein (2006). $^{+}$ $p < .20$, * $p < .10$, ** $p < .05$, *** $p < .01$

Table 5: Robustness Checks: Using Alternative Instruments and Samples

	Baseline IV	BEC Category IV	Ng & Yeats IV
	(1)	(2)	(3)
(Panel A: Full sample)			
ln(1+Imports) (β_1)	-0.0881	-0.0075	0.0035**
	(0.0774)	(0.0602)	(0.0016)
EXP $\times$ ln(1+Imports) (β_2)	0.0453^{+}	0.0086	0.0053**
	(0.0333)	(0.0286)	(0.0018)
ln(1+Imports) $\times(\boldsymbol{\rho-\sigma})$ (β_3)	-0.0005***	-0.0004***	-0.0004***
	(0.0001)	(0.0001)	(0.0001)
EXP=1	0.0224	0.0035	0.0083
	(0.0428)	(0.0253)	(0.0095)
(Panel B: Dropping industries with high import shares from advanced economies)			
ln(1+Imports) (β_1)	-0.0697	0.0358	0.0015
	(0.1008)	(0.1324)	(0.0013)
EXP $\times$ ln(1+Imports) (β_2)	0.0343	-0.0153	0.0030^{+}
	(0.0430)	(0.0607)	(0.0017)
ln(1+Imports) $\times(\boldsymbol{\rho-\sigma})$ (β_3)	-0.0005***	-0.0004**	-0.0004***
	(0.0002)	(0.0001)	(0.0001)
EXP=1	0.0207	0.0173	0.0066
	(0.0450)	(0.0351)	(0.0077)
Firm Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes

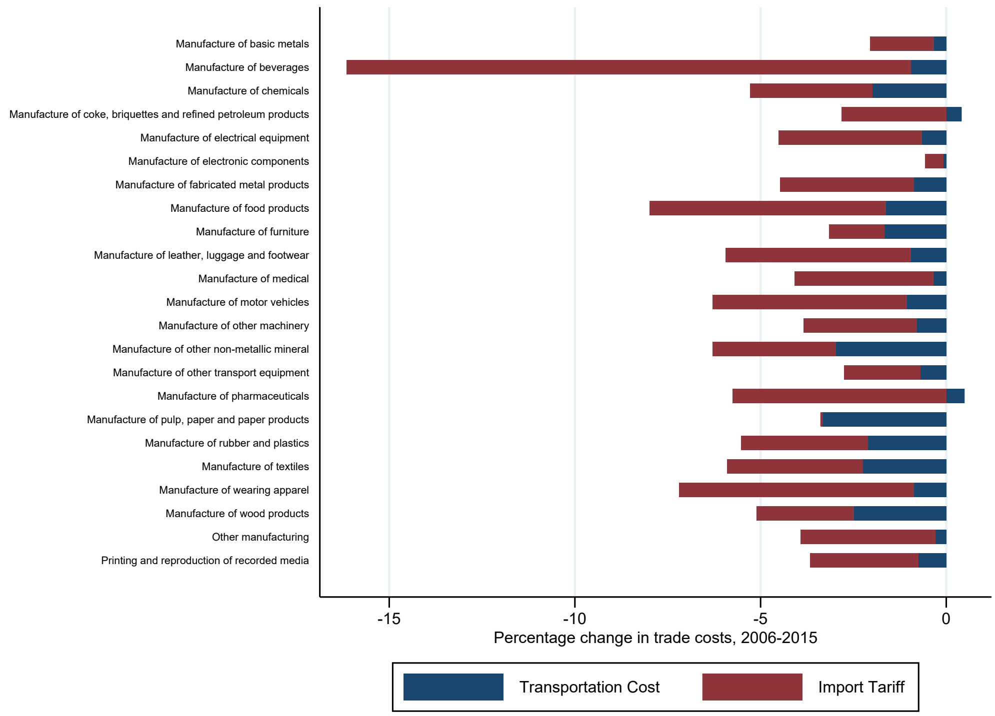
Note: $N = 32798$ in Panel A, and $N = 18766$ in Panel B. Table reports various robustness checks for IV regressions with firm and year fixed effects. Dependent variables are log of employment. Column 1 reports the baseline 2SLS results; column 2 reports results based on the instrumental variable constructed from only using intermediate inputs according to the UN BEC category; column 3 reports results based on the instrumental variable constructed from only using parts and components as per Ng and Yeats (1999). To test the robustness of our baseline results, we have also experimented with dropping industries that had a relatively larger share of imports from high-income countries. Those dropped industries are: Manufacture of chemicals and chemical products; except pharmaceuticals and medicinal chemicals, Manufacture of pharmaceuticals, medicinal chemical and botanical products, Manufacture of other machinery and equipment, and Manufacture of motor vehicles, trailers and semitrailers. Robust standard errors in parentheses are clustered at the firm level.
$^{+}$ $p < .20$, * $p < .10$, ** $p < .05$, *** $p < .01$

