Regional Effect of Trade Liberalization on the Firm-level Exports

Tan, Yong and An, Liwei and Hu, Cui

Department of International Economics Trade, Nanjing University

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Regional Effects of Export Tax Rebate on Exporting Firms: Evidence From China

Liwei An[a] Cui Hu[b] Yong Tan[a†]

a: Department of International Economics & Trade, Nanjing University, 22 Hankou Road, Nanjing, P.R. China, 200093

b: School of International Trade and Economics, Central University of Finance and Economics, 39 South College Road, Haidian District, Beijing, P.R.China, 100081.

Abstract

This paper extends the model of Melitz (2003) to separate the direct and indirect impact of an export tax rebate on the intensive margin of firm-level export sales at the subnational level. The direct impact of the rebate is associated with a reduction of an exporting firm's variable costs, while the indirect impact manifests itself through higher regional wages as a result of increased demand for local labor. First, the empirical results imply that a 1% rise in the export tax rebate rate increases the export sales among continuing exporters by 0.2% through the direct channel. Second, through the indirect channel, a 1% difference in the regional rebate causes a 0.02% difference in exporters' sales growth. Both effects are statistically significant, and are consistent with the model's predictions.

Keywords: Export Tax Rebate · Regional Labor Market · Direct Impact · Indirect Impact

JEL Classification: D22·F10·F14·L10

[†]Contact information: anliwei@nju.edu.cn (L. An) pkucuihu@gmail.com (C. Hu), and yong.tan@nju.edu.cn (Y. Tan). Yong Tan is the corresponding author.

1. Introduction

Value-added taxes are an indirect tax imposed at each stage of the production process based on the amount of value-added associated production value. Most of the world's value-added taxes are imposed only on goods and services consumed within their own taxing jurisdiction, also known as destination based VAT (Desai and Hines, 2005). Feldstein and Krugman (1990) show that a destination based VAT system with a complete tax rebate has no effect on exports and imports. Therefore, unlike export subsidies, the VAT rebate (hereafter, ETR) has been considered to be consistent with the World Trade Organization's (WTO) main function of ensuring free and smooth trade. According to Bird and Gendron (2007), until January 2007, at least 150 nations use an ETR regime. There is a general belief that the ETR rate and firms' exports are positively correlated when the rebate rate is incomplete. A significant number of studies have found evidence to support this claim (e.g. Chao et al., 2001; Chen et al., 2006; Chandra and Long, 2013). However, all those papers investigate the direct effect of ETR on export volume. In our paper, we argue that in addition to direct effect, the ETR also has an indirect effect on export volume through differential industrial composition. Without taking the indirect effect into account, previous research neglects the unequal indirect effect of ETR on the exports of firms located in different regions, and an additional channel through which the ETR plays its role

While the direct effect of the ETR on firms' exports reduces the variable cost of exporting, the indirect effect of the ETR arises from competition for local laborers among exporting firms. Specifically, when an increase in the ETR makes exporting more profitable, exporting firms expand their production thus necessitating an increase in demand for labor. This increased demand drives up the laborer's wage. As a consequence, the firm-level output and exports will be depressed.

We develop a theoretical model to illustrate both the direct and indirect mechanisms and examine them empirically in this paper. The principal goal of the theoretical model is to uncover both the direct and indirect effect of the ETR on firm-level export behavior. In line with most of the recent international trade literature (Melitz, 2003; Melitz and Ottaviano, 2008), we assume that labor is the only input in the production and firms are heterogeneous in their productivity. Within a country, each region is treated as a subeconomy with a different industrial distribution of labor. When labor mobility is limited, the model shows that a nation wide change in the ETR will lead to different firm-level export responses. Intuitively, if other things are equal, and the ETR changes are identical in all industries, the wage changes more in regions where more labor work in the exporting sectors. This implies that the indirect effect is larger in regions experiencing a larger average regional ETR change.

We evaluate the model's testable predictions using Chinese Customs data from 2000 to 2006. This data has several significant advantages. First, China offers an ideal setting to investigate the impact of the ETR on firms' exports. On the one hand, it has experienced spectacular growth in international trade since the 1980s (Wang and Wei, 2007), it annually exports the largest volume of products in the world (Lin, 2010), and its outstanding trade growth has attracted considerable attention because of the trade policies implemented by the Chinese government (e.g. Eckaus, 2006; Girma et al., 2009). On the other hand, the Chinese government frequently changes the ETR rates to adjust its exports. Gourdon et al. (2014) indicate that during the 2002 to 2012 period, 87% of products at the HS6-

product classifications have undergone at least one ETR change. Second, China's setting also meets our assumption within the theoretical model, since labor mobility between regions in China is limited. In the era of the planned economy, China introduced the Residence Registration System (Hukou system) to implement its industrial development strategy. Under this system, labor mobility is extremely restricted (Cai et al., 2002). Although restrictions on labor mobility have gradually relaxed, labor mobility is still broadly restrained. This fact is helpful for identifying the indirect effect of the ETR changes on firms' exports, as exporting firms located in regions, with different industrial compositions respond differently to the same nation wide ETR changes. Third, we also directly observe the HS code of export product and the location of exporting firms in this data set. This feature is essential for us to construct measures of the industrial and regional ETR rates, respectively.

Endogeneity of the ETR rate is one of the biggest concerns in the empirical analysis (e.g. Chandra and Long, 2013; Gourdon et al., 2014). Specifically, the ETR rates may be set higher for industries where the majority of firms have high export growth potential, or for industries where the majority of firms have poor exporting performance in order to boost their exports. Either case suggests that the OLS estimators might be biased. To ease this concern, we take advantage of China's dual trade regime to obtain our instrument variable. In China, firms export under two regimes. One is the "ordinary" regime, which is common throughout the world. The other is the "processing" regime, under which firms with supplied materials are not eligible to receive any rebate. Since fiscal pressures are often the driving force behind the Chinese government's adjustment of the ETR rates, we expect that industries with a larger share of processing trade firms face less fiscal pressure, and this in turn results in higher ETR rates. Meanwhile, the share of processing trade within an industry would be independent of firm-level export growth. As such, it can be used as an instrument to determine how the ETR affect firms' exports. In robustness checks, we also use the provincial deficit rate suggested by Chandra and Long (2013) as an IV for the ETR rate. All results are quite similar.

By using industry-level ETR and regional weighted average ETR to capture direct and indirect effects, respectively, we find that a 1% increase in the ETR rate will increase firm-level exports by 0.5%, while a 1% increase in the weighted average ETR rate will decrease the firm-level exports by 0.2%. After using the instrumental variable and controlling for firm's self-selection into exporting, we find that a 1% increase in the ETR rate will increase firm-level exports by 0.2%, and a 1% increase in the regional weighted ETR rate will decrease firm-level exports by about 0.02%. These results verify that the OLS estimator tends to be upward biased, and that endogeneity bias should not be ignored when investigating the impact of ETR on export sales among continuing exporters. The estimated indirect effect of the ETR is negative and statistically significant, which is consistent with the model's prediction. This result indicates that the direct effect of the ETR on firms' exports will be offset by the indirect effect caused by local wage changes.

It is important to note that the indirect effect measures the relative impact of ETR changes on firms located in different regions. It does not measure the level effect of regional wage change on firm-level exports. Thus, this paper captures the fact that the indirect effect is not equal throughout the country, and regions are differentially affected by ETR changes through the indirect channel.

This paper contributes to the literature in two distinct manners. First, we disentangle both the direct and indirect effect of the ETR on firms' export sales among continuing exporters. In theory, Feldstein and Krugman (1990) first point out that the increase in the ETR rate will lead to a rise in exports. Chen et al. (2006) develop a Cournot quantity competition model to examine the effect of the ETR on export performance. Empirically, several papers investigate the relationship between the ETR rate and export performance at the industrial or firm level (e.g. Chen et al., 2006; Chandra and Long, 2013; Gourdon et al., 2014). However, none of them document the role which industrial composition plays in the implementation of the ETR. Industrial distribution of labor is an essential factor affecting exports (Cassey and Schmeiser, 2013; Krautheim, 2012), and failing to consider it leads to overestimating the importance of the ETR on boosting exports.

Second, this paper also provides some insights into the recent growing body of work that examines the export spillover effect. For example, Aitken et al (1997) find that the export probability of Mexican plants is positively related with the presence of multinational firms in the same state. Greenaway et al. (2004) find that multinational firms have a positive influence on the export decision of UK domestic firms. Greenaway and Kneller (2008) show that regional and sectoral agglomeration encourages the entry of new firms in export markets. However, Barrios et al (2003), in contrast, find no evidence to indicate that Spanish firms can benefit from other exporters. Bernard and Jesen (2004) conclude the exporting spillover effect does not exist among American manufacturing firms. Our paper, which emphasizes the competition effect, can provide an explanation for these inconsistent findings. That is, although the presence of other exports can have positive externality by sharing information, or knowledge spillovers, it also might exert negative effects on other firms by competing for scarce resources.

The structure of this paper is as follows. In section 2, we describe the model and the hypotheses; Section 3 introduces the ETR system in China and describes the construction of main variables in the empirical analysis. Section 4 reports the estimated results of the direct and indirect impact on exporting firms' intensive margin. In section 5, we conduct robustness checks. Section 6 concludes.

2. Model

In this section, we develop a model to explain the direct and indirect mechanisms through which the ETR affects firm-level export behavior.

2.1. Labor Supply

Consider a country that consists of many regions, indexed by j. Each industry in this economy is denoted by i. Labor is the only input in production, and is assumed to be mobile between industries, but not across regions. As a result, the wage level is identical across different industries within a region, but can vary across regions.[1] In each region, labor is assumed to be inelastically supplied at its aggregate level L_j.[2] In what follows, we suppress the regional index j for notional simplicity.

[1] We can relax this assumption by assuming a fixed migration cost across regions. Labor will not move across regions due to small regional wage differences.

[2] We have tried other forms for the labor supply function, such as $L_j = a_j + b_j \omega_j$, where L_j and ω_j are labor supply and wages in region j. This function gives us the same results as the inelastic labor supply function above.

2.2. Labor Demand

A representative consumer's preferences over varieties takes the CES form:

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

where σ is the elasticity of substitution between any two products, and $\sigma > 1$.[3]

Each firm in a region maximizes its profits by optimally choosing its output, which determines the individual firm's labor demand. The total regional labor demand is constituted by the sum of labor demand in each industry

$$L = \sum_i L_i \tag{2}$$

where L_i is the total labor demand in industry i, which is the aggregate labor demand of firms in industry i. We further divide labor demand for any firm in industry i into domestic and foreign production labor demand. In this way, we treat a firm as if it uses some of its labor to produce products for sale in the domestic market, and uses the rest of its labor to produce the products for sale in the foreign market. In particular,

$$l_i(\omega, \phi, t_i) = l_i^{ne}(\omega, \phi) + 1_{ex} \cdot l_i^{e}(\omega, \phi, t_i) \tag{3}$$

where 1_{ex} is an indicator function of firm-level export status, which takes value 1

[3]We assume that the substitution of elasticity across different varieties in the same industry is the same with that across different varieties from different industries. This assumption is to simplify the proof of the model. However, we can show that our results will still hold if the elasticity of substitution between varieties from the same industry is different from that between varieties from different industries. The proof will be available by request.

if this firm exports, and 0 otherwise. The variable $l_i^e(\omega, \phi, t_i)$ is the labor demand of an exporting firm hired to serve the foreign market at wage level $\omega = \{\omega_j, \omega_{-j}\}$, ETR rate t_i and productivity ϕ. ω_j denotes the wage in region j, and ω_{-j} is a wage vector denotes the wage in all other regions. Notice that the labor demand of a representative firm located in a particular region j will be affected by wages in other regions, ω_{-j}. Because wages in other regions affect the residual demand faced by firms in region j.[4] $l_i^{ne}(\omega, \phi)$ is the labor demand that the firm which serves the domestic market.[5] For a non-exporting firm, it only hires labor to serve the domestic market. The total labor demand in industry i is the aggregate labor demand of individual firms used to serve the domestic and foreign markets. That is,

$$L_i = \int_{\underline{\phi}_i(\omega)} l_i^{ne}(\omega, \phi) M_i f(\phi)\, d\phi + \int_{\underline{\phi}_i^e(\omega, t_i)} l_i^e(\omega, \phi, t_i) M_i f_i(\phi)\, d\phi \tag{4}$$

where $\underline{\phi}_i(\omega)$ and $\underline{\phi}_i^e(\omega, t_i)$ are the productivity cutoffs of industry i which serve domestic and foreign markets, respectively, M_i is the total number of firms in industry i located in this region, and $f_i(\phi)$ is the productivity distribution in industry i.[6] Note that in this model, we are considering a short term phenomenon; thus the mass of firms, M_i, is given,[7] but the mass of operating firms, M_i^a =

[4] This is a regional interaction. We thank a referee for pointing out this issue. Details will be further discussed in the next section.

