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Minimum Wage and Export: Evidence from Chinese Firm-level Data*

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Abstract

This paper proposes a two-country trade equilibrium model with heterogeneous firms to investigate the influences of minimum wages and productivity on firms' exports. It shows that the influence of minimum wages on firms' exporting probability and foreign sales is negative while that of firms' productivity on their exports is positive. Econometric analysis based on the Annual Survey of Chinese Industrial Firms as well as the data of minimum wages collected ourselves from 1998 to 2007 verifies these predictions. Holding the other variables constant, if minimum wages and their productivity increase by 100%, then the elasticity of minimum wage on firms' exporting sales is -8.6% while that of firms' productivity is 75.6%, and firms' exporting possibility decreases by 1.1% and increases by 1.6%, respectively.

Keywords: Minimum wage, heterogeneous firm, productivity, export

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1 Introduction

This paper constructs a two-country and two-factor trade equilibrium model with heterogeneous firms to investigate the impacts of minimum wages on firms' exports. In our model, firms are heterogeneous in productivity. A firm must pay a fixed entry cost before it observes its productivity, which is ex ante random. After that, it decides whether or not to start production. In the latter case another fixed production cost is incurred. The firm employs capitals and labors to produce its variety, where the price of capital is determined by the market while that of labor is exogenously determined and is usually above its equilibrium level. In this situation, labor market does not clear. The firm can decide to export its product to the foreign market or not. In the former case it has to pay another exporting fixed cost. According to the above setting, we find that the increase of the domestic minimum wage decreases firms' exporting possibilities by selection effect (i.e., forcing low-productivity firms to exit the market) and decreases firms' exporting sales by increasing their unit production costs. Moreover, firms' productivity has positive impacts on their exports.

We also apply firm-level data from the Annual Survey of Industrial Firms cross-sectional data collected by the National Bureau of Statistics of China between 1998 and 2007 to estimate the impacts of domestic minimum wage and firms' productivity on their exports. We first estimate each firm's productivity in each year for each industry and then regress firms' exports with respect to their productivity, minimum wages, industrial capital stocks and other control variables. The empirical results verify our theoretic results. Specifically, firms' exporting probability decreases by 1.5% while their exporting sales decreases by 9% if minimum wages doubles.

The rest of this paper is arranged as follows. Section 2 reviews the literatures on the relationship between minimum wage and international trade. Section 3 introduces the closed-economy model with heterogeneous firms and minimum wages. Section 4 analyzes the open-economy model and the impact of minimum wages on firms' exports. Empirical models are introduced in Section 5. Section 6 gives a brief description of the data used in this paper. Empirical results are stated in Section 7. Section 8 concludes the paper.

2 Literature review

Literatures on the relationship between minimum wages and international trade can be classified into two groups. One considers the case that inter-industry wages are distorted while real wages are flexible. The other considers the case that all industrial wages are distorted. Hagen (1958), Bhagwati and Ramaswami (1963) and Magee (1976) investigated the first case. Summarizing their findings, we can see that the increase of the minimum wage in an industry leads to the increase of capital intensity and the decrease of outputs within this industry and the decrease of capital intensities and the increase of outputs in other industries if capitals are industry-specific and labors are mobile across industries. This implies that the increase of the minimum wage in an industry leads to the increase of exports in this industry and the decrease of imports in labor-intense industries if the country exports capital-intense and import labor-intense goods before the change of minimum wages, Vice versa. If labors are not mobile across industries, then the results still hold as before. However, unemployment occurs in the industry whose minimum wage increases.

Haberler (1950), Brecher (1974a,b) investigated the second case. Brecher (1974a,b) analyzed the case with two countries, two goods, two factors and constant-return-to-scale production technologies. They showed that the increase of the minimum wage in a labor-abundant country decreases the exports of labor-intensive goods and increases the exports of capital-intensive goods. The situation is reversed if the country is capital-abundant. The decrease of the minimum wage in a country may lead the reverse of trade directions. That is, the country may change to import capital-intensive while export labor-intensive goods. Their models were extended to the case with multiple goods and multiple factors by Schweinberger (1978), where the number of goods and that of factors are equal. Based on Schweinberger (1978)'s idea, Brecher (1980) considered a small-country open economy with three factors (capital, labor and land) and two goods. It found that the increase of the minimum wage in a country will increase the exports of both capital-intensive and labor-intensive goods if the country specializes incompletely, the production technologies of the two goods are constant return to scale and one good is more capital-intensive and more labor-intensive. Neary (1985) further investigated the case that the number of factors are larger than that of goods and concluded similar results to those given in Brecher (1974a,b).

The above findings may change if the interaction effects between endowment and trade structure are involved into consideration. Flug and Galor (1986) constructed a general equilibrium with two countries, two goods and two factors (skilled and unskilled labors) , where an unskilled labor can change to skilled labor by accumulating human capitals. It showed that the increase of the minimum wage on the unskilled labors in a small country leads to the increase of the exports of skilled-labor-intensive goods if this country specializes incompletely. The result is reversed if the country exports unskilled-labor-intensive goods. The case for large countries is a little different. If the country exports unskilled-labor-intensive good at first, then the increase of the minimum wage on the unskilled labors may reverse the trade structure. When the minimum wage is sufficiently high, the country will specialize in the production of and export the skilled-labor-intensive goods in the short run and its exports will keep increasing in the long run.

The above researches are based on the assumption of homogeneous firms and their results are only industry-level. Firms' heterogeneity needs to be considered to investigate the impacts of minimum wages on individual firms' exporting behaviors. However, this can not be done under the frameworks of the Ricardian model, the Heckscher-Ohlin theory and the new trade theory. [1] In fact, few literatures are focusing on this topic. This paper constructs a trade equilibrium model with heterogeneous firms and minimum wages to investigate the impacts of minimum wages on firms' exports. Different from Melitz (2003), countries in our model are asymmetric and the number of factors is two (capital and labor). Because of the minimum wages on labor are above their market-equilibrium levels, only the capital markets clears. Our model is also different from that in Egger et al. (2009), in which there is only one production factor (labor) and there is one final good and many intermediate goods whose number is endogenously determined. Moreover, it did not investigate the impact of minimum wages on firms' exports. According to our model, we get the following main result: the increase of domestic minimum wage will decrease all firms' exporting probabilities and their exporting sales.