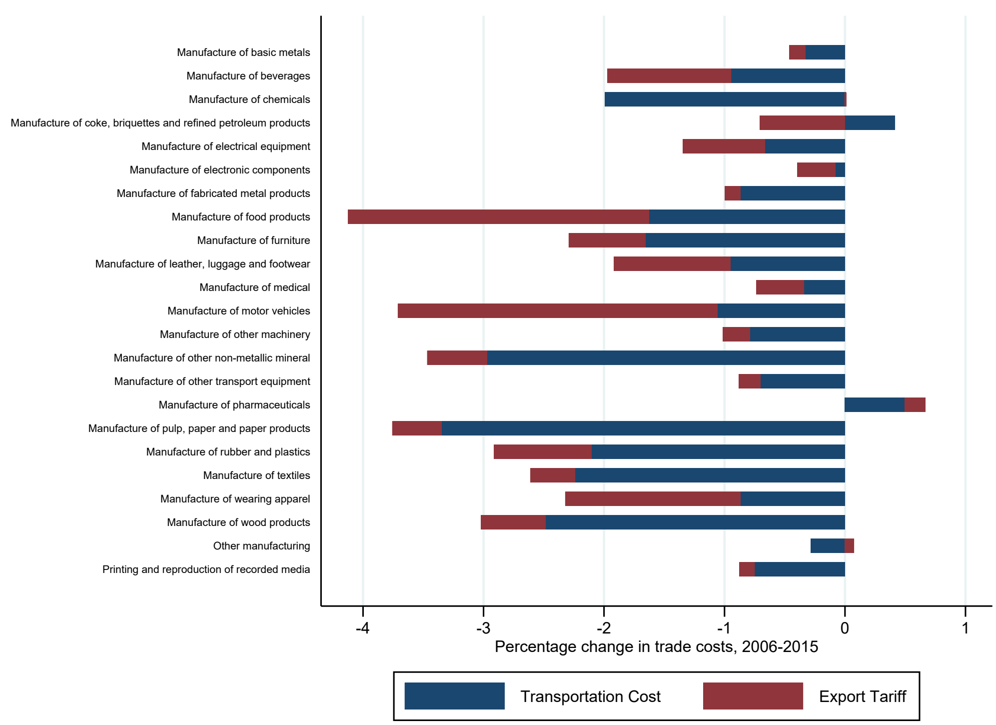
Figure 1: Trade Costs



Note: We use the average of effectively applied rates weighted by the product import shares from the World Integrated Trade Solution (WITS) and transport costs from Schott to construct our trade costs. Import trade cost (MTC) is the sum of transportation cost and import tariff; export trade cost (XTC) is the sum of transport cost and export tariff. The construction of the input trade cost (ITC) is based on the import trade cost (MTC). Data are classified using the Harmonized System of trade at the six-digit level. Tariff line data were matched to Standard International Trade Classification (SITC) revision 3 codes to define commodity groups and import weights. Weights were calculated using the United Nations Statistics Division's Commodity Trade (Comtrade) database. Effectively applied tariff rates at the six-digit product level are averaged for products in each commodity group. When the effectively applied rate is unavailable, the most favored nation rate is used instead.

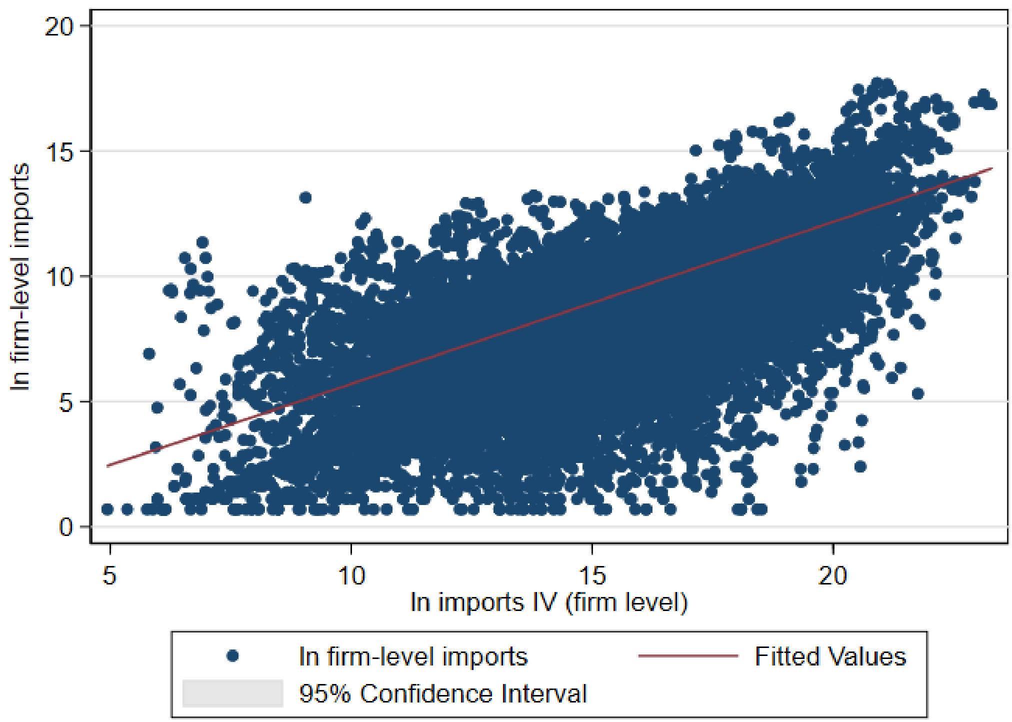
Figure 2: Changes in trade cost variation by industry, 2006-2015