[5] Note that the ETR rate t_i only directly affects the labor demands of exporting firms' needed to serve foreign markets, through changing their variable cost. It does not directly affect the labor demand of firms, necessary for serving the domestic market.

[6] We have assumed that the mass of firms paying the entry cost is fixed. That says, we analyze a short term impact of the ETR changes on firms' performance.

[7] This assumption is used to obtain the subsequent analytical solutions. In particular, when the productivity distribution follows a Pareto distribution, the mass of firms paying the entry cost would be fixed. We thank a referee for pointing out this issue.

$(1 - F(\underline{\phi}_i))M_i$, is endogenously determined by the productivity cutoff $\underline{\phi}_i$.

Similar to Melitz (2003), the labor demand of a firm with productivity ϕ, hired to serve the domestic market, is determined by

$$\begin{aligned} l_i^{ne}(\omega, \phi) &= \frac{q(\omega, \phi)}{\phi} \\ q(\omega, \phi) &= A_i(\omega) p(\omega_j, \phi)^{-\sigma} \\ p(\omega_j, \phi) &= \frac{\sigma}{\sigma - 1} \left(\frac{\omega_j}{\phi} \right) \end{aligned}$$

Note that when firm-level sales and labor demand are determined by wage vector, $\omega = \{\omega_j, \omega_{-j}\}$ because of regional interations, firm-level price only relies on the regional wage ω_j.[8] Consequently, the labor demand for a firm with productivity ϕ used to serve the domestic market is as follows

$$l_i^{ne}(\omega, \phi) = A_i(\omega) \left(\frac{1}{\phi} \right)^{1-\sigma} \left(\frac{\sigma}{\sigma - 1} \right)^{-\sigma} \omega_j^{-\sigma} \tag{5}$$

where $q(\omega, \phi)$ and $p(\omega_j, \phi)$ are the optimal sales and price in the domestic market, respectively. $A_i(\omega) = A_i(\omega_j, \omega_{-j})$ is the domestic residual demand for the products of industry i, which depends on wage in region j and all other regions.[9] Note that the domestic residual demand also depends on the foreign wage, and we treat

[8] We thank a referee for pointing out this issue.

[9] In this version of the manuscript, the fixed production cost is assumed to be paid by using capital instead of labor. However, we can show that if the fixed cost is paid by labor, all of the following conclusions still hold. To show this we only need to write the labor demand $l_i^{ne}(\omega, \phi) = \frac{q(\omega,\phi)}{\phi} + f_i = \gamma(\phi) \frac{q(\omega,\phi)}{\phi}$, where $\gamma(\phi) = f_i / \frac{q(\omega,\phi)}{\phi}$. In the proof and the simulation, we treat the fixed cost being paid by labor.

foreign country as region 0, with wage ω_0. In particular,

$$A_i(\omega) = \frac{\sum_{j=1}^{J} \omega_j L_j}{P} P^{\sigma}; \tag{6}$$

$$P = \left[\sum_{j=0}^{J} \sum_{i=1}^{I} \int_{\underline{\phi}_i(\omega_j, \omega_{-j})} \left(\frac{\sigma}{\sigma - 1} \frac{\omega_j}{\phi_i} \right)^{1-\sigma} M_j f(\phi_i) d\phi_i \right]^{\frac{1}{1-\sigma}}$$

Several issues are worth addressing here. First, firms of industry i located in different regions face the same domestic residual demand. This is because residual demand is determined by the home country's aggregate income, $\sum_{j=1}^{J} \omega_j L_j$, and the price index, P. These two variables exhibit no regional variation. Second, equation (6) implies that a change in the regional wage ω_j will affect residual demand faced by firms in region j and other regions, and hence affect firm-level production in other regions.[10] Note that an increase in the regional wage, ω_j, will increase the residual demand faced by firms in different regions by the same amount.

Accordingly, the labor demand of an exporting firm with productivity ϕ, used to serve the foreign markets, is given by

$$l_i^e(\omega, \phi, t_i) = A_i^*(\omega) \left(\frac{1}{\phi} \right)^{1-\sigma} \left(\frac{\sigma}{\sigma - 1} \right)^{-\sigma} (\widetilde{\tau}\omega)^{-\sigma} \tag{7}$$

$$\text{where, } \widetilde{\tau} = \frac{\tau}{(1 - \frac{\tau_2}{\tau}\sigma)^{\frac{1}{\sigma_i - 1}}}, \tau_2 = r - t_i$$

$$A^*(\omega) = \frac{\omega_0 L_0}{P^*} {P^*}^{\sigma}; P^* = \left[\sum_{j=0}^{J} \sum_{i=1}^{I} \int \left(\frac{\sigma}{\sigma - 1} \frac{\widetilde{\tau}\omega_j}{\phi_i} \right)^{1-\sigma} M_j f(\phi_i) d\phi_i \right]^{\frac{1}{1-\sigma}}$$

[10] This is how regions interact. We thank a referee for pointing out this issue. Intuitively, if ω_j increases, the residual demand faced by firms in other region increases as the domestic consumers become richer. Therefore, all other things equal, an increases in ω_j increases the labor demand in other regions.

where $A_i^*(\omega) = A_i^*(\omega_j, \omega_{-j})$ is the residual demand for products from industry i in the foreign market, and P^* is the price index in the foreign country; r is the official VAT rate collected; τ_2 is the actual VAT rate paid after receiving the rebate, τ is the iceberg transportation cost, and $\widetilde{\tau}$ is the rebate adjusted trade cost.[11] Note that when $j = 0$, $\widetilde{\tau}$ =1 since the foreign firms do not pay the trade cost in the foreign market.

2.3. Equilibrium

In this section, we summarize the equilibrium in the economy with limited labor mobility.

1. Consumers maximize their utility according to the preferences defined in equation (1) and their income. The total income in the home country is $\sum_{j=1}^{J} \omega_j L_j$, while the total income in the foreign country is $\omega_0 L_0$.
2. Active firms located in each region maximize their profit by optimally hiring labor and setting their price in domestic and foreign markets according to equations (5)-(7).
3. In equilibrium, firms with cutoff productivity $\underline{\phi}_i(\omega)$ earn zero total profit and firms with cutoff productivity $\underline{\phi}_i^e(\omega, t_i)$ earn zero profit in the foreign market.

$$\pi(\omega, \underline{\phi}_i(\omega)) = \frac{A_i(\omega)}{\sigma} \frac{\sigma}{\sigma - 1} \frac{\omega_j}{\underline{\phi}_i(\omega)} - \omega_j f_i = 0 \qquad \text{(Zero Profit)}$$

$$\pi^*(\omega, \underline{\phi}_i^e(\omega, t_i), t_i) = \frac{A_i^*(\omega)}{\sigma} \frac{\sigma}{\sigma - 1} \frac{\widetilde{\tau}\omega_j}{\underline{\phi}_i(\omega)} - \omega_j f_i^* = 0$$

where $\omega_j f_i$ and $\omega_j f_i^*$ are the fixed cost in the domestic and foreign markets, respectively.

[11] The proof is in the Appendix.

The expected value for any potential firm in region j and industry i is zero:

$$\int_{\underline{\phi}_i(\omega)} \left[\pi(\omega, \phi_i) + 1(\phi > \underline{\phi}_i^e(\omega, t_i)\pi^*(\omega, \underline{\phi}_i^e(\omega, t_i), t_i)\right] f(\phi_i) = \omega_j Fe \tag{Free Entry}$$

4. The free entry and zero profit conditions together determine the productivity cutoffs, $\underline{\phi}_i(\omega)$ and $\underline{\phi}_i^e(\omega, t_i)$, for different industries across regions as functions of regional wages and the ETR rates, t_i. The regional wages, $\omega = \{\omega_j, \omega_{-j}\}$ adjust until regional labor markets clear and trade balance.

$$L = \sum_i L_i \tag{Labor Market Clearning}$$

$$\sum_{j=1}^{J} \sum_i X_{ij} = \sum_i X_{i0} \tag{Balance of Trade}$$

where L_i is the labor demand in industry i in a particular region defined in equation (4) and L is the total labor supply in the same region. X_{ij} is the total export value in region j of industry i, and X_{i0} is the aggregate export value by the foreign country of industry i.

$$X_{ij} = \int_{\underline{\phi}_i^e} A_i^*(\omega)[\tau_i p(\omega_j, \omega_{-j}, \phi)]^{1-\sigma} M_i f(\phi) d\phi$$

In sum, in the equilibrium, consumers maximize their utility and firms maximize their profit. Their optimal behaviors and regional wages determine the productivity cutoffs, price index, residual demand, clear the labor market in each region and balance trade. In the subsequent section, we introduce how a shock affects the equilibrium.

2.4. The Impact of the ETR on Exporting Firms' Intensive Margin

From equation (7), the change in the ETR affects the variable cost of exporting firms through the adjusted trade cost $\widetilde{\tau}$. We can derive the following negative relationship between the ETR rate, t_i, and the adjusted trade cost $\widetilde{\tau}$.

$$\frac{\partial \widetilde{\tau}}{\partial t_i} = \frac{\partial \widetilde{\tau}}{\partial \tau_2}\frac{\partial \tau_2}{\partial t_i} = \tau_1 \left(-\frac{1}{\sigma - 1}\right) (1+\tau_2)^{-\frac{\sigma}{\sigma-1}} \left(\frac{\sigma}{\tau}\right) < 0. \tag{8}$$

Equation (8) implies that, an increase in the ETR is identical to a decrease in the rebate-adjusted trade cost $\widetilde{\tau}$. From this it is evident that we can demonstrate the following inequalities:

$$\frac{\partial l_i^{ne}(\omega, \phi)}{\partial \omega_j} < 0 \tag{9.1}$$

$$\frac{\partial l_i^{e}(\omega, \phi, t_i)}{\partial \omega_j} < 0 \tag{9.2}$$

$$\frac{\partial l_i^{e}(\omega, \phi, t_i)}{\partial t_i} > 0 \tag{9.3}$$

$$\frac{\partial \omega_j}{\partial t_i} > 0 \tag{9.4}$$

Inequalities (9.1) and (9.2) imply that the labor demand of firms located in region j, regardless whether the labor is used to serve the domestic and foreign markets, is decreasing in the regional wage level ω_j ($\omega = \{\omega_j, \omega_{-j}\}$).[12] The intuition is that when facing a regional wage increase, all other things equal, firms located in that region have a comparative disadvantage relative to firms located

[12]As shown in the appendix, A_i and A_i^* are homogeneous of degree σ in (ω_j, ω_{-j}), which implies $\sum_j \frac{\partial A_i}{\omega_j}\omega_j = \sigma A_i$, $\sum_j \frac{\partial A_i^*}{\omega_j}\omega_j = \sigma A_i^*$. $\frac{\partial l_i^{ne}(\omega,\phi)}{\partial \omega_j} = A_i(\frac{\sigma}{\sigma-1})^{-\sigma}\left(\frac{1}{\phi}\right)^{1-\sigma}(-\sigma)\omega_j^{-\sigma-1} + (\frac{\sigma}{\sigma-1})^{-\sigma}\left(\frac{1}{\phi}\right)^{1-\sigma}\omega_j^{-\sigma-1}\frac{\partial A_i}{\partial \omega_j}\omega_j < 0$. Note that we make use of the feature $\sigma > 1$.

in other regions. As such, their market share will be stolen by their competitors located in other regions and hence their sales and labor demand are smaller. Inequality (9.3) implies that the direct impact of the ETR on exporting firms' labor demand, used to serve foreign markets, is positive. This is because an increase in the ETR rate reduces exporting firms' rebate-adjusted trade cost, $\widetilde{\tau}$, and hence increases labor demand among firms serving the foreign market. Last, inequality (9.4) indicates a positive correlation between the ETR rate and the regional wage level.[13] The intuition for this result is that when industry i receives a higher ETR, exporting firms expand their production, and as such increase the labor demand hired to serve foreign markets. All other things equal, the equilibrium wage level increases. All results continue to hold after allowing for firm-level entry and exit in the domestic and foreign markets.