[1] Many empirical results since 1990s have shown that firms in the same industry in a country have different exporting behaviors. First, exporters are relatively few among all firms in an industry. Second, exporters are relatively more larger and more productive. Third, most exporters exports only a small part of their outputs. Fourth, exporters' performance variables affect significantly and positively their exports. Fifth, exporters have higher wages and higher innovation levels. Please refer to Tybout (2003) for a survey of these literatures and Melitz (2003) and Bernard et al. (2003) for theories developed to explain these phenomena.

3 Closed economy with minimum wage and heterogeneous firms

In the economy we investigate are there two countries (i.e., the domestic and the foreign country, denoted by H and F, respectively). In each country, there are M monopolistically competitive industries. We assume that each variety in each of which is produced by only one firm. Suppose that there are N_l and N_l^* firms in industry l in H and F, respectively (hereafter we use "*" to index the corresponding variables of F). The production of each variety uses two factors, the capital (K) and the labor (L), where K is industry-specific, which is only mobile within the same industry, while L is mobile across industries. As this paper does not investigate the impact of country size on firms' exports, we assume that each country is normalized with one unit of infinitely divisible labor. Suppose that the preferences of consumers of both countries are the same, which can be represented by the following utility function

$$U = \prod_{l=1}^{M}\left(\int_0^{N_l} x_{li}^{\rho_l} di\right)^{\frac{\beta_l}{\rho_l}}, \ 0 < \beta_l, \rho_l < 1, \ \sum_{l=1}^{M}\beta_l = 1, \tag{1}$$

where β_l represents the share of consumption in industry l among total consumption expenditure, $\rho_l = \frac{\sigma_l - 1}{\sigma_l}$, σ_l is the substitution elasticity between varieties in industry l and x_{li} is the consumption of variety i in industry l. Suppose that each consumer's income comes only from his wage w.[2] As what we investigate is the impact of minimum wage standard on firms' exports, i.e., the labor wage in the economy shall be larger than or equal to the minimum wage, we make the following assumption.

Assumption 1 *The minimum wages are higher than or equal to the market equilibrium wages in H and F, respectively. Moreover, they are set so that each consumer in the two countries can get at least the minimum wage income.*

Our rationale to make Assumption 1 is as follows. If the minimum wage in a country is lower than the market wage, then it has no impact on the market equilibria, and thus we do not need to consider it. Furthermore, if the minimum wage can not guarantee that all the labors's expected incomes are higher than it,

[2] When the firms' entry attains its equilibrium, their expected profits are zero, so that each consumer's capital income is 0.

then the minimum wage standard is of no sense.[3]

Under Assumption 1, unemployment occurs in the economy as the minimum wage are larger than the market equilibrium wage. As firms are rational, they must pay the labors the minimum wage if there's no incomplete information or labor market sticky or other institutional barriers.

In this section, we only consider the home country. Let the price index in industry l be P_l, where $P_l = \left(\int_0^{N_l} p_{li}^{1-\sigma_l} di\right)^{\frac{1}{1-\sigma_l}}, l = 1, \cdots, M$. Then the demand q_{li} for and the expenditure r_{li} on variety i in industry l are, respectively,

$$q_{li} = Q_l \left(\frac{p_{li}}{P_l}\right)^{-\sigma_l}, \ r_{li} = R_l \left(\frac{p_{li}}{P_l}\right)^{1-\sigma_l}, l = 1, \cdots, M, \tag{2}$$

where $Q_l = \frac{\beta_l w}{P_l}$ is the total consumption and $R_l = P_l Q_l = \beta_l w$ is the total expenditure on varieties in industry l in the economy.

As all industries have similar monopolistic competitive market structure, we only consider the representative firm's behaviors in industry l, and thus ignore the firm-index i in the sequel. Suppose the representative firm's production function is $Y = \theta K^{\alpha_l} L^{1-\alpha_l}$ (herein the capital-output elasticity α_l varies with industries), where Y, K, L are, respectively, the firm's output, capital and labor hired, and θ is its productivity. In each industry l, firms' productivity is heterogeneous. Suppose that the distribution function of firms' productivity in industry l is of the following form:

$$G_l(\theta) = \begin{cases} 1 - (b_l/\theta)^{k_l} & \theta \geq b_l, \\ 0 & \text{else}, \end{cases} \tag{3}$$

where $b_l > 0$ is the lower bound and $k_l > 2$ is the shape parameter of $G_l(\theta)$, which measures the concentration degree of firms' productivity distribution in industry l.

Each firm does not know its productivity level before it enters into the market. It observes its productivity θ after it pays the industry-specific fixed entry cost F_l, which is invested in the form of entrepreneur spirit but is measured by money.[4] After it observes its productivity, the firm needs to decide whether or not

[3]The minimum wage standard which is higher than the market equilibrium wage always leads to unemployment, and thus each labor's income is equal to the unemployment rate times the minimum wage.