Note: This figure shows the changes in trade costs by industry, in terms of changes in tranport cost and tariff. Data source: WITS.

Figure 3: First Stage Regression



6 Theoretical Appendix

6.1 Derivation of theoretical results

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

$$\pi(\psi;\tau,\lambda) = \left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_s(\psi)}{\varphi}\right)^{1-\sigma}\left(\frac{P^{\sigma-\eta}\mathbb{L} + (\tau t_x)^{1-\sigma}AI_x}{\sigma}\right) - f - f_o I_o - f_x I_x \tag{27}$$

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

$$\left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_n}{\widehat{\varphi}}\right)^{1-\sigma}\frac{P^{\sigma-\eta}\mathbb{L}}{\sigma} - f = 0 \tag{28}$$

The above gives the value of $\widehat{\varphi}$ for given P.

Next, we derive a set of conditions under which the marginal surviving firm neither exports nor imports.

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 ($c_o(\psi)|_{t_o=1}$ is the cost of offshored input for the firm that draws $t_o = 1$). Since (28) is satisfied for this firm, the above can be written as

$$\left(\frac{c_n}{c_o(\psi)|_{t_o=1}}\right)^{\sigma-1} f < f + f_o. \tag{29}$$

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 (28) 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 (29) 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 $\left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_o(\psi)|_{t_o=1}}{\widehat{\varphi}}\right)^{1-\sigma}\left(\frac{\tau^{1-\sigma}A}{\sigma}\right)<f_x$. Note that 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 conditions needed for the marginal firm to neither export nor offshore are

$$\left(\left(\frac{c_n}{c_o(\psi)|_{t_o=1}}\right)^{\sigma-1}-1\right)f<f_o;\ \frac{A}{\sigma}\left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_o(\psi)|_{t_o=1}}{\widehat{\varphi}}\right)^{1-\sigma}<\tau^{\sigma-1}f_x. \tag{30}$$

The former requires the offshoring fixed cost, f_o, to be high relative to the fixed cost of operation f while the latter requires the fixed cost of exporting, f_x, and the common variable cost of exporting, τ, to be high relative to the size of the Foreign market captured by A.

We will assume the inequalities in (30) are satisfied in equilibrium.

Next, substituting out $P^{\sigma-\eta}$ in (27) using (28), the net profits can be written as

$$\pi(\psi,\widehat{\varphi};\tau,\lambda)=\left(\frac{\widehat{\varphi}c_s(\psi)}{\varphi c_n}\right)^{1-\sigma}f+\left(\left(\frac{\sigma}{\sigma-1}\right)\frac{c_s(\psi)}{\varphi}\right)^{1-\sigma}\left(\frac{(\tau t_x)^{1-\sigma}A}{\sigma}\right)I_x-f-f_oI_o-f_xI_x \tag{31}$$

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

$$\Pi \equiv \int_{\widehat{\varphi}}^{\infty} \int_{t_o} \int_{t_x} \pi(\psi, \widehat{\varphi}; \tau, \lambda) g(\psi) dt_x dt_o d\varphi = f_e \tag{32}$$

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 $t_x \in [1, \overline{t_x}]$.