One concern is that inequalities (9.1) - (9.4) could be violated by regional interactions. In particular, wage and export changes in one region could essentially affect the residual demand (domestic or foreign) faced by firms located in other regions, which in turn determines firm-level exports and labor demand.[14] We have proved in the Appendix that even after accounting for regional interaction effect, inequalities (9.1) - (9.4) still hold. The intuition is that the regional interaction effects operate through residual demand, $A_i(\omega)$ and $A_i^*(\omega)$. When the wage, ω_j, in region j increases, firms located in different regions experience identical changes in residual demand and, as such, after pinning down the regional interaction effect, the indirect effect still manifests regional differences. A detailed proof is in the

[13]The detailed proof is in the Appendix.

[14]The residual demand in the domestic and foreign market, A_i, and A_i^*, are functions of the price index in the domestic and foreign markets, respectively. The price indexes are affected by operating firms in all regions.

Appendix.

Using similar logic, we argue that the balance of trade does not affect inequalities (9.1) - (9.4). When the ETR rate, t_i, increases, the foreign wage must fall to balance the trade. This is due to the fact that the foreign country imports more, which leads the least productive foreign firms to exit. As such, the aggregate labor demand curve shift down in the foreign country. The adjustment of the foreign wage, ω_0, only affect $A_i(\omega)$ and $A_i^*(\omega)$. The change in residual demand has an identical impact for exporters located in different regions. After pinning down this effect, the indirect effect still manifests regional differences.

From the above analysis, the ETR affects the firm-level intensive margin of exports through two respective channels. The first is the direct channel, in which the ETR affects the variable cost of exporting firms by refunding firms the tax they pay. The other is the indirect channel in which the ETR affects the intensive margin through changing the regional wage. To evaluate the impact of ETR changes on the behavior of exporters, we have to disentangle the direct and indirect impact of ETR changes.

2.5. Regional Differentiation in the Indirect Effect

Regions are heterogeneous in the distribution of labor across industries. The differences in industrial composition across regions could be caused by regional comparative advantage, e.g. geographic or policy advantages (Cai et al., 2002).[15]

[15] For instance, firms producing $i-$type goods located in different regions may face different transportation costs. Suppose there are two industries, one is a tradable industry, and the other is a non-tradable industry. Following Hsu et al. (2014), we can assume that each firm draws a distinct variety by paying an entry cost, and the variety will be in the export sector with probability λ. A firm with productivity ϕ in region j earns revenue from exporting: $r_j(\phi) = \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} A^* c(\phi)^{1-\sigma} \tau_j^{1-\sigma}$, $j = 1$ or 2. A^* is the residual demand in the foreign market. If

A consequence of differing industrial composition across regions is that the regional wage adjusts differently in response to the ETR changes. This model yields the following relationship between wage changes and regional weighted average ETR changes:

$$\Delta\omega_j = \sum_i \beta_i \Delta t_i \tag{10}$$

$$\text{where, } \beta_i = \frac{L_i^e \left(-\sigma\right) \widetilde{\tau} \frac{\partial \widetilde{\tau}}{\partial t_i} - C_i}{\sum_k \frac{\sigma}{\omega_j} L_k + B}, \;\; L_i^e = \;\; \sum_i \int_{\underline{\phi}^e} l_i^e(\omega, \phi, t_i) M_i f(\phi) d\phi$$

$$B = \sum_k l_k^e(\omega, \underline{\phi}_k^e, t_k) M_k f_k \left(\underline{\phi}_k^e\right) \frac{\partial \underline{\phi}_k^e}{\partial \omega_j}, \;\; C_i = l_i^e(\omega, \underline{\phi}_i^e, t_i) M_i f_i(\underline{\phi}_i^e) \frac{\partial \underline{\phi}_i^e}{\partial t_i}$$

where L_i^e is the total labor demand of exporting firms hired to serve foreign markets, in industry i, and $l_i^e(\omega, \underline{\phi}^e, t_i)$ is the labor demand of firms, in industry i, with cutoff productivity, $\underline{\phi}^e$, serving the foreign market. If we consider that the change in the ETR is relatively small and its impact on the firm-level extensive margin (entry and exit) is negligible, β_i has a simplified presentation: $\beta_i = \frac{L_i^e(-\sigma)\widetilde{\tau}\frac{\partial \widetilde{\tau}}{\partial t_i}}{\frac{\sigma}{\omega_j} L}$. Equation (10) implies a positive correlation between the weighted average ETR change, $\sum_i \beta_i \Delta t_i$, and the change in the regional wage, $\Delta\omega_j$. β_i is positively correlated with $\alpha_i = \frac{L_i^e}{\sum_j L_j}$, the share of labor in industry i employed for export production, up to an industry specific constant term.[16] This implies that when

$\tau_1 > \tau_2$, and other things being equal, export firms will account for a larger share in region 2 relative to that in region 1. This simple example demonstrates that even two regions that are identical in nearly every aspect, but have different transportation costs, may end up with having differing industrial composition.

[16] $\beta_i = \frac{(-\sigma)\widetilde{\tau}\frac{\partial \widetilde{\tau}}{\partial t_i}}{\frac{\sigma}{\omega_j} + \frac{1}{L} B} \alpha_i - \frac{\frac{1}{L} C_i}{\frac{\sigma}{\omega_j} + \frac{1}{L} B}$. When the ETR change is small and its effect on firm-level extensive margin is negligible, $\frac{\partial \underline{\phi}_k^e}{\partial t_i} \approx 0$, we have $\beta_i = \frac{L_i^e(-\sigma)\widetilde{\tau}\frac{\partial \widetilde{\tau}}{\partial t_i}}{\sum_k \frac{\sigma}{\omega_j} L_k} = \omega_j \left(-\frac{\partial \widetilde{\tau}}{\partial t_i}\right) \alpha_i$. Since $-\frac{\partial \widetilde{\tau}}{\partial t_i} > 0$, the coefficient on α_i is positive, and β_i is positively correlated with α_i. In the general case, when the impact of ETR change on firm-level extensive margin is nontrivial, the result still holds. Notice

two industries experience the same ETR change, the sector with a greater number of employees (a higher β_i) will have a larger impact on the regional wage. We summarize the predictions of the model in the following proposition.

Proposition 1. *When the mobility of the regional labor force is limited, an ETR increase has a positive direct impact and a negative indirect impact on the intensive margin of firm-level export sales. The impact of industry-level ETR changes on firm-level exports is smaller in regions experiencing larger weighted average ETR changes.*

The proposition implies that if the ETR changes are identical in all industries, the intensive margin of exporting firms will change less in regions, where more of labor is allocated to exporting sectors.

2.6. Comparative Statistics

In this section, we discuss the comparative statistics of the model to further develop the intuition for our empirical results.[17] In what follows, we focus our discussion on a particular region j.

We first depict the influence of the residual demand on regional labor demand curve in Figure 1. According to equations (5) and (7), at any given wage, the individual firm's labor demand is increasing in residual demand. Therefore, since the aggregate regional labor demand is a sum of the individual firm's labor demand, at any given wage, it too is increasing in residual demand.

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that B is independent of L^e, and from equation (10) it is positive ($\frac{\partial \phi^e_{-k}}{\partial_{\omega_j}} > 0$). The numerator of $\frac{(-\sigma)\tilde{\tau}\frac{\partial \tilde{\tau}}{\partial t_i}}{\frac{\sigma}{\omega_j}+\frac{1}{L}B}$ is positive and the denominator is also positive. As such, β_i is again positively correlated with α_i.

[17]We thank a referee for suggesting a simple, graphic interpretation of our model.

Figure 1: The Influence of Residual Demand on the Regional Labor Demand Curve

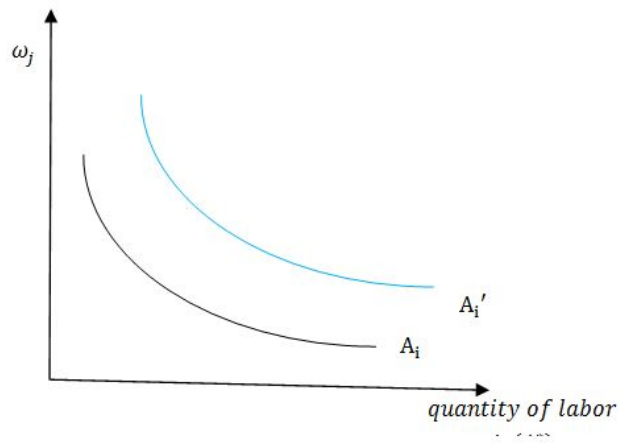
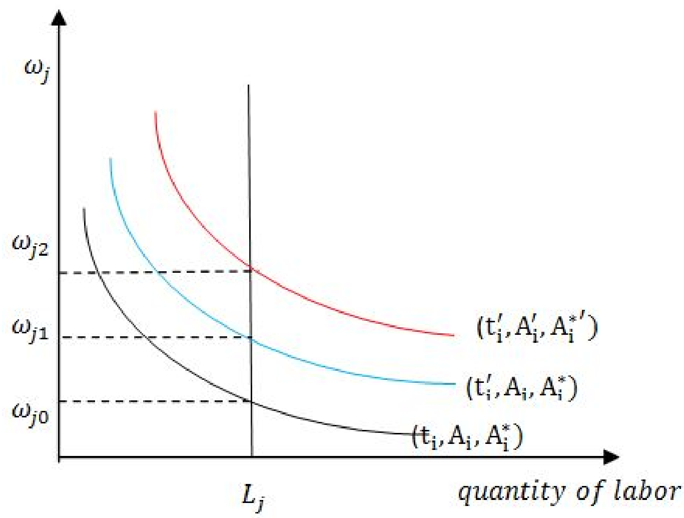


Figure 1 demonstrates that when the residual demand, A_i, increases to A_i' (There is a similar argument for A_i^*), the regional labor demand curve will shift up from the black curve, A_i, to the blue curve, A_i'.

We next depict the influence of an ETR change on the regional wage in Figure 2.

Figure 2: The Indirect Effect of an ETR Change on the Regional Wage



In Figure 2 the X-axis is the quantity of labor, and the Y-axis is ω_j, the regional wage. The black curve (t_i, A_i, A_i^*), is the labor demand curve in region j at ETR rate t_i, residual demand A_i and A_i^* in the home and foreign countries respectively. The vertical curve is the aggregate labor supply in this region, at $L = L_j$. The intersection of the black curve and the vertical line determine the market clearing regional wage, ω_{j0}, at t_i.

Now, consider an increase in the ETR, from t_i to t_i', and $t_i' > t_i$. We first assume away any change in residual demand, A_i and A_i^*. As we have shown in the main text, when the ETR increases in one industry i, without considering any change in residual demand, exporting firms in this industry will expand production. This is because $l_i^e(\omega, \phi, t_i) = A_i^*(\omega_j, \omega_{-j}) \left(\frac{1}{\phi}\right)^{1-\sigma} \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} (\widetilde{\tau}\omega)^{-\sigma}$. When $A_i^*(\omega_j, \omega_{-j})$ is unchanged, an increase in t_i decreases the trade cost, $\widetilde{\tau}$, which increases the labor demand needed to serve the foreign market. This expansion will increase regional labor demand. Therefore, the labor demand curve shifts up to the blue curve (t_i', A_i, A_i^*). The new labor market clearing wage is ω_{j1}.