[4]Here we assume that entrepreneur spirits are supplied without elasticity. It's worthy to point out that analysis will be much more complicated if the fixed entry cost F_l is invested in the form of labor or capital.

to produce and sell its variety. In the former case, another fixed production cost f_l is incurred, which is also invested in the form of entrepreneur spirit but is measured by money. If the firm begins to produce and sell its variety, it is faced with the demand function given in (2). Thus, its optimal capital and labor inputs are, respectively,

$$K = \rho_l^{\sigma_l} P_l^{\sigma_l} Q_l \varpi_l^{1-\sigma_l} \theta^{\sigma_l - 1} \left(\frac{r_l}{\alpha_l}\right)^{-1}, \; L = \rho_l^{\sigma_l} P_l^{\sigma_l} Q_l \varpi_l^{1-\sigma_l} \theta^{\sigma_l - 1} \left(\frac{w}{1-\alpha_l}\right)^{-1}, \tag{4}$$

where $\varpi_l = \left(\frac{r_l}{\alpha_l}\right)^{\alpha_l} \left(\frac{w}{1-\alpha_l}\right)^{1-\alpha_l}$ is the unit production cost of varieties in industry l. Therefore, the firms' optimal output and pricing rule are, respectively,

$$q_l = \rho_l^{\sigma_l} P_l^{\sigma_l} Q_l \varpi_l^{-\sigma_l} \theta^{\sigma_l}, \; p_l = \frac{\varpi_l}{\rho_l \theta}. \tag{5}$$

(5) implies that: (1) a firm's output is higher and its price is lower, the higher is its productivity; (2) a firm's output is lower and its price is higher, the higher is the industrial unit production cost ϖ_l. The net profit of the firm with productivity θ in industry l in each period is

$$\pi_l \;\; = \;\; (1-\rho_l) D_l - f_l, \tag{6}$$

where $D_l = M_l \theta^{\sigma_l - 1}$ is the firm's domestic sale and $M_l = \rho_l^{\sigma_l - 1} P_l^{\sigma_l} Q_l \varpi_l^{1-\sigma_l}$. Define the weighted productivity level as $\tilde{\theta}_l = \left[\int_0^{+\infty} \theta^{\sigma_l - 1} \mu_l(\theta) d\theta\right]^{\frac{1}{\sigma_l - 1}}$, where $\mu_l(\theta)$ is the density function of productivity distribution of incumbents in industry l. Then we have

$$P_l = N_l^{\frac{1}{1-\sigma_l}} \frac{\varpi_l}{\rho_l \tilde{\theta}_l}, \; Q_l = N_l^{\frac{1}{1-\sigma_l}} \frac{\beta_l \rho_l w \tilde{\theta}_l}{\varpi_l}. \tag{7}$$

The firm decides to produce only if $\pi_l \geq 0$, from which we can get $\underline{D}_l$ and $\underline{\theta}_l$, the cut-offs of firms' domestic sales and their productivity (such that the profit of the firms with $\underline{D}_l$ is zero):

$$\underline{D}_l = \sigma_l f_l, \; \underline{\theta}_l = \left(\frac{\sigma_l f_l}{\beta_l w}\right)^{\frac{1}{\sigma_l - 1}} N_l^{\frac{1}{\sigma_l - 1}} \tilde{\theta}_l. \tag{8}$$

This implies that the productivity cut-off $\underline{\theta}_l$ is higher, the higher is the industrial weighted productivity level $\tilde{\theta}_l$.

According to the relationship between the ex post productivity distribution $\mu_l(\theta)$ and the ex ante one $g_l(\theta)$, and also by the form of $G_l(\theta)$, we rewrite the industrial weighted productivity level $\tilde{\theta}_l$ as

$$\tilde{\theta}_l(\underline{\theta}_l) = \left(\frac{k_l}{k_l + 1 - \sigma_l}\right)^{\frac{1}{\sigma_l - 1}} \underline{\theta}_l. \tag{9}$$

Substituting (9) into (8), we can solve the equilibrium number of firms N_l as:

$$N_l = \frac{\beta_l w}{\sigma_l f_l} \frac{k_l + 1 - \sigma_l}{k_l}. \tag{10}$$

This implies that the number of firms in the industry in equilibrium is larger, the larger is the minimum wage.

As the minimum wage is fixed above the market equilibrium wage, only the capital market clears in equilibrium. Substituting (8), (9) and (10) into the clearing condition of capital market, we can solve the equilibrium interest of the capital in industry l:

$$\frac{r_l}{\alpha_l} = \rho_l \beta_l w \bar{K}_l^{-1}, \tag{11}$$

which implies that the lower minimum wage and the higher capital stock lead to the higher interest of the capital in industry. This indicates that the increase of the minimum wage will increase the industrial unit production cost ϖ_l, which can be simplified as $\varpi_l = (\beta_l \rho_l)^{\alpha_l}(1 - \alpha_l)^{-(1-\alpha_l)} \bar{K}_l^{-\alpha_l} w$.

Substituting (11) into (7), we can get the equilibrium expressions of P_l and Q_l, respectively, as follows:

$$P_l = N_l^{\frac{1}{1-\sigma_l}} \beta_l^{\alpha_l} ((1 - \alpha_l)\rho_l)^{-(1-\alpha_l)} \bar{K}_l^{-\alpha_l} w \tilde{\theta}_l^{-1}, Q_l = N_l^{\frac{1}{1-\sigma_l}} (\beta_l \rho_l (1 - \alpha_l))^{1-\alpha_l} \bar{K}_l^{\alpha_l} \tilde{\theta}_l. \tag{12}$$

Moreover, by (10), (12) and (6), we can find the equilibrium output of the firm with productivity θ in industry l as

$$q_l = \frac{\rho_l k_l \sigma_l f_l}{k_l + 1 - \sigma_l} \theta^{\sigma_l} \tilde{\theta}_l^{1-\sigma_l} \varpi_l^{-1}, \tag{13}$$

which implies that the firm's output is higher, the higher is its productivity and the lower is the minimum wage.

The free entry condition implies that each firm's ex ante expected net profit upon entry shall be zero, which determines the equilibrium number of incumbents in the industry. The entry condition can be written as follows:

$$\frac{1 - G_l(\underline{\theta}_l)}{\delta_l} f_l \left[\left(\frac{\tilde{\theta}(\underline{\theta}_l)}{\underline{\theta}_l} \right)^{\sigma_l - 1} - 1 \right] = F_l, \qquad (14)$$

where δ_l is the survival probability of firms in each period in industry l. As G_l is given by (3), we can get the equilibrium productivity cut-off $\underline{\theta}_l$ as follows:

$$\underline{\theta}_l = \left(\frac{f_l}{\delta_l F_l} \frac{\sigma_l - 1}{k_l + 1 - \sigma_l} \right)^{1/k_l} b_l. \qquad (15)$$

According to (15) and the expression of $\tilde{\theta}(\underline{\theta}_l)$, we know that both industrial productivity cut-off and industrial weighted productivity are not affected by the minimum wage level.