Proof of existence: We show that $\frac{d\Pi}{d\widehat{\varphi}} < 0$. Taking the derivative of (32) with respect to $\widehat{\varphi}$ obtain

$$\frac{d\Pi}{d\widehat{\varphi}} = -\int_{t_o} \int_{t_x} \pi(\psi|_{\widehat{\varphi}}, \widehat{\varphi}; \tau, \lambda) g(\psi) dt_x dt_o + \int_{\widehat{\varphi}}^{\infty} \int_{t_o} \int_{t_x} \frac{\partial \pi(\psi, \widehat{\varphi}; \tau, \lambda)}{\partial \widehat{\varphi}} g(\psi) dt_x dt_o d\varphi, \tag{33}$$

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 (31). 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 $\widehat{\varphi} \to \infty$. *QED*

Once we have $\widehat{\varphi}$ then P is obtained by (28). The mass of domestic and foreign firms can be determined by noting that the price index, P, is given by

$$P = \left[M_d \int_{\psi} p_d(\psi)^{1-\sigma} dG(\psi) + M_f \int_{\widehat{\varphi}_x} p_f(\varphi)^{1-\sigma} dF(\varphi) \right]^{\frac{1}{1-\sigma}} \tag{34}$$

where M_f is the mass of foreign exporters exporting to the home market and $F(\varphi)$ is the distribution function of the productivity of these exporters, M_d is the mass of domestic firms, and $\widehat{\varphi}_x$ is the productivity cutoff of foreign firms exporting to Korea. M_f is going to be a subset of the mass of foreign firms, N_i^f.

The cutoff productivity $\widehat{\varphi}_x$ is determined as follows. A foreign firm charging a price $p_f(\varphi)$ faces demand $z_f(\varphi) = p_f(\varphi)^{-\sigma} P^{\sigma-\eta} \mathbb{L}$ in the Home market. Suppose the unit cost of a foreign firm with productivity φ is $\frac{c_f}{\varphi}$. Then the cost of serving the Home market inclusive of the variable trade cost, τ^f, is $\frac{\tau^f c_f}{\varphi}$. The firm will charge a price of $p_f(\varphi) = \frac{\sigma}{\sigma-1} \frac{\tau^f c_f}{\varphi}$. Therefore, the profit from exporting will be $\left(\frac{\sigma}{\sigma-1} \frac{\tau^f c_f}{\varphi} \right)^{1-\sigma} \left(\frac{P^{\sigma-\eta} \mathbb{L}}{\sigma} \right) - f^f$. For a given P, the exporting productivity cutoff $\widehat{\varphi}_x$ is the solution to $\left(\frac{\sigma}{\sigma-1} \frac{\tau^f c_f}{\varphi} \right)^{1-\sigma} \left(\frac{P^{\sigma-\eta} \mathbb{L}}{\sigma} \right) = f^f$ which can be written as

$$\widehat{\varphi}_x = \left(\frac{\sigma \tau^f c_f}{\sigma - 1} \right) \left(\frac{\sigma f^f}{P^{\sigma-\eta} \mathbb{L}} \right)^{\frac{1}{\sigma-1}}. \tag{35}$$

Once we know $\widehat{\varphi}_x$, the mass of foreign firms that export will be $M_f = N_i^f(1 - F(\widehat{\varphi}_x))$ and the corresponding M_d is obtained from the expression for the price index, P. Clearly, an increase in τ^f increases $\widehat{\varphi}_x$ which in turn reduces M_f and for a given P it raises M_d, the mass of domestic varieties.

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 (31). 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 which is useful in comparative statics below.

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

Proof: The free entry condition (32) 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 (32)

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

The inequality above follows from the fact that $\frac{\partial\pi(\psi,\widehat{\varphi};\tau,\lambda)}{\partial\tau} \leq 0$ (easily verified from (31)) for any ψ. Since (33) 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 (32)

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

Once again, the inequality above follows from the fact that $\frac{\partial\pi(\psi,\widehat{\varphi};\tau,\lambda)}{\partial\lambda} \leq 0$ for any ψ as is easily verified from (31). Therefore,

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

QED.

So, the lemma above says that 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.

6.2 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 (6), 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 (7) and (28) 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

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

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

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

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 $\widehat{\varphi}$.

In our empirical exercise, we use transportation costs, Korean tariffs and tariffs on Korean exporters as our measures of output trade cost. τ is captured by transportation cost and tariffs facing Korean exporters. λ is constructed based on the transportation cost and Korean tariffs upon using the input output relationship. It is worth pointing out that a change in the tranportation cost or Korean tariffs is also a proxy for τ^f, the trading cost facing firms exporting to Korea. We have seen earlier that a decrease in τ^f increases M^f and reduces M^d. Therefore, a change in the transportation cost or Korean tariffs will affect M^f and M^d by changing the productivity cutoff $\widehat{\varphi}_x$ relevant for firms exporting to Korea. As is clear from (34), $\widehat{\varphi}_x$ also depends on P. Therefore, a change in the transportation cost or Korean tariffs will affect $\widehat{\varphi}_x$ through τ^f as well as through P.

6.3 Expressions for Employment

Given the unit cost for Y in (6), 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 (7) and (28) 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.