However, the residual demand in the home and foreign countries will increase when ω_j increases. Notice that the wage increase in other regions also increase the residual demand faced by firms in region j. This so-called regional interaction will increase the residual demand even more. The increase in the residual demand will further increase the labor demand necessary to serve both the domestic and foreign markets as depicted in Figure 1. As such the aggregate labor demand curve shifts up further in region j in response to the increase in the residual demand. The regional wage continues to increase, which again increases the residual demand. Note that although residual demand keeps increasing, it shifts up the labor demand curve at a diminishing rate due to two reasons: for the same increase in residual demand, when the labor demand curve is in a higher position, on the one hand, the continuing firms expand their labor demand less according to equations (5) and (7) as they face a higher regional wage;[18] on the other hand, the number of firms expanding their labor demand is fewer as a higher regional wage requires a higher productivity cutoff. The two points together imply that the movement of the regional labor demand curve would stop at a upper limit. This process lasts until the the labor demand curve reaches the position of the red curve $(t_i, A_i^{'}, A_i^{*'})$. The regional wage ω_{j2} and wages in other regions determine the new residual demand $A_i^{'}$ and $A_i^{*'}$. The adjusted residual demand and new regional wages clear every regional labor market.

In sum, an increase in the ETR, t_i, will shift up the wage in a particular region from ω_{j0} to ω_{j2}, with $\omega_{j2} > \omega_{j0}$. This increase in the regional wage implies that an increase in the ETR, will decrease firm-level exports by increasing the regional wage. Therefore, the indirect effect is negative.

Last, we use Figure 3 to illustrate how the indirect effect of the ETR differs across regions. Suppose two regions are identical in every aspect, such as the aggregate labor demand curve, the total population of labor, etc, except for their industrial composition. In particular, we assume region 1 has a large share of labor working in industry i, while no workers are employed in industry i in region 2.[19]

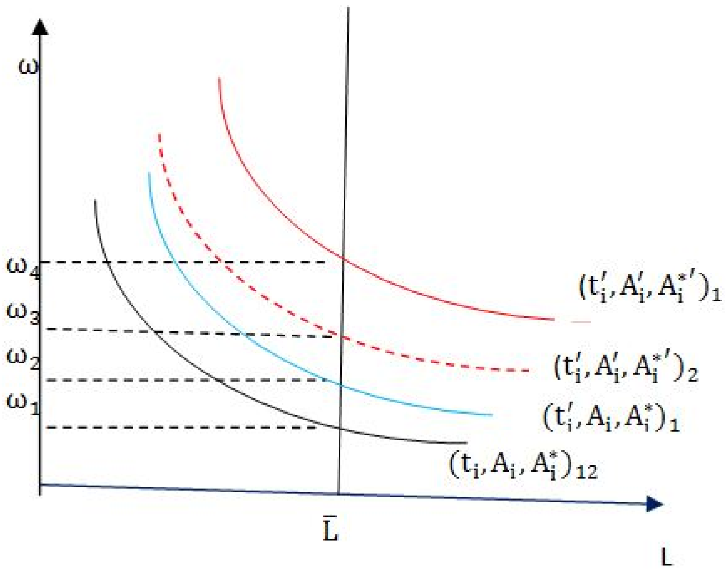
[18] In particular, an increase in residual demand proportionally increases the firm-level labor demand according to equations (5) and (7). When the regional wage is higher, the firm-level labor demand is lower and hence the proportional increase in the firm-level labor demand is smaller.

[19] Suppose everything is identical in region 1 and 2, but region 1 has an industry i while region 2 has an industry i'. The firms in these two industries have the same productivity distribution, and the two industries face the same trade costs and ETR rates initially. If the remaining industrial composition is the same in the two regions and industry i and i' are exactly symmetric, region 1 and region 2 would have the same aggregate labor demand curve.

Initially the labor demand curves in both regions are depicted by the black curve $(t_i, A_i, A_i^*)_{12}$. Now suppose there is an increase in the ETR rate, t_i, in industry i. According to the analysis above, the aggregate labor demand in region 1 will shift up without accounting for the changes in the residual demand. In contrast, nothing changes in region 2 as no firms produce in industry i.[20] For simplicity, we ignore new entrants in both regions. This would be true when the entry cost is large and the ETR change is small. However, we argue in footnote 17 that even after taking new entrants into account, the demand curve in region 1 shifts more than that in region 2. The aggregate demand curve in region 1 shifts to the solid blue curve position, $(t_i^{'}, A_i, A_i^*)_1$, and the aggregate labor demand curve in region 2 stay in the black solid curve position $(t_i, A_i, A_i^*)_{12}$.

[20] It is true that some firms may enter into industry i in region 2 after the increase in ETR. In this case, the labor demand will also increase in region 2 because of the expanding labor demand in industry i. Intuitively, the labor demand in industry i will increase more in region 1 relative to region 2, as there are incumbent exporters in region 1 and also new entrants. Therefore, even if considering the new entrants, we still have that in region 2 the aggregate labor demand curve shift up less relative to that in region 1.

Figure 3: The Different Indirect Effect



The equilibrium wage in region 1 becomes to ω_2, and $\omega_2 > \omega_1$. This change increases the residual demand of A_i and A_i^* and drives up aggregate labor demand in both regions. Therefore, the aggregate labor demand curve in region 1 shifts from the solid blue curve to solid red curve, $(t_i', A_i', A_i^{*\prime})_1$ while that in region 2 shifts from the solid black curve to the dash red curve, $(t_i', A_i', A_i^{*\prime})_2$. The regional wage in region 1 and region 2 are ω_4 and ω_3, respectively, where $\omega_4 > \omega_3$.

So far, we have used figures to show that the indirect effect of ETR changes is negative and exhibit regional difference.

3. Background and Data

In China, industrial composition differs significantly across regions. Candelaria et al. (2013) show that the regional differences in industrial composition explain about half of regional wage differences. The ratio of provincial exports to provincial

GDP also varies considerably across provinces. During the period 2002-2006, the minimum regional export share was less than 5%, while the maximum counterpart was more than 70%. Table 1 reports the 25th, 50th and 75th percentile of export shares between 2002-2006.

[Table 1 is to be here]

Table 1 indicates significant differences in regional export shares. The data shows that the maximum regional export share is 20 times larger than the minimum. These regional differences reflect the regional variation in industrial composition.[21]

Export revenue is an important component in China's GDP. In 2006, Chinese export revenue accounted for 37% of GDP. Knowing the important role exports play in its economy, the Chinese government announced a series of policies to stimulate exports. The ETR system was established to encourage exports. It partially refunds exporting firms the value-added and consumption tax they pay for their inputs. In particular, the ETR is applicable for exporting firms engaged in ordinary trade or processing trade with imported materials. For firms engaged in processing trade with supplied materials, the value-added tax has already been exempted when they purchase the inputs, and as such they cannot receive any ETR. The ETR rates vary substantially across industries with a range from 0 to 17% in 2006. As a policy tool to adjust the composition of exports (e.g. shifting China's exports toward more value-added and high-tech products by providing a high ETR in these industries), the ETR rate has been frequently modified. From 2002 - 2012, more than 80% of products at 4 digit HS classification level

[21]The data is available in *CEnet Statistics Database*: http://db.cei.gov.cn/page/Default.aspx

underwent at least one ETR change. The ETR system has proved effective in boosting exports in China. Gourdon et al. (2014) show that every 1% increase in the ETR rate in a given industry causes a 6% increase in export sales in the same industry. In addition, the Chinese government increased the ETR rates several times when faced with the East-Asian Crisis in 1997, which stabilized Chinese exports and the economy. After 1999, a four-tired ETR system (17%, 15%, 13%, and 5%) was implemented with an average ETR rate of 15%. In October 2003, the Chinese government announced a reduction in the average ETR rate from 15.11% to 12.11% due to fiscal pressures. Since January of 2004, a five-tired ETR system (17%, 13%, 11%, 8%, and 5%) was implemented.

To conduct the empirical analysis, we match three sources of information. One of the data sources is collected by the Chinese Customs Trade Statistics (CCTS) and contains a report of export quantities, and f.o.b values for exporting firms in the eight-digit Harmonized System over the 2000-2006 period. The second data source is from the Chinese Annual Survey of Industrial Firms (CASIF). The CASIF dataset covers all state-owned enterprises (SOEs) and non-SOEs with annual sales above RMB 5 million, which is equivalent to approximately 700 thousand US dollars.

We carefully matched the two datasets following Brandt and Zhang (2012) using firm names, telephone numbers, and zipcodes. Table 2 provides annual summaries of information from the matched sample. Since non-SOEs in the survey dataset are those with annual sales of $770,000 or above, the non-SOEs in the matched sample appear to be larger in scale than the small SOEs. According to Table 2, the SOEs and non-SOEs in the matched sample account for 31.49% – 49.83% of total export value, and 25.14% – 49.83% of the number of all exporting firms. The export value of the matched sample accounts for 41.15% of total exports on average.

[Table 2 is to be here]

Using the matched dataset, we compute the firm-product level TFP following Foster et al. (2008), and developed by Hu et al. (2015):

$$\ln TFP_{ikt} = \ln q_{ikt} - \alpha_{iK} \ln K_{ikt} - \alpha_{iL} \ln L_{ikt} - \alpha_{iM} \ln M_{ikt} \tag{11}$$

where q_{ikt} is the physical units of output i exported by firm k in year t across all destinations. K_{ikt}, L_{ikt} and M_{ikt} represent the firm-product-year measures of capital, labor and materials input, respectively. α_{iK}, α_{iL}, and α_{iM} are the input share for capital, labor and intermediate materials, respectively.[22]

The third data source is the ETR rates from the Chinese Customs Information Release Center[23], which covers all exported products between 2002 - 2006. We match this dataset with the CCTS data using HS codes. The weighted average ETR in each region is constructed as follows:

$$ETR\_prov_{jt} = \sum_i ETR_{it} \frac{\exp_{ijt}}{GDP_{jt}} \tag{12}$$

where ETR_prov_{jt} is the weighted average ETR of province j in year t, and exp_{ijt} is the export revenue of industry i in province j at year t, and GDP_{jt} is the total GDP of province j in year t. The regional weighted average ETR, ETR_prov_{jt}, varies across provinces and over time.

[22]The detailed procedures of construction input shares is in the Appendix.

[23]The web page is: http://www.china-customs.com

Note that our model is best suited for manufacturing firms which export directly, but a considerable number of Chinese exporters are intermediary firms. Following Ahn et al. (2011), we identify the set of intermediary firms by their name[24] and drop all of them in the empirical regressions.

Finally, we have a matched dataset of exporting firms with variables containing firm-level export quantities and TFP, industry-level ETR rates, and the regional revenue weighted ETR rates.

4. Empirical Evidence

In this section, we test the model's prediction of the direct and indirect impact of the ETR on the firm-level intensive margin of exports. The direct and indirect effects are captured by the industry-level ETR and regional weighted average ETR, respectively.

$$\ln Q_{kijt} = \beta_0 + \beta_1 \ln ETR_{it} + \beta_2 \ln \left(ETR\_prov_{jt}\right) + \beta_3 \ln TFP_{kit} + \chi + \varepsilon_{kijt} \quad (13)$$

where Q_{kit} is the export units of product i produced by firm k located in region j in year t. ETR_{it} is the ETR rate of industry i in year t, and ETR_prov_{jt} is the regional revenue weighted ETR in region j in year t. $\chi = \chi_t + \chi_i + \chi_k + \chi_j$ are used to control for the year, industry firm and region fixed effects, respectively. The results are reported in Table 2.

[Table 3 is to be here]

[24] Specifically, we identify the set of intermediary firms by their Chinese name that mean "trading", "importer", and "export". In Pinying, the name containing these phrases: "jin4chu1kou3", "jing1mao4", "ke1mao", and "wai4jing1" is treated as intermediary firms.

Table 3 indicates that an increase in the industry ETR rate will increase the intensive margin of exports, while an increase in the regional weighted average ETR will have the opposite effect. A positive impact of the industry ETR on firms' exports captures the impact of the firm-level rebate adjusted trade cost $\widetilde{\tau}$, defined in equation (7). The negative impact of the weighted average ETR on the intensive margin of exports captures the impact of changing regional wages. In particular, the regions experiencing a weighted average ETR increase will expand their exports and hence raise the regional labor demand. The rising regional labor demand pushes up the regional wage, which in turn increases the exporting firms' production costs. As such, a weighted average ETR increase has a negative impact on firm-level exports. The direct impact of the ETR changes on a firm's exports dominates the indirect impact. These results are consistent with the model's predictions.