According to (9), (10), (15) and the fact $\sigma_l > 1$, (12) implies that industrial price index P_l and industrial output Q_l are higher, the higher is the minimum wage. One interesting result is that industrial output is positively correlated with the minimum wage, which implies that consumers' total consumption and hence their welfare increases with the increase of the minimum wage in the closed economy under Assumption 1.[5] This result conflicts with our intuition, as the increase of the minimum wage increases firms' unit production costs. However, it holds because the increase of the minimum wage increases consumers' demand and hence industrial output.

Summarizing the above discussion, we have the following proposition.

Proposition 1 *In the closed economy and under Assumption 1, the increase of the minimum wage will increase industrial capital interest, industrial unit production cost, industrial price index, industrial output, and the equilibrium number of firms in the industry. Moreover, it will decease each firm's output and increase their pricing rules. However, it does not change industrial productivity cut-off and industrial weighted productivity level.*

We can explain the latter part of Proposition 1 as follows. Under Assumption 1, all labors get the minimum wage. Though the increase of the minimum wage increases firms' unit production costs and thus the industrial price index, it increases faster than the industrial price index, and thus consumers' purchasing powers

[5] It seems that this result will cause the following paradox - the increase of the minimum wage will increase infinitely consumers' welfare. This paradox is caused by Assumption 1. But this assumption holds conditionally, i.e., the total output are enough to pay each consumer the minimum wage. However, this condition will be broken when the minimum wage is set enough high.

increase, which attracts more firms to enter into the market. Furthermore, as all firms are faced with the same increasing unit production cost, the increase of the minimum wage does not change the industrial productivity cut-offs and thus does not change the industrial weighted productivity levels.

Although Proposition 1 holds in the closed economy, it does not hold in the open economy. In the latter case, firms in the home country are faced with different increasing competition pressures from those in the foreign country - the competition power of domestic firms decreases while that of foreign firms increases. Under free trade, the increase of the domestic minimum wage will increase industrial productivity cut-offs and hence industrial weighted productivity levels.

4 The impact of the minimum wage on the exports of heterogeneous firms

4.1 Equilibrium in the open economy

Firms in industry l must pay a fixed exporting cost κ_l to enter into the foreign market. Suppose the iceberg transportation cost is τ_l for transporting one unit of good from the home country to the foreign market. For simplification, we assume that the corresponding variables κ_l^* and τ_l^* in the foreign country are, respectively, equal to those in the home country. Then the exporting profit of the firm with productivity θ in industry l in the home country is:

$$\pi_{Xl} = \max\left\{0, (1-\rho_l)M_{Xl}^*\theta^{\sigma_l-1} - \kappa_l\right\}, \tag{16}$$

where $M_{Xl}^* = \rho_l^{\sigma_l-1}P_l^{*\sigma_l}Q_l^*\varpi_l^{1-\sigma_l}\tau_l^{1-\sigma_l}$, and P_l^* and Q_l^* are, respectively, foreign industrial price index and foreign total output in industry l. The firm chooses to export only if $\pi_{Xl} \geq 0$, from which we can get the domestic and foreign exporting productivity cut-offs in industry l, as follows:

$$\begin{aligned} \underline{\theta}_{Xl} &= (N_l^* + N_{Xl})^{\frac{1}{\sigma_l-1}} \frac{\kappa_l^{\frac{1}{\sigma_l-1}}\rho_l\tau_l\frac{\varpi_l}{\varpi_l^*}}{[(1-\rho_l)\beta_l w^*]^{\frac{1}{\sigma_l-1}}}\tilde{\theta}_{Tl}^*, \\ \underline{\theta}_{Xl}^* &= (N_l + N_{Xl}^*)^{\frac{1}{\sigma_l-1}} \frac{\kappa_l^{\frac{1}{\sigma_l-1}}\rho_l\tau_l\frac{\varpi_l^*}{\varpi_l}}{[(1-\rho_l)\beta_l w]^{\frac{1}{\sigma_l-1}}}\tilde{\theta}_{Tl}, \end{aligned} \tag{17}$$

where $\tilde{\theta}_{Tl}$ and $\tilde{\theta}^*_{Tl}$ are the domestic and foreign aggregate productivity, respectively, which have the following forms:

$$\tilde{\theta}_{Tl}^{\sigma_l-1} = \frac{k_l}{k_l+1-\sigma_l}\frac{N_l\underline{\theta}_l^{\sigma_l-1}+N^*_{Xl}\underline{\theta}_{Xl}^{*\sigma_l-1}}{N_l+N^*_{Xl}}, \tilde{\theta}_{Tl}^{*\sigma_l-1} = \frac{k_l}{k_l+1-\sigma_l}\frac{N^*_l\underline{\theta}_l^{*\sigma_l-1}+N_{Xl}\underline{\theta}_{Xl}^{\sigma_l-1}}{N^*_l+N_{Xl}}, \tag{18}$$

in which N_{Xl} and N^*_{Xl} are, respectively, the domestic and foreign numbers of exporters. After knowing the exporting productivity cut-offs of domestic and foreign firms in industry l, it's easy for us to find the productivity distributions $\mu_{Xl}(\theta)$ and $\mu^*_{Xl}(\theta)$ of domestic and foreign exporters. When $G_l(\theta)$ adopts the form given in (3), we can conclude the expressions of $\tilde{\theta}_{Tl}^{\sigma_l-1}$ and $\tilde{\theta}_{Tl}^{*\sigma_l-1}$ from (18) and solve $\underline{\theta}_{Xl}^{\sigma_l-1}$ and $\underline{\theta}_{Xl}^{*\sigma_l-1}$, respectively, as follows:

$$\underline{\theta}_{Xl}^{*\sigma_l-1} = \frac{\kappa_l}{f_l}\left(\frac{\rho_l\varpi^*_l}{\varpi_l}\right)^{\sigma_l-1}\underline{\theta}_l^{\sigma_l-1}, \underline{\theta}_{Xl}^{\sigma_l-1} = \frac{\kappa_l}{f_l}\left(\frac{\rho_l\varpi_l}{\varpi^*_l}\right)^{\sigma_l-1}\underline{\theta}_l^{*\sigma_l-1}. \tag{19}$$