As mentioned in a series of papers by Dai et al. (2014), Yu (2013) and Gourdon et al. (2014), processing trade is organized differently from ordinary trade. In particular, firms engaged in the processing trade are typically less productive, and rely more on global supply chains. Most importantly, the processing trade firms with supplied materials do not qualify to receive the ETR as they are exempted from paying value added tax when they purchase their inputs. To ease the concern that the firms engaged in processing trade may potentially bias the empirical results in Table 2, we estimate the coefficients in equation (13) using only firms engaged in ordinary trade.

[Table 4 is to be here]

In Table 4, the results show a similar pattern to that in Table 3. Every 1% increase in industry ETR rate will increase the firm-level intensive margin of export sales by 0.5%. In contrast, compared to a region experiencing no change in the average regional ETR, a region experiencing a 1% increase in the average regional ETR, will reduce its firms' exports by about 0.2%.

A second concern arises from reverse causality: the Chinese government may use the ETR to subsidize poor-performing industries and boost their exports. Alternatively, the ETR may subsidize industries with high export-growth potential. In either case, our regression framework may potentially suffer from endogeneity bias. To address this issue we use an instrumental variable approach. During the 2002 - 2006 period, the Chinese government adjusted the ETR rates frequently because of fiscal pressure (Chandra and Long, 2013). For each industry, the fiscal pressure partially depends on the share of processing trade firms with supplied materials, because these firms are not eligible to receive any rebate. This implies that industries with a larger share of processing trade firms with supplied materials, will account for less fiscal pressure on the government, and will be subject to smaller ETR reductions. Meanwhile, the share of processing trade within a industry does not affect the firm-level export growth. Therefore, the export share of processing trade with supplied materials in each exporting industry can be used as an instrument. The results are reported in the second column of Table 4 and Table 5 for the full sample and ordinary trade firms, respectively.

A third concern is selection bias. In particular, all firms experiencing changes in the intensive margin of export sales are survivors. These firms may have higher growth potential compared to those firms which exit.[25] This implies that the impact of the ETR on the firm-level intensive margin of export sales might be upward biased. To control for the selection bias, we implement the estimation in two steps. In the first step, we compute the firm-level survival probability using a Probit regression. In the selection equation, the selection variables contain firm-level TFP, the quantity of sales in the last period, industry-year and region fixed effects.

$$\Pr(y_{kijt} = 1) = \Pr(\alpha_0 + \alpha_1 \ln TFP_{k,t-1} + \alpha_2 \ln sale_{ki,t-1} + \psi + \xi_{kijt} > 0) \quad (14)$$

where $\ln TFP_{k,t-1}$ and $\ln sale_{ki,t-1}$ are firm-level log productivity and log sales in last period, respectively, and $\psi = \psi_t + \psi_i + \psi_j$ captures the year, industry, region fixed effects.

In the second step, we add the survival probability into equation (13) and use IV regressions to obtain the final estimates. We report the results with the selection bias correction in the third column of Table 5 and Table 6 for the full sample and ordinary trade, respectively.

[Table 5 is to be here]

[Table 6 is to be here]

The results in Table 5 and Table 6 imply that although the impact of the weighted average ETR on firms' exports fall, the effect is still negative and statistically significant after controlling for the endogeneity and selection bias. Specifically, on

[25] Consistent with our theoretical model, some least productive firms exit when experiencing an ETR increase, which leads to a higher regional wage.

the one hand, every 1% increase in industry ETR rate will increase the firm-level export sales by 0.2%. On the other hand, compared to a region experiencing no change in the average regional ETR, exports will decrease by about 0.02% for firms located in regions experiencing a 1% average regional ETR increase.

5. Robustness Check

We have conducted a series of robustness checks to verify our empirical results obtained in the last section. The first robustness check relates to adding more province-year controls. This is to ease the concern that the time varying provincial level economic variables may also affect firm exports.[26] We add provincial FDI stocks and the number of special economic zones to control for regional openness and policy-driven export advantages. The results are reported in Tables 7 and 8, respectively. The results are consistent with our baseline results: while an increase in the ETR encourages firm-level exports, the increase in the average regional ETR discourages firm-level exports.

[Table 7 is to be here]

[Table 8 is to be here]

Another concern arises from the validity of the IV we used in the regressions.[27] Chandra and Long (2013) use the regional deficit rate as their instrumental variable instead. The reason is that after 2003 the regional governments need to pay up

[26] We are grateful to an anonymous referee for suggesting this robustness check.

[27] We are grateful to an anonymous referee for pointing out the possibility that firms' choice of operating under the processing regime might be heavily influenced by credit constraints(Manova and Yu , 2015). This may cause a non-zero correlation between the IV and the errors in the current regressions.

to 25% of the ETR requested by local exporters whose exports are in excess of their 2003 level. The regional government's fiscal deficit rate is constructed from their region's business tax revenue and government administrative expenditure as follows:

$$deficitrate_{jt} = \frac{(government\ administration\ expenditure_{jt} - businesstax_{jt})}{government\ administration\ expenditure_{jt}} \tag{15}$$

We re-estimate equation (13) using $deficitrate_{jt}$ as an IV. As the quasi-natural experiment is after 2004, following Chandra and Long (2013), we use samples over 2004-2006 period. The results are reported in Table 9 and Table 10, respectively. The results still indicate that an increase in the ETR increases firm-level exports, while the increase in the average regional ETR decrease firm-level exports. The Magnitudes are all similar to those in Table 5 and Table 6.

[Table 9 is to be here]

[Table 10 is to be here]

6. Conclusion

In this paper, we extend the Melitz (2003) model to investigate the impact of ETR changes on the firm-level intensive margin of export sales. The model predicts that an increase in the ETR will have both a direct and indirect impact on firms' exports due to the immobility of the regional labor force. On one hand, an increase in the ETR decreases firm-level variable costs, and hence increases firm-level exports. On the other hand, an increase in the ETR increases local labor demand as production expands among exporting firms. Rising local labor demand raises the regional wage, which drives up the variable production costs. As a result, firm-level export volumes decline. Using Chinese firm-level export data and industry-level ETR rates during the 2002-2006 period, we test the predictions of the model. The results indicate that an increase in the industry-level ETR increases firm-level exports, while the increase in the weighted average ETR drives down firm-level exports. The results are robust to controlling for potential endogeneity and selection bias. This paper suggests that, due to an unbalanced industrial composition across regions, a national wide ETR policy would have differential impacts on exports across Chinese provinces.

Appendix (Tables)

Table 1: The Export Shares in Different Percentiles

Year	25th	50th	75th	Min	Max
2002	4.07%	5.72%	17.32%	3.20%	73.00%
2003	4.70%	7.10%	18.98%	3.84%	80.30%
2004	5.14%	6.84%	20.48%	4.26%	84.42%
2005	4.80%	7.78%	21.63%	3.53%	87.54%
2006	5.81%	8.39%	24.31%	4.35%	91.61%

Notes: Guandong Province has the largest export share during the period 2002-2003. The inland provinces, e.g. Henan and Hunan, normally have the lowest export shares.

Table 2: Descriptive Statistics on the Matched Sample

Share of total			
	Export Value	Export Volume	Number of Exporters
2000	31.49%	22.86%	25.14%
2001	35.92%	22.12%	28.45%
2002	38.34%	23.11%	28.18%
2003	40.64%	27.17%	28.18%
2004	49.83%	36.08%	34.69%
2005	47.82%	37.14%	30.16%
2006	46.75%	38.30%	29.45%

Notes: On average, the export value of the matched sample accounts for 41.15% of the total export.

Table 3: The Impact of ETR on the Firm-level Export Volume (Full Sample)

$lnETR_{it}$	0.5540***	0.5542***
	(*0.0236*)	(*0.0236*)
$lnETR\_prov_{jt}$		-0.1522***
		(*0.0107*)
$lnTFP_{kt}$	0.6160***	0.6160***
	(*0.0017*)	(*0.0017*)
Ownership	Yes	Yes
Year FE	Yes	Yes
Region FE	Yes	Yes
Industry FE	Yes	Yes
Firm FE	Yes	Yes
R^2	0.53	0.53
Obs	1,082,046	1,082,046

Notes: Table 3 presents the impact of the ETR on the firms' export volume. Industry, year firm and region fixed effects have been included. Standard errors are clustered at province level, ***, ** and *, respectively, denoting significance at the 1%, 5%, and 10% levels.

Table 4: The Impact of ETR on the Firm-level Export Volume (Ordinary Trade)

$lnETR_{it}$	0.4668***	0.4810***
	(*0.0258*)	(*0.0258*)
$lnETR\_prov_{jt}$		-0.2022***
		(*0.0124*)
$lnTFP_{kt}$	0.6761***	0.6762***
	(*0.0020*)	(*0.0020*)
Ownership	Yes	Yes
Year FE	Yes	Yes
Region FE	Yes	Yes
Industry FE	Yes	Yes
Firm FE	Yes	Yes
R^2	0.56	0.56
Obs	777,060	777,060

Notes: Table 4 presents the impact of the ETR on the ordinary trade firms' export volume. Industry, year firm and region fixed effects have been included. Standard errors are clustered at province level, ***, ** and *, respectively, denoting significance at the 1%, 5%, and 10% levels.

Table 5: The Impact of ETR on the Firm-level Export Volume (Full Sample-IV)

	IV	IV+Selection
$lnETR_{it}$	0.2024***	0.1540***
	(0.0404)	*(0.0415)*
$lnETR\_prov_{jt}$	-0.055***	-0.0129**
	(0.0045)	*(0.0046)*
$lnTFP_{kt}$	0.6420***	0.7075***
	(0.0031)	*(0.0035)*
Ownership	Yes	Yes
Year FE	Yes	Yes
Region FE	Yes	Yes
Industry FE	Yes	Yes
Firm FE	Yes	Yes
First Stage F-test	40.15	12.25
Select		
$lnTFP_{k,t-1}$		0.0151***
		(0.0008)
$lnExp_{k,t-1}$		0.1516***
		(0.0006)
LR test (rho=0):		0.0002***
R^2	0.47	0.47
Obs	1,082,061	1,082,061

Notes: Table 5 presents the impact of the ETR on the exporting firms' export volume by using IV regressions and controlling for firm exit. Industry, year firm and region fixed effects have been included. Standard errors are clustered at province level, ***, ** and *, respectively, denoting significance at the 1%, 5%, and 10% levels.

Table 6: The Impact of ETR on the Firm-level Export Volume (Ordinary Trade-IV)

	IV	IV+Selection
$lnETR_{it}$	0.1350**	0.1879***
	(0.0439)	*(0.0465)*
$lnETR\_prov_{jt}$	-0.0579***	-0.0172**
	(0.0053)	*(0.0056)*
$lnTFP_{kt}$	0.6775***	0.7926***
	(0.0036)	*(0.0042)*
Ownership	Yes	Yes
Year FE	Yes	Yes
Region FE	Yes	Yes
Industry FE	Yes	Yes
Firm FE	Yes	Yes
F-test for excluded instruments	35.70	12.15
Select		
$lnTFP_{k,t-1}$		0.0315***
		(0.0009)
$lnExp_{k,t-1}$		0.1891***
		(0.0006)
LR test (rho=0):		0.0000***
R^2	0.49	0.49
Obs	777,052	777,052

Notes: Table 6 presents the impact of the ETR on the ordinary trade firms' export volume by using IV regression and controlling for firms' exit. Industry, year firm and region fixed effects have been included. Standard errors are clustered at province level, ***, ** and *, respectively, denoting significance at the 1%, 5%, and 10% levels.