Moreover, we have

$$P_l^{\sigma_l}Q_l = \frac{f_l\tau_l^{\sigma_l-1}}{1-\rho_l}\left(\frac{\varpi_l}{\rho_l}\right)^{\sigma_l-1}\underline{\theta}_l^{1-\sigma_l},\ P_l^{*\sigma_l}Q^*_l = \frac{f_l\tau_l^{\sigma_l-1}}{1-\rho_l}\left(\frac{\varpi^*_l}{\rho_l}\right)^{\sigma_l-1}\underline{\theta}_l^{*1-\sigma_l}. \tag{20}$$

When a firm exports, its optimal capital and labor inputs are

$$\begin{aligned} K_X &= \left[\rho_l P^*_l Q_l^{*\frac{1}{\sigma_l}}\tau_l^{1-\sigma_l}\theta^{\rho_l}\varpi_l^{-\rho_l}\right]^{\sigma_l}\left(\frac{r_l}{\alpha_l}\right)^{-1}, \\ L_X &= \left[\rho_l P^*_l Q_l^{*\frac{1}{\sigma_l}}\tau_l^{1-\sigma_l}\theta^{\rho_l}\varpi_l^{-\rho_l}\right]^{\sigma_l}\left(\frac{w}{\alpha_l}\right)^{-1}. \end{aligned} \tag{21}$$

Under Assumption 1, only the capital market clears. Hence according to the clearing condition of the capital market (20) and (21), we have

$$\begin{aligned} \frac{r_l}{\alpha_l} &= \frac{\rho_l k_l\bar{K}_l^{-1}\tau_l^{\sigma_l-1}}{(1-\rho_l)(k_l+1-\sigma_l)}\left[f_lN_l+\tau_l^{1-\sigma_l}\kappa_lN_{Xl}\right], \\ \frac{r^*_l}{\alpha_l} &= \frac{\rho_l k_l\bar{K}_l^{*-1}\tau_l^{\sigma_l-1}}{(1-\rho_l)(k_l+1-\sigma_l)}\left[f_lN^*_l+\tau_l^{1-\sigma_l}\kappa_lN^*_{Xl}\right]. \end{aligned} \tag{22}$$

When $G_l(\theta)$ adopts the form given by (3), we can get an incumbent's ex ante exporting probability in industry l as follows:

$$\varsigma_l = \frac{N_{Xl}}{N_l} = \frac{1-G_l(\underline{\theta}_{Xl})}{1-G_l(\underline{\theta}_l)} = \left(\frac{\underline{\theta}_l}{\underline{\theta}_{Xl}}\right)^{k_l} = \left[\frac{\kappa_l}{f_l}\left(\frac{\rho_l\varpi_l}{\varpi^*_l}\right)^{\sigma_l-1}\right]^{-\frac{k_l}{\sigma_l-1}}\left(\frac{\underline{\theta}_l}{\underline{\theta}^*_l}\right)^{k_l}. \tag{23}$$

Then the ex ante expected profit that a firm enters into the market is:

$$\bar{\pi}_l \;=\; \bar{\pi}_{Dl}(\tilde{\theta}_l) + \varsigma_l \bar{\pi}_{Xl}(\tilde{\theta}_{Xl}), \tag{24}$$

where $\bar{\pi}_{Dl}$ is the firm's expected profit from selling domestically, and $\bar{\pi}_{Xl}$ is its expected profit from selling in the foreign market. We thus have

$$\bar{\pi}_l = \frac{\sigma_l - 1}{k_l + 1 - \sigma_l}(f_l + \varsigma_l \tau_l^{1-\sigma_l}\kappa_l),\ \bar{\pi}_{Xl} = \frac{\sigma_l - 1}{k_l + 1 - \sigma_l}\tau_l^{1-\sigma_l}\kappa_l. \tag{25}$$

The sum of expenditures on industry l from both countries is equal to that of all the firms' profits in this industry in both countries. Therefore, we have

$$f_l N_l + \tau_l^{1-\sigma_l}\kappa_l N_{Xl} + f_l N_l^* + \tau_l^{1-\sigma_l}\kappa_l N_{Xl}^* = \frac{k_l + 1 - \sigma_l}{\sigma_l - 1}\beta_l(w + w^*). \tag{26}$$

Moreover, suppose that the probability that a domestic firm in industry l exits the market is δ_l. Then we have $(1 - G_l(\underline{\theta}_l))\bar{\pi}_l/\delta_l = F_l$ for the long-term entry condition, from which we have

$$f_l N_l + \tau_l^{1-\sigma_l}\kappa_l N_{Xl} = \frac{k_l + 1 - \sigma_l}{(\sigma_l - 1)b_l^{k_l}} N_l \underline{\theta}_l^{k_l}. \tag{27}$$

(27) implies that a firm's ex ante exporting probability (equal to $\frac{N_{Xl}}{N_l}$) is increasing in the productivity cut-off $\underline{\theta}_l$ of entry into industry l. Combining (27) with that of the foreign country, we can finally get

$$\Omega_l \triangleq \left(\frac{\underline{\theta}_l}{\underline{\theta}_l^*}\right)^{k_l} = \frac{f_l - \tau_l^{1-\sigma_l}\kappa_l\left(\frac{\kappa_l}{f_l}\rho_l^{\sigma_l-1}\right)^{-\frac{k_l}{\sigma_l-1}}\left(\frac{\varpi_l}{\varpi_l^*}\right)^{k_l}}{f_l - \tau_l^{1-\sigma_l}\kappa_l\left(\frac{\kappa_l}{f_l}\rho_l^{\sigma_l-1}\right)^{-\frac{k_l}{\sigma_l-1}}\left(\frac{\varpi_l^*}{\varpi_l}\right)^{-k_l}}. \tag{28}$$

(28) implies that Ω_l is decreasing in w if $\omega_l \triangleq \varpi_l/\varpi_l^*$ is increasing in w. This together with (23) yields the following lemma.

Lemma 1 *Under Assumption 1, if ω_l is increasing in the domestic minimum wage w, then ς_l is decreasing in w. That is, the increase of the minimum wage leads to the decrease of firms' ex ante exporting probability.*

Proof. See the appendix. ∎

The economic meaning of Lemma 1 is straightforward. If the relative unit production cost of the home country to the foreign one increases with the domestic minimum wage in industry l, then the relative variety price of the home country will increase, and thus domestic firms' competitive powers and their foreign sale profits will decrease. This further makes lower-productivity domestic firms exit the exporting market. Therefore, domestic firms' ex ante exporting probability decreases with the domestic minimum wage.

From (23), we have $N_{Xl} = N_l \varsigma_l$, $N^*_{Xl} = N^*_l = \varsigma^*_l$. Substituting (19) into (20) and (18), we can get a two-equation system of N_l and N^*_l. Substituting $N_{Xl} = N_l \varsigma_l$, $N^*_{Xl} = N^*_l = \varsigma^*_l$ into the above system, we can find the expressions of N_l and N^*_l (see (38) and (39) in the appendix). Further, according to (26) and (27), we can finally get the following results:

$$\underline{\theta}_l^{k_l} = \frac{\beta_l b_l^{k_l}}{\delta_l F_{El}} \frac{w + w^*}{N_l + N^*_l \Omega_l^{-1}}, \underline{\theta}_l^{*k_l} = \frac{\beta_l b_l^{k_l}}{\delta_l F_{El}} \frac{w + w^*}{N_l \Omega_l + N^*_l}. \tag{29}$$

Applying (38) and (39) in the appendix, we can prove the following lemma.

Lemma 2 *$\underline{\theta}^*_l$ is increasing in w.*

Proof. See the appendix. ∎

Lemma 29 indicates that the increase of the domestic minimum wage will force the low-productivity domestic firms to exit the market, which increase the average productivity of exporting incumbents in the home country. This further forces those low-productivity firms in the foreign country to exit the market. And thus the exporting productivity cut-off in the foreign country increases.

Finally, to find how the increase of the domestic minimum wage affects firms' exporting behaviors in the home country, we need to know the relationship between $\frac{\varpi_l}{\varpi^*_l}$ and w. According to (22) , (27) and the definitions of ϖ_l and ϖ^*_l, we have:

$$\frac{\varpi_l}{\varpi^*_l} = \left(\frac{w}{w^*}\right)^{1-\alpha_l} \left(\frac{\bar{K}^*_l}{\bar{K}_l}\right)^{\alpha_l} \left(\frac{N_l \underline{\theta}_l^{k_l}}{N^*_l \underline{\theta}_l^{*k_l}}\right)^{\alpha_l} = \left(\frac{w}{w^*}\right)^{1-\alpha_l} \left(\frac{\bar{K}^*_l}{\bar{K}_l}\right)^{\alpha_l} \left(\frac{N_l}{N^*_l} \Omega_l\right)^{\alpha_l}. \tag{30}$$

Using (30), we can analyze the relationship between $\frac{\varpi_l}{\varpi^*_l}$ and $\frac{w}{w^*}$ and prove the following result.

Lemma 3 *Under Assumption 1, $\frac{\varpi_l}{\varpi^*_l}$ is increasing in the relative wage $\frac{w}{w^*}$. That is, the increase of the gap between the domestic minimum wage and the foreign one will increase the difference between the domestic and the foreign unit production cost for each industry.*

Proof. See the appendix. ∎

Lemma 3 indicates that the increase of the domestic minimum wage has different impacts on domestic and foreign industrial unit production costs - the former increases more faster than the latter. This result coincides with our intuition.

4.2 The impact of the minimum wage on firms' exports

According to the expression of M_{Xl}^*, (20) implies that the increase of the domestic minimum wage will increase industrial exporting productivity cut-offs. Moreover, by (20) and (16), if a firm exports, its exporting sale is

$$X_l = \frac{f_l}{1-\rho_l}\left(\frac{\varpi_l^*}{\varpi_l}\right)^{\sigma_l-1}\left(\frac{\theta}{\underline{\theta}_l^*}\right)^{\sigma_l-1}. \tag{31}$$

From Lemma 3, $\frac{\varpi_l^*}{\varpi_l}$ is increasing in w, given the foreign minimum wage w^*. From Lemma 2, $\underline{\theta}_l^*$ is increasing in w. Hence by (31) and Lemma 1, we have the following main proposition of this paper.

Proposition 2 *In the open economy and under Assumption 1, the increase of the domestic minimum wage will decrease firms' ex ante exporting probabilities and exporting sales. Moreover, firms' exporting sales increase with their productivity levels.*

It's necessary to briefly illustrate Proposition 2. First, it implies that firms' ex ante exporting possibilities and their exporting sales are all increasing in their productivity, which coincides with the theoretical result proposed in Melitz (2003) and many other empirical literatures. Second, as the main result in the paper, the increase of the domestic minimum wage will decrease firms' ex ante exporting possibilities and their exporting sales. This result is easy to understand. On the one hand, the increase of the domestic minimum wage may change the structure of comparative advantages between the two countries, so that the home country uses capitals while the foreign country uses labors more intensely. This increases prices of capitals and thus those of firms' exporting varieties. On the other hand, the increase of the domestic minimum wage will increase the home country's demands for varieties of the foreign country and thus increases their prices. The synthetic effect is that the difference between the two countries' industrial unit production costs increases. Because of the same reason, the increase of the domestic wage will select low-productivity domestic firms out of the exporting markets, and thus increase industrial exporting productivity cut-offs in the home country. This further lowers firms' ex ante exporting probabilities.

5 Empirical models

According to (31) and the fact that capital interests are affected by industrial capital stocks, we know that firms' productivity, the minimum wages and industrial capital stocks all affect firms' exporting behaviors. In this section, we test their impacts on firms' exports using firm-level data from Annual Survey of Chinese Industrial Firms. We first estimate firms' productivity, and then regress firms' exporting choices and exports with regard to their productivity, the minimum wage, industrial capital stocks and other control variables.