Table 7: The Impact of ETR on the Firm-level Export Volume (Full Sample-More Controls)

	IV	IV+Selection
$lnETR_{it}$	0.1804***	0.1470***
	(0.0402)	*(0.0431)*
$lnETR\_prov_{jt}$	-0.1206***	-0.0168**
	(0.0071)	*(0.0062)*
$lnTFP_{kt}$	0.6424***	0.7162***
	(0.0031)	*(0.0037)*
$lnFDI_{jt}$	0.0505***	0.2707**
	(0.0045)	*(0.1140)*
Economic $Zones_{jt}$	0.1100***	0.0751***
	(0.0072)	*(0.0040)*
Ownership	Yes	Yes
Year FE	Yes	Yes
Region FE	Yes	Yes
Industry FE	Yes	Yes
Firm FE	Yes	Yes
First Stage F-test	39.83	12.83
Select		
$lnTFP_{k,t-1}$		0.0287***
		(0.0009)
$lnExp_{k,t-1}$		0.1846***
		(0.0006)
LR test (rho=0):		0.0000***
R^2	0.47	0.47
Obs	1,082,061	1,082,061

Notes: Table 7 presents the impact of ETR on exporting firms' export volume by using IV regression and controlling for firms' exit. Industry, year firm and region fixed effects have been included. Standard errors are clustered at province level, ***, ** and *, respectively, denoting significance at the 1%, 5%, and 10% levels.

Table 8: The Impact of ETR on the Firm-level Export Volume (Ordinary Trade-More Controls)

	IV	IV+Selection
$lnETR_{it}$	0.1444***	0.1840***
	(0.0429)	*(0.0482)*
$lnETR\_prov_{jt}$	-0.0206***	-0.0243***
	(0.0053)	*(0.0076)*
$lnTFP_{kt}$	0.8151***	0.7422***
	(0.0107)	*(0.0044)*
$lnFDI_{jt}$	0.0505***	0.0425**
	(0.0045)	*(0.0139)*
Economic $Zones_{jt}$	0.1100***	0.0735***
	(0.0072)	*(0.0040)*
Ownership	Yes	Yes
Year FE	Yes	Yes
Region FE	Yes	Yes
Industry FE	Yes	Yes
Firm FE	Yes	Yes
First Stage F-test	35.10	12.72
Select		
$lnTFP_{k,t-1}$		0.0326***
		(0.0010)
$lnExp_{k,t-1}$		0.1716***
		(0.0007)
LR test (rho=0):		0.0000***
R^2	0.49	0.49
Obs	777,052	777,052

Notes: Table 8 presents the impacts of the ETR on the ordinary trade firms' export volume by using IV regressions and controlling for firm exit. Industry, year firm and region fixed effects have been included. Standard errors are clustered at province level, ***, ** and *, respectively, denoting significance at the 1%, 5%, and 10% levels.

Table 9: The Impact of ETR on the Firm-level Export Volume (Full Sample-New IV)

	IV	IV+Selection
$lnETR_{it}$	0.1820***	0.1530***
	(*0.0402*)	(*0.0356*)
$lnETR\_prov_{jt}$	-0.0306***	-0.0356**
	(*0.0070*)	(*0.0080*)
$lnTFP_{kt}$	0.6420***	0.7154***
	(*0.0031*)	(*0.0037*)
$lnFDI_{jt}$	0.0510***	1.19e-7***
	(*0.0045*)	(*2.40e-8*)
Economic $Zones_{jt}$	0.1080***	0.0265***
	(*0.0072*)	(*0.0081*)
Ownership	Yes	Yes
Year FE	Yes	Yes
Region FE	Yes	Yes
Industry FE	Yes	Yes
Firm FE	Yes	Yes
First Stage F-test	39.83	12.90
Select		
$lnTFP_{k,t-1}$		0.0287***
		(*0.0009*)
$lnExp_{k,t-1}$		0.1845***
		(*0.0006*)
LR test (rho=0):		0.0000***
R^2	0.48	0.48
Obs	649,236	649,236

Notes: Table 9 presents the impact of the ETR on all exporting firms' export volume by using IV regressions and controlling for firm exit. The sample contains firms in 2004-2006. Industry, year firm and region fixed effects have been included. Standard errors are clustered at province level, ***, ** and *, respectively, denoting significance at the 1%, 5%, and 10% levels.

Table 10: The Impact of ETR on the Firm-level Export Volume (Ordinary Trade-New IV)

	IV	IV+Selection
$lnETR_{it}$	0.1098***	0.1538***
	(0.0437)	*(0.0434)*
$lnETR\_prov_{jt}$	-0.0276***	-0.0291**
	(0.0080)	*(0.0080)*
$lnTFP_{kt}$	0.6778***	0.7163***
	(0.0036)	*(0.0037)*
$lnFDI_{jt}$	0.0510***	1.09e-7***
	(0.0053)	*(2.41e-8)*
Economic $Zones_{jt}$	0.1198***	0.0250***
	(0.0084)	*(0.0081)*
Ownership	Yes	Yes
Year FE	Yes	Yes
Region FE	Yes	Yes
Industry FE	Yes	Yes
Firm FE	Yes	Yes
First Stage F-test	35.08	12.74
Select		
$lnTFP_{k,t-1}$		0.0327***
		(0.0010)
$lnExp_{k,t-1}$		0.1717***
		(0.0007)
LR test (rho=0):		0.0000***
R^2	0.49	0.49
Obs	466,231	466,231

Notes: Table 10 presents the impacts of the ETR on the ordinary trade firms' export volume by using IV regression and controlling for firms' exit. The sample contains firms in 2004-2006. Industry, year firm and region fixed effects have been included. Standard errors are clustered at province level, ***, ** and *, respectively, denoting significance at the 1%, 5%, and 10% levels.

Input Shares

We assume that the output of each product is produced by a Cobb-Douglas function. To compute firm-product level productivity, we need to calculate input shares for labor, materials and capital, α_{iL}, α_{iM} and α_{iK}, respectively, for each product i. Let $\tilde{\omega}_{kit}$ denote firm k's total nominal wage payments in year t in industry i. Hsieh and Klenow (2008) suggest that the wage bill, $\tilde{\omega}_{kit}$ tends to underestimate the labor share in the Chinese manufacturing data. Following their approach, we multiply each firm's wage bill by a constant parameter, $\tilde{\rho}$, to inflate the wage bill in each firm. We determine the size of the constant parameter by choosing the parameter so that the aggregate labor compensation in the manufacturing sector matches the labor share in national accounts (roughly 50 percent).

Specifically, we denote the total, observed payments to workers as

$$t\omega = \sum_k \sum_t \tilde{\rho}\tilde{\omega}_{kit} = \tilde{\rho} \sum_k \sum_t \tilde{\omega}_{kit} = \tilde{\rho}\widetilde{t\omega}$$

where $\tilde{\rho}$ is the unknown inflation parameter we need to determine and $\widetilde{t\omega}$ denotes the total observed labor compensation. We denote total revenues tr and total intermediate materials tm. Hsieh and Klenow (2009) suggest that the ratio of total wage payments to value-added is roughly 50% from the Chinese national accounts and input-output tables. This implies that

$$\frac{t\omega}{tr - tm} = 0.5 \Rightarrow \frac{\tilde{\rho}\widetilde{t\omega}}{tr - tm} = 0.5 \Rightarrow \tilde{\rho} = 0.5\frac{tr - tm}{\widetilde{t\omega}}$$

After $\tilde{\rho}$ is determined, we calculate the labor share in each of exporting industries we focus on as:

$$\alpha_{iL} = \frac{1}{\tilde{N}} \sum_{t} \sum_{k} \frac{\tilde{\rho}\tilde{\omega}_{kit}}{\tilde{r}_{kit}}$$

where $\tilde{r}_{kit}$ are the nominal revenues of firm k in industry i, and $\tilde{N}$ is the total number of firm observations in each year. Similarly, we calculate the intermediate materials share as the average share of intermediate inputs in total revenues,

$$\alpha_{iM} = \frac{1}{\tilde{N}} \sum_{t} \sum_{k} \frac{\tilde{\rho}\tilde{m}_{kit}}{\tilde{r}_{kit}}$$

where $\tilde{m}_{kit}$ is the total value of intermediate materials firm k used in year t. Finally, in the absence of reliable capital share information, we follow Hsieh and Klenow (2009) and assume constant returns to scale so that $\alpha_{iK} = 1 - \alpha_{iL} - \alpha_{iM}$.

Appendix (For Reviewer)

The ETR system refunds the pure exporting firms according to their export revenues: $\frac{t_i}{\tau} p_v^* q_v^*$, where $p_v^* = \tau \frac{\sigma}{\sigma - 1} \frac{\omega}{\phi_v}$, and $q_v^* = A_i^* \left(p_v^*\right)^{-\sigma}$. However, the incomplete ETR system in China only partially refunds most exporting firms, which makes the non-rebatable part, $r - \widetilde{\tau}_2$ (r is the official tax collection rate), an effective tax on exports. The exporting firms' optimization problem in the foreign market becomes:

$$\begin{aligned} &\max_{p_v^*} \left(p_v^* - \tau \frac{\omega}{\phi_v}\right) \left(A_i^* p_v^{*-\sigma}\right) - \frac{1}{\tau} p_v^* \cdot A_i^* p_v^{*-\sigma} (r - t_i) \\ &\qquad \Rightarrow p_v^* = \frac{\sigma}{\sigma - 1} \left(\widetilde{\tau} \frac{\omega}{\phi_v}\right) \qquad \text{(A1)} \\ &\text{where, } \widetilde{\tau} = \frac{\tau}{\left(1 - \frac{\tau_2}{\tau}\sigma\right)^{\frac{1}{\sigma-1}}}, \tau_2 = r - t_i \end{aligned}$$

From equation (A1), the optimal quantity and the corresponding labor demand for foreign markets are as follows:

$$\begin{aligned} q_v^* &= A_i^* \left(p_v^*\right)^{-\sigma} \\ &= A_i^* \left[\frac{\sigma}{\sigma - 1} \left(\widetilde{\tau} \frac{\omega}{\phi_v}\right)\right]^{-\sigma} \\ &\Rightarrow l_i^e(\omega, \phi_v, t_i) = A^* \left(\frac{1}{\phi_v}\right)^{1-\sigma} \left(\frac{\sigma}{\sigma - 1}\right)^{-\sigma} (\widetilde{\tau}\omega)^{-\sigma} \qquad \text{(A2)} \end{aligned}$$

Proof of Equation (9.4)

Before proving inequality (9.4), we show the following three inequalities hold with respect to the productivity cutoffs

$$\frac{\partial \underline{\phi}_i(\omega_j, \omega_{-j})}{\partial \omega_j} > 0, \frac{\partial \underline{\phi}_i(\omega_j, \omega_{-j})}{\partial \omega_{-j}} < 0 \tag{A3.1}$$

$$\frac{\partial \underline{\phi}_i^e(\omega_j, \omega_{-j}, t_i)}{\partial \omega_j} > 0, \frac{\partial \underline{\phi}_i^e(\omega_j, \omega_{-j}, t_i)}{\partial \omega_{-j}} < 0 \tag{A3.2}$$

$$\frac{\partial \underline{\phi}_i(\omega_j, \omega_{-j}, t_i)}{\partial t_i} < 0 \tag{A3.3}$$

where $\underline{\phi}_i(\omega_j, \omega_{-j})$ is the productivity threshed where a firm earns zero profit in the domestic market and $\underline{\phi}_i^e(\omega_j, \omega_{-j}, t_i)$ is the productivity threshold where a firm earns zero profit in the foreign market. Let ω_j and ω_{-j} denote the wage level in region j and all other regions (including foreign countries), respectively. Note that the domestic productivity cutoff only depends on the regional wage, while the cutoff in the foreign market relies on both the regional wage and the ETR rate, t_i.