5.1 Estimation of firm-level productivity

By Proposition 2, firms export more if their productivity is higher. Therefore, to analyze firms' exporting behaviors, we shall first estimate their productivity. Many methods have been developed to estimate firm-level productivity, such as the Olley-Pakes approach (OP) proposed by Olley and Pakes (1996), the Levinsohn-Petrin approach (LP) developed by Levinsohn and Petrin (2003), the ordinary least square method (OLS) and the fixed effect model (FE). In this paper, we follow strictly the idea of the Melitz model (Melitz 2003), which assumes that a firm's productivity is constant over all periods if it is in the market when the economy attains its stationary state. This implies that we shall apply the FE method to estimate firms' productivity. We don't use the popular OP approach because of the following several reasons. First, the OP method also implicitly assumes that firms' productivity does not change over time (Tian and Yu, 2011). However, it considers the impacts of firms' exporting states, capital stocks and productivity expectations on firms' productivity. As we consider only firms' productivity when the economy attaints its stationary state, it is not necessary to use the OP method to estimate firms' productivity. Second, to use the OP method, the form of firms' investment functions shall be specified in advance, whose choices will affect the estimation results of firms' productivity for the same dataset. Third, as shown in Sun et al. (2011), the productivity-estimation results from the LP method and the FE model are more similar, while those from the OLS and the OP method are similar. This is also the reason we apply the FE model but not the OLS and the LP methods to estimate firms' productivity.

Suppose we measure a firm's total factor productivity (TFP) by Solow's residual and the firm's production function is $Y_{lit} = \theta_{li} K_{lit}^{\alpha_l} L_{lit}^{1-\alpha_l}$, then we can estimate the capital-output elasticity α_l of industry l by estimating the following equation:

$$\ln Y_{lit} - \ln L_{lit} = \ln \theta_{li} + \alpha_l (\ln K_{lit} - \ln L_{lit}) + \mu_{lit}, \tag{32}$$

where θ_{li} is the productivity of firm i in industry l, Y_{lit}, K_{lit} and L_{lit} are firm i's output, capital and labor inputs, respectively. Given the estimated value $\hat{\alpha}_l$ of α_l, we can calculate the firm's productivity in period t, as follows:

$$\hat{\theta}_{lit} = \frac{Y_{lit}}{K_{lit}^{\hat{\alpha}_l} L_{lit}^{1-\hat{\alpha}_l}}. \tag{33}$$

Another method to estimation firms' productivity is to divide the time-period 1998-2007 into 5 time intervals, which is called 5-period method in this paper. This method has the following advantages relative to the above one. First, it seizes the changes of a firm's productivity over periods. Second, it does not affect the estimation of the capital-output elasticities as we can eliminate firms' productivity fixed effects by differentiating the two neighboring-period equations. Substituting the estimated capital-output elasticities into (33), we can calculate 5 productivity levels for each firm i in each industry l. We then take their average as firm i's constant productivity level in industry l.

5.2 Firms' exporting behaviors

According to (31), our estimation equations of firms' exporting behaviors are as follows:

$$DX_{rlit} = \tau_r + \eta_l + \gamma_i + \lambda_t + \xi \ln \bar{K}_{lt} + \psi \ln w_{rt} + \zeta \ln \hat{\theta}_{rlit} + \varphi Z_{rlit} + \varepsilon_{rlit}, \tag{34}$$

$$\ln X_{rlit} = \tau_r + \eta_l + \gamma_i + \lambda_t + \xi \ln \bar{K}_{rlt} + \psi \ln w_t + \zeta \ln \hat{\theta}_{rlit} + \varphi Z_{rlit} + \varepsilon_{rlit}, \tag{35}$$

where Equation (34) and (35) correspond to firms' exporting choices and exporting sale, $\bar{K}_{rlt}$ and w_{rt} measures industrial capital stock and minimum wage in region r in period t, $\hat{\theta}_{rlit}$ is the estimated productivity of firm i in industry l in region r in period t, $\lambda_t, \eta_l, \gamma_i$ and τ_r are, respectively, time, industry, firm and region fixed effects, Z_{rlit} is a vector containing firm i' characteristic variables, including its capital-debt ratio, inventory-output ratio, per-output profit and other firm-level control variables, DX_{rlit} is a dummy of firm i' exporting state, with 1 for exporter and 0 for non-exporter, and X_{rlit} is firm i's exporting sale in period t, r, l, i, t are region, industry, firm and time indices , respectively. We can apply the LPM model, the Probit model and the Logit model to estimate (34), whose estimation results are similar. In this paper, we apply only the LPM model based on panel data and the consideration of eliminating firm fixed effects.

5.3 Data descriptions

This paper applies plant-level data from the Annual Survey of Industrial Firms (**ASIF**) cross-sectional data collected by the National Bureau of Statistics of China between 1998 and 2007 to test Proposition 2. The data set contains detailed information (including more than 100 financial variables listed in the main accounting sheets of these firms) for all state-owned and non-state firms above a designated scale (above 5 million RMB) in 40 industries indexed from 6 to 46, with industry 38 vacant (see Table 3 in the appendix for the industry codes and their corresponding names). The data set exploited in this paper covers every firm's output value, value added, capital stock, labor hired, domestic sale value, exporting sale, inventories, scale type, exporting status, operational status, ownership, age, wages, other main financial variables, etc., between 1998 and 2007, in each industry. We dropped those samples which does not follow standard accounting principles, those which are public institutions, government entities, nongovernmental organizations and private nonbusiness firms, those which are not on business.

We also collect data of minimum wage standards and other macroeconomic variables of Chinese cities from 1998 to 2007. As there is no a uniformly statistical origin, we collect data of city minimum wages from websites and statistical bulletins of local governments. This leads to the losses of some cities' minimum wages. Finally, we get totally 1240 minimum wages, covering 37.13$\%$ of total 334 prefecture-cities (autonomous prefectures or prefectures) all around China. We also collect domestic gross values, populations, average annual wages, average employments and other macroeconomic variables of these cities. We match firm-level data with city-level data by firms' location information and match those samples with both firm-level data and city minimum wages. We finally get totally 960 thousand samples.