The domestic profit for a firm with the cutoff productivity, $\underline{\phi}_i(\omega_j, \omega_{-j})$, is defined as:

$$\pi = \left(\frac{\sigma}{\sigma - 1} \frac{\omega_j}{\underline{\phi}_i(\omega_j, \omega_{-j})} - \frac{\omega_j}{\underline{\phi}_i(\omega_j, \omega_{-j})} \right) A \left(\frac{\sigma}{\sigma - 1} \frac{\omega_j}{\underline{\phi}_i(\omega_j, \omega_{-j})} \right)^{-\sigma} - \omega_j f_i = 0$$

$$A = \frac{\sum \omega_k L_k}{P} P^{\sigma}; \; P = \left[\sum_j \sum_i \int_{\underline{\phi}_i(\omega_j, \omega_{-j})} \left(\frac{\sigma}{\sigma - 1} \frac{\omega_j}{\phi_i} \right)^{1-\sigma} M_j f(\phi_i) d\phi_i \right]^{\frac{1}{1-\sigma}}$$

where f_i is the per-period fixed cost for each firm in industry i, A is the domestic residual demand, and P is the price index in the domestic market. Notice that in order to offer a clean proof, we have assume the substitution of elasticity between any two products to be σ. Whereas, we are aware that the substitution of elasticity between two varieties within the same industry, σ_2 could be higher than σ_1 the substitititution of elasticity for any two varieties belonging to different industries, $\sigma_2 > \sigma_1$.[28] M_j is the mass of firms from region j which produce for the domestic market. We assume that M_j is determined by the free entry condition in each region, and that further entry is not possible over a short period. We can compute the domestic cutoff $\underline{\phi}_i(\omega_j, \omega_{-j})$ as follows:

$$\underline{\phi}_i(\omega_j, \omega_{-j}) = \left[\frac{\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \omega_j^{-\sigma} \sum \omega_k L_k P^{\sigma-1}}{\sigma f_i} \right]^{\frac{1}{1-\sigma}} \tag{A3.4}$$

We first claim that $\underline{\phi}_i(\omega_j, \omega_{-j})$ is HD0 in (ω_j, ω_{-j}), which implies $\underline{\phi}_i(\omega_j, \omega_{-j}) = \underline{\phi}_i(t\omega_j, t\omega_{-j})$. This is because wage is a nominal term, if the wage in every region including the foreign country[29] simultaneously increases t times, this does not affect the productivity cutoff, $\underline{\phi}_i(\omega_j, \omega_{-j})$. As such, P is HD1 in (ω_j, ω_{-j}). The intuition is that if the wage increases (or decreases) the same amont in every region, the price index must increase (or decrease) the same amount.

Differentiating equation (A3.4) w.r.t. ω_j

$$\frac{\partial \underline{\phi}_i(\omega_j, \omega_{-j})}{\partial \omega_j} = sign \left(\sigma \omega_j^{-\sigma-1} \sum_k \omega_k L_k P^{\sigma-1} - \omega_j^{-\sigma} L_j P^{\sigma-1} - \omega_j^{-\sigma} \sum_k \omega_k L_k (\sigma-1) P^{\sigma-2} \frac{\partial P}{\partial \omega_j} \right)$$

[28]We also offer the proof under the more general case in which $\sigma_2 > \sigma_1$. The proof is available upon request.

[29]For conceptual simplicity, we could treat the foreign country is another region, which is denoted as region 0, and with wage ω_0.

$$\sigma\omega_j^{-\sigma-1}\sum_k \omega_k L_k P^{\sigma-1} - \omega_j^{-\sigma} L_j P^{\sigma-1} - \omega_j^{-\sigma}\sum_k \omega_k L_k(\sigma-1)P^{\sigma-2}\frac{\partial P}{\partial \omega_j}$$
$$> (\sigma-1)\omega_j^{-\sigma-1}\sum_k \omega_k L_k P^{\sigma-1} - \omega_j^{-\sigma}\sum_k \omega_k L_k(\sigma-1)P^{\sigma-2}\frac{\partial P}{\partial \omega_j}$$
$$= (\sigma-1)\omega_j^{-\sigma-1}\sum_k \omega_k L_k P^{\sigma-1}\left[1-\frac{1}{P}\frac{\partial P}{\partial \omega_j}\omega_j\right]$$
$$> 0$$

The last inequality holds because P is HD1 in (ω_j, ω_{-j}), which means $\sum_j \frac{\partial P}{\partial \omega_j}\omega_j = P$. This further implies $\frac{\partial P}{\partial \omega_j}\omega_j < \sum_j \frac{\partial P}{\partial \omega_j}\omega_j = P$, and therefore $1 - \frac{1}{P}\frac{\partial P}{\partial \omega_j}\omega_j > 1 - \frac{1}{P}P = 0$, which proves condition (A3.1). Since $\underline{\phi}_i(\omega_j, \omega_{-j})$ is HD0 in (ω_j, ω_{-j}), which implies that $\sum_{-j} \frac{\partial \underline{\phi}_i(\omega_j,\omega_{-j})}{\partial \omega_{-j}}\omega_{-j} + \frac{\partial \underline{\phi}_i(\omega_j,\omega_{-j})}{\partial \omega_j}\omega_j = 0$. Therefore, $\frac{\partial \underline{\phi}_i(\omega_j,\omega_{-j})}{\partial \omega_{-j}} < 0$

Similarly, among exporting firms, export profits can be shown to be decreasing in the regional wage, ω_j, and increasing in the ETR rate, t_i. For a firm with productivity $\underline{\phi}_i^e(\omega_j, \omega_{-j}, t_i)$, its profit in the foreign market is:

$$\pi^* = \left(\frac{\sigma}{\sigma-1}\widetilde{\tau}_{ij}\frac{\omega_j}{\underline{\phi}_i^e(\omega_j,\omega_{-j},t_i)} - \widetilde{\tau}_{ij}\frac{\omega_j}{\underline{\phi}_i^e(\omega_j,\omega_{-j},t_i)}\right) A^* \left(\frac{\sigma}{\sigma-1}\widetilde{\tau}_{ij}\frac{\omega_j}{\underline{\phi}_i^e(\omega_j,\omega_{-j},t_i)}\right)^{-\sigma} - \omega_j f_i^* = 0$$
$$A^* = \frac{\omega_0 L_0}{P^*}P^{*\sigma};\; P^* = \left[\sum_j\sum_i \int \left(\frac{\sigma}{\sigma-1}\frac{\widetilde{\tau}_{ij}\omega_j}{\phi_i}\right)^{1-\sigma} M_j f(\phi_i)d\phi_i\right]^{\frac{1}{1-\sigma}}$$

where f_i^* is the per-period fixed cost in the foreign market for firms belonging to industry i, A^* is the foreign residual demand, and $\widetilde{\tau}_{ij}$ is the rebate-adjusted trade cost for firms located in region j and export product i. $\widetilde{\tau}_{ij} = \widetilde{\tau}_{ij'} = \widetilde{\tau}_i > 1$, for $\forall j$, j' and $j \neq j' \neq 0$.[30] For a foreign firm, $\widetilde{\tau}_{i0} = 1$. The wage and total labor in

[30]The rebate-adjusted trade cost is industry-specific, but in the foreign market, the foreign firms do not pay this cost. We use the subscript j is to distinguish the different trade cost facing foreign and domestic firms.

the foreign country are denoted by ω_0 and L_0, respectively. We can compute the productivity cutoff for firms from region j in the foreign market as follows:

$$\underline{\phi}_i^e(\omega_j, \omega_{-j}, t_i) = \left[\frac{\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \widetilde{\tau}_{ij}^{-\sigma} \omega_j^{-\sigma} \omega_0 L_0 \left(P^*\right)^{\sigma-1}}{\sigma f_i^*} \right]^{\frac{1}{1-\sigma}} \tag{A3.5}$$

Differentiating equation (A3.5) w.r.t. ω_j $(j \neq 0)$

$$\frac{\partial \underline{\phi}_i^e(\omega_j, \omega_{-j}, t_i)}{\partial \omega_j} = sign\left(-\sigma \omega_j^{-\sigma-1} \omega_0 L_0 \left(P^*\right)^{\sigma-1} + \omega_j^{-\sigma} \omega_0 L_0 (\sigma - 1) \left(P^*\right)^{\sigma-2} \frac{\partial P^*}{\partial \omega_j} \right)$$

$$\begin{aligned}
&\sigma \omega_j^{-\sigma-1} \omega_0 L_0 \left(P^*\right)^{\sigma-1} - \omega_j^{-\sigma} \omega_0 L_0 (\sigma - 1) \left(P^*\right)^{\sigma-2} \frac{\partial P^*}{\partial \omega_j} \\
&> (\sigma - 1) \omega_j^{-\sigma-1} \omega_0 L_0 \left(P^*\right)^{\sigma-1} - \omega_j^{-\sigma} \omega_0 L_0 (\sigma - 1) \left(P^*\right)^{\sigma-2} \frac{\partial P^*}{\partial \omega_j} \\
&= (\sigma - 1) \omega_j^{-\sigma-1} \omega_0 L_0 \left(P^*\right)^{\sigma-1} \left[1 - \frac{1}{P^*} \frac{\partial P^*}{\partial \omega_j} \omega_j \right] \\
&> 0
\end{aligned}$$

Simliar to the arguement in P, P^* is also HD1 in (ω_j, ω_{-j}). This implies that $\frac{\partial P^*}{\partial \omega_j} \omega_j < \sum_j \frac{\partial P^*}{\partial \omega_j} \omega_j = P^*$, and therefore $1 - \frac{1}{P^*} \frac{\partial P^*}{\partial \omega_j} \omega_j > 1 - \frac{1}{P^*} P^* = 0$. Thus we have inequality (A3.2).

Likewise, differentiating equation (A3.5) w.r.t. t_i

$$\frac{\partial \underline{\phi}_i^e(\omega_j, \omega_{-j}, t_i)}{\partial t_i} = \frac{\partial \underline{\phi}_i^e(\omega_j, \omega_{-j}, t_i)}{\partial \widetilde{\tau}_i} \frac{\partial \widetilde{\tau}_i}{\partial t_i} \tag{A3.6}$$

$$\frac{\partial \underline{\phi}_i^e(\omega_j, \omega_{-j}, t_i)}{\partial \widetilde{\tau}_i} = sign\left(\sigma \omega_j^{-\sigma} \widetilde{\tau}_i^{-\sigma-1} \omega_0 L_0 \left(P^*\right)^{\sigma-1} - \omega_j^{-\sigma} \widetilde{\tau}_i^{-\sigma} \omega_0 L_0 (\sigma - 1) \left(P^*\right)^{\sigma-2} \frac{\partial P^*}{\partial \widetilde{\tau}_i} \right)$$

$$
\begin{aligned}
&\sigma\omega_j^{-\sigma}\widetilde{\tau}_i^{-\sigma-1}\omega_0 L_0 \left(P^*\right)^{\sigma-1} - \omega_j^{-\sigma}\widetilde{\tau}_i^{-\sigma}\omega_0 L_0(\sigma-1)\left(P^*\right)^{\sigma-2}\frac{\partial P^*}{\partial \omega_j} \\
&> (\sigma-1)\omega_j^{-\sigma}\widetilde{\tau}_i^{-\sigma-1}\omega_0 L_0 \left(P^*\right)^{\sigma-1} - \omega_j^{-\sigma}\widetilde{\tau}_i^{-\sigma}\omega_0 L_0(\sigma-1)\left(P^*\right)^{\sigma-2}\frac{\partial P^*}{\partial \widetilde{\tau}_i} \\
&= (\sigma-1)\omega_j^{-\sigma}\widetilde{\tau}_i^{-\sigma-1}\omega_0 L_0 \left(P^*\right)^{\sigma-1}\left[1-\frac{1}{P^*}\frac{\partial P^*}{\partial \widetilde{\tau}_i}\widetilde{\tau}_i\right] \\
&> 0
\end{aligned}
$$

P^* is HD1 in $\{\widetilde{\tau}_i\}_{i=0}^N$, and hence $\sum_i \frac{\partial P^*}{\partial \widetilde{\tau}_i}\widetilde{\tau}_i = P^*$. This is because that if the rebate-adjusted trade cost increases (or decreases) the same amount in all industry i and even for foreign firms, $\widetilde{\tau}_{i0}$, it is equivalent to the same change in wages $\{\omega_j, \omega_{-j}\}$. As a result, P^* will increase the same amount. The last inequality is because $1 - \frac{1}{P^*}\frac{\partial P^*}{\partial \widetilde{\tau}_i}\widetilde{\tau}_i > 1 - \frac{1}{P^*}P^* = 0$. Combining this result with $\frac{\partial \widetilde{\tau}_i}{\partial t_i} < 0$, we have inequality (A3.3). Since $\underline{\phi}_i^e(\omega_j, \omega_{-j})$ is HD0 in (ω_j, ω_{-j}), which implies that $\sum_{-j} \frac{\partial \underline{\phi}_i^e(\omega_j,\omega_{-j})}{\partial \omega_{-j}}\omega_{-j} + \frac{\partial \underline{\phi}_i^e(\omega_j,\omega_{-j})}{\partial \omega_j}\omega_j = 0$. Therefore, $\frac{\partial \underline{\phi}_i^e(\omega_j,\omega_{-j})}{\partial \omega_{-j}} < 0$

Now, we can prove inequality (9.4) by making use the regional labor market clearing condition (Here, we suppress the region subscript j):

$$
\begin{aligned}
&\sum_k \int_{\underline{\phi}_k} \left[l_k^{ne}(\omega,\phi) + 1(\phi > \underline{\phi}^e) l_k^e(\omega,\phi,t_k)\right] M_k f_k(\phi)\, d\phi = L \\
\Leftrightarrow &\sum_k \int_{\underline{\phi}_k} l_k^{ne}(\omega,\phi) M_k f_k(\phi)\, d\phi + \int_{\underline{\phi}_k^e} l_k^e(\omega,\phi,t_k) M_k f_k(\phi)\, d\phi = L
\end{aligned} \tag{A3.7}
$$

where M_k is the mass of firms in industry k located in a given region, and $f_k(\phi)$ is the truncated productivity distribution for $\phi(\omega) \geq \underline{\phi}_k(\omega)$ in industry k.

Differentiating equation (A3.7) w.r.t. t_i, we find

$$\sum_k \left[\underbrace{\int_{\underline{\phi}_k} \frac{\partial l_k^{ne}}{\partial \omega_j} M_k f_k(\phi)\, d\phi + \int_{\underline{\phi}_k^e} \frac{\partial l_k^{e}}{\partial \omega_j} M_k f_k(\phi)\, d\phi - l_k^{ne} \frac{\partial \underline{\phi}_k}{\partial \omega_j} - l_k^{ne} \frac{\partial \underline{\phi}_k^e}{\partial \omega}}_{X1} \right] \frac{\partial \omega_j}{\partial t_i}$$

$$+ \sum_{-j} \sum_k \left[\underbrace{\int_{\underline{\phi}_k} \frac{\partial l_k^{ne}}{\partial \omega_{-j}} M_k f_k(\phi)\, d\phi + \int_{\underline{\phi}_k^e} \frac{\partial l_k^{e}}{\partial \omega_{-j}} M_k f_k(\phi)\, d\phi - l_k^{ne} \frac{\partial \underline{\phi}_k}{\partial \omega_{-j}} - l_k^{ne} \frac{\partial \underline{\phi}_k^e}{\partial \omega_{-j}}}_{X2} \right] \frac{\partial \omega_{-j}}{\partial t_i}$$

$$= - \int_{\underline{\phi}_i^e} \frac{\partial l_i^e}{\partial t_i} M_i f_i(\phi)\, d\phi + l_i^e \frac{\partial \underline{\phi}_i^e}{\partial t_i} \tag{A3.8}$$

First, making use of the inequalities we have shown, we know $X1 < 0$, $X2 > 0$, and the RHS of the equation is negative. In particular, $X1$ measures the within region wage effect, and $X2$ captures the regional interaction effect (other regional wage effect). If the second term on the LHS of equation (A3.8) (regional interaction effect) is positive, we must have $\frac{\partial \omega_j}{\partial t_i} > 0$. Suppose that the second term on the LHS of equation (A3.8) is negative, which implies that at least one regional wage decreases in t_i. Among all regions experiencing a wage decrease in response to an increase in t_i, we pick the region with the largest wage reduction, say region j. Denote the wage in region j as $\omega_j' = \frac{1}{t}\omega_j$, $t > 1$, after t_i increases. The individual firm's labor demand after the increase in t_i becomes

$$\begin{aligned} l^{ne\prime} &= A' \left(\frac{1}{\phi}\right)^{1-\sigma} \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} \left(\omega_j'\right)^{-\sigma} > \left(\frac{1}{t}\right)^{\sigma} A \left(\frac{1}{\phi}\right)^{1-\sigma} \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} \omega_j^{-\sigma} t^{-\sigma} = l^{ne} \\ l^{e\prime} &= A^{*\prime} \left(\frac{1}{\phi}\right)^{1-\sigma} \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} \left(\widetilde{\tau}\omega_j'\right)^{-\sigma} > \left(\frac{1}{t}\right)^{\sigma} A^* \left(\frac{1}{\phi}\right)^{1-\sigma} \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} \left(\widetilde{\tau}\omega_j\right)^{-\sigma} t^{-\sigma} = l^e \end{aligned} \tag{A3.9}$$

where, $l^{ne\prime}$ and A' are the domestic labor demand and residual demand after t_i increases, respectively. $l^{e\prime}$ and $A^{*\prime}$ are the foreign labor demand and residual demand, respectively. These equalities arise because region j experiences the largest wage reduction, and hence $A' > \left(\frac{1}{t}\right)^{\sigma} A$, and $A^{*\prime} > \left(\frac{1}{t}\right)^{\sigma} A^*$.[31] Inequalities (A3.9) imply that the individual labor demand in region j increases and hence the aggregate labor demand must also increase after t_i increases. As such, the regional wage must increase to clear the labor market. This is a contradiction. Therefore, the second term on the LHS of equation (A3.8) must be positive, and as a result $\frac{\partial \omega_j}{\partial t_i}$ must be positive.

[31] Recall that A and A^* are both HD σ in ω. When other regions' wage decrease are smaller than t times, the residual demand will decrease less than t times.

Proof of Equation (10)

When labor supply is fixed in each region, the impact of the ETR changes in industry i on the regional wage is as follows:

$$
\begin{aligned}
L &= \sum_k \left[\int_{\underline{\phi}_k} l_k^{ne}(\omega,\phi) M_k f_k(\phi)\, d\phi + \int_{\underline{\phi}_k^e} l_k^e(\omega,\phi,t_k) M_k f_k(\phi)\, d\phi \right] \\
&\Rightarrow \frac{\partial L}{\partial t_i}\Delta t_i = 0 \\
&\Rightarrow \sum_k \left[\int_{\underline{\phi}_k} \left(\frac{\partial l_k^{ne}(\omega,\phi)}{\partial \omega}\right) M_k f_k(\phi)\, d\phi + \int_{\underline{\phi}_k^e} \left(\frac{\partial l_k^{e}(\omega,\phi,t_k)}{\partial \omega}\right) M_k f_k(\phi)\, d\phi \right] \frac{\partial \omega}{\partial t_i}\Delta t_i = 0 \\
&= \sum_k \left[\int_{\underline{\phi}_k} \left(\frac{\partial l_k^{ne}(\omega,\phi)}{\partial \omega}\right) M_k f_k(\phi)\, d\phi + \int_{\underline{\phi}_k^e} \left(\frac{\partial l_k^{e}(\omega,\phi,t_k)}{\partial \omega}\right) M_k f_k(\phi)\, d\phi \right] \frac{\partial \omega}{\partial t_i}\Delta t_i \\
&+ \int_{\underline{\phi}_i^e} \frac{\partial l_i^e(\omega,\phi,t_i)}{\partial t_i} M_i f_i(\phi)\, d\phi \Delta t_i - B_k \frac{\partial \omega}{\partial t_i}\Delta t_i - C_i \Delta t_i \\
&= \sum_k \frac{-\sigma}{\omega} \left[\int_{\underline{\phi}_k} \left[l_k^{ne}(\omega,\phi) - f_k\right] M_k f_k(\phi)\, d\phi + \int_{\underline{\phi}_k^e} \left[l_k^{e}(\omega,\phi,t_k) - f_k^*\right] M_k f_k(\phi)\, d\phi \right] \frac{\partial \omega}{\partial t_i}\Delta t_i \\
&- \sigma \int_{\underline{\phi}_i^e} \left[l_i^e(\omega,\phi,t_i) - f_i^*\right] \widetilde{\tau} M_i f_i(\phi)\, d\phi \frac{\partial \widetilde{\tau}}{\partial t_i}\Delta t_i - B_k \frac{\partial \omega}{\partial t_i}\Delta t_i - C_i \Delta t_i \\
&= \left(\sum_k \frac{-\sigma}{\omega} L_k\right) \frac{\partial \omega}{\partial t_i}\Delta t_i + L_i^e(-\sigma)\,\widetilde{\tau}\frac{\partial \widetilde{\tau}}{\partial t_i}\Delta t_i - B_k \frac{\partial \omega}{\partial t_i}\Delta t_i - C_i \Delta t_i \\
&\Rightarrow \frac{\partial \omega}{\partial t_i}\Delta t_i = \frac{L_i^e(-\sigma)\,\widetilde{\tau}\frac{\partial \widetilde{\tau}}{\partial t_i}\Delta t_i - C_i\Delta t_i}{\sum_k \frac{\sigma}{\omega} L_k + B}
\end{aligned}
$$

where $B = \sum_k M_k \left[l_k^e(\omega,\underline{\phi}_k^e,t_k) f_k\left(\underline{\phi}_k^e\right)\frac{\partial \underline{\phi}_k^e}{\partial \omega} - \frac{\sigma}{\omega}\left[f_k\left(1 - F_k(\underline{\phi}_k)\right) + f_k^*\left(1 - F_k(\underline{\phi}_k^e)\right)\right]\ \right]$

$$C_i = l_i^e(\omega,\underline{\phi}_i^e,t_i) M_i f_i(\underline{\phi}_i^e)\frac{\partial \underline{\phi}_i^e}{\partial t_i}$$

L_k^e is the total labor demand for serving the foreign market in industry i, and L_k

is the total labor demand in industry k. The third equation is derived as follows:

$$\frac{\partial l_k^{ne}(\omega,\phi)}{\partial \omega} = \frac{-\sigma}{\omega}\left[l_k^{ne}(\omega,\phi) - f_k\right] \tag{A4.1}$$

$$\frac{\partial l_k^{e}(\omega,\phi,t_k)}{\partial \omega} = \frac{-\sigma}{\omega}\left[l_k^{e}(\omega,\phi,t_k) - f_k^*\right] \tag{A4.2}$$

$$\begin{aligned}
\frac{\partial l_i^{e}(\omega,\phi,t_i)}{\partial t_i} &= A_i^*\left(\frac{1}{\phi}\right)^{1-\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma}(\omega)^{-\sigma}\;(-\sigma)\,\widetilde{\tau}^{-\sigma-1}\frac{\partial\widetilde{\tau}}{\partial t_i} \\
&= A^*\left(\frac{1}{\phi}\right)^{1-\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma}(\widetilde{\tau}\omega)^{-\sigma}\,(-\sigma)\,\widetilde{\tau}\frac{\partial\widetilde{\tau}}{\partial t_i} \\
&= \left[l_i^{e}(\omega,\phi,t_i) - f_i^*\right](-\sigma)\,\widetilde{\tau}\frac{\partial\widetilde{\tau}}{\partial t_i} \qquad \text{(A4.3)}
\end{aligned}$$

From (A4.3), we can derive the impact of ETR changes across all industries on the regional wage:

$$\begin{aligned}
\Delta\omega &= \sum_i \frac{\partial\omega}{\partial t_i}\Delta t_i \\
&= \sum_i \frac{L_i^e\,(-\sigma)\,\widetilde{\tau}\frac{\partial\widetilde{\tau}}{\partial t_i} - C_i}{\sum_j \frac{-\sigma}{\omega}L_j + B}\Delta t_i \\
&= \sum_i \beta_i\Delta t_i \qquad \text{(A4)} \\
\text{where } \beta_i &= \frac{L_i^e\,(-\sigma)\,\widetilde{\tau}\frac{\partial\widetilde{\tau}}{\partial t_i} - C_i}{\sum_j \frac{-\sigma}{\omega}L_j + B}
\end{aligned}$$

Define $\alpha_i = \frac{L_i^e}{\sum_j L_j}$, the share of labor in industry i for export production. It is obviously that the absolute value of β_i is increasing in α_i. This is because that all other things equal, when L_i^e increases, the absolute value of β_i and α_i increase simultaneously.

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