Table 1 in the appendix describes the variables used in this paper. We see in the table that the mean of city minimum wages is 532 yuan, which is around 40% of the per capita wage of the samples, and there are 27.6% of exporters among the samples, whose average exporting sale is 2.156 million yuan. The samples' capitals are larger than their debts and their inventories occupy 33% of their gross values.

5.4 Regression results

5.4.1 Firms' productivity

Table 2 in the appendix gives the estimation results of capital-output elasticities of all industries. The mean of them is about 0.56, which is close to those estimated by many literatures. The capital-output elasticities of labor-intense industries are relatively smaller, such as industry 20 (0.38), 21 (0.39), 17 (0.49), 18 (0.48), where the number in the "()" is the corresponding capital-output elasticity in the industry. However, those in the capital-intense industries are relatively larger, such as industry 7 (0.87), 16 (0.88), 40 (0.7) and 45 (0.74). The mean of the capital-output elasticity of all industries increased from 0.54 in 1998 to 0.58 in 2005, and then decreased to 0.56 in 2007.

Table 3 shows the estimated industrial capital-output elasticities applying panel-data regressions. Similarly, the average capital-output elasticity in industry 7 is the highest at 0.9, while those in industry 20 and 21 are the lowest at 0.39. Figure 1 shows the two results estimated by the full-period method and the 5-period method, which are very close. In the sequel, we regress (35) applying the two kinds of firm-level productivity calculated using the two kinds of estimated industrial capital-output elasticities to avoid errors caused by different estimation method of capital-output elasticity.

5.4.2 Firms' exporting choices and sales

Table 4 in the appendix shows the estimation results of (34) using the fixed-effect model. The second column shows that the city minimum wage has significant impact on a firm's exporting possibility, which decreases by 1.5% if it doubles. Moreover, the exporting possibility of a firm decreases by 1.3% if its productivity decreases by 100%. Industrial capital stock has little influence on firms' exporting possibilities, which is only significant at 10% level. The third column shows the regression result by adding firm-level control variables to the regression of the first column, which does not change much. The fourth column shows the regression result by adding city-level macroeconomic (including city GDP, population, average annual income and employment) variables to the regression of the third column to eliminate the endogeneity of city minimum wages when time varies.

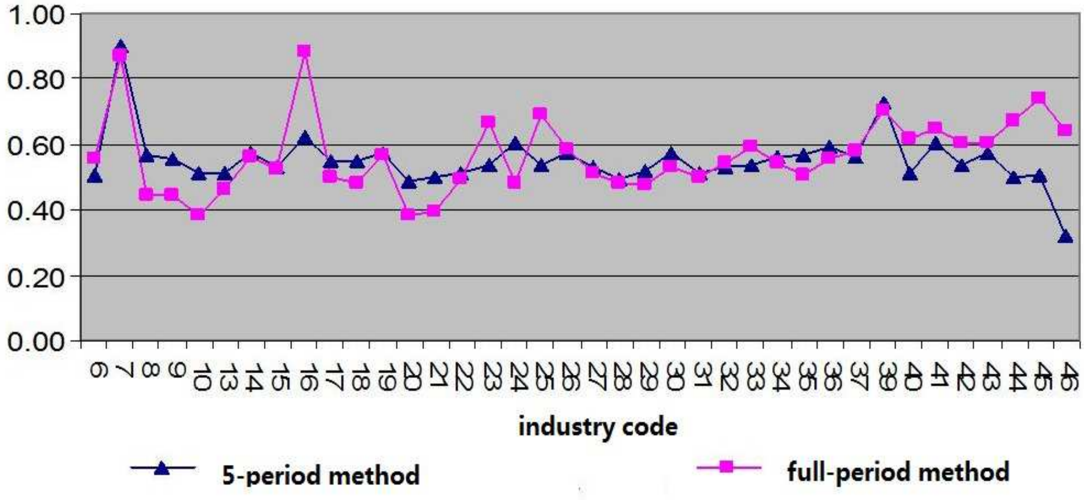

Figure 1: Average industrial capital-output elasticities estimated by the full-period method and the 5-period method

It shows that the result is still constant to the previous ones. The fifth column shows the regression result of the fourth column but we replace firms' productivity by that estimated using the 5-period method. It shows that the result holds very closely to that given in the fourth column. This implies that estimation methods of firm-level productivity has few impacts on the regression results.

The regression results of (35) using the fixed-effect model are shown in Table 5 in the appendix. It's shown in the secpmd column that city minimum wage decreases firms' exporting sales, which is only significant at 10% level. A firm's exporting sale decreases by 0.086% if its city minimum wage increases by 1%. A firm's productivity has significant influence on its exporting sale, with the latter increasing by 0.69% if the former increases by 1%. Industrial capital stock has significant effect on firms' exports, with the latter increasing by 0.053% if the former increases 1%. The third and the fourth column show the regression results controlling firm-level control variables and city-level macroeconomic variables, respectively. The influences of city minimum wages, firms' productivity and industrial capital stocks have very close impacts on firms' exporting sales. This result estimated by replacing firms' productivity estimated using the 5-period method does not change much than that shown in the fifth column.

6 Conclusion

This paper constructs a trade-equilibrium model with heterogeneous firms to investigate the impacts of minimum wages on firms' exports. The results show that the increase of the minimum wage in a country has negative influences on firms' ex ante exporting probabilities and their exporting sales. Empirical analysis using firm-level data of Chinese enterprises confirms this theoretical result and gives quantitative influences of the minimum wage on firms' exports.

Based on the framework given in this paper, we can further analyze the welfare effects of minimum wages in the open economy. We can also relax Assumption 1 to investigate the impacts of minimum wages on firms' exports when real wages are affected by unemployment. As minimum wages affect firms' organization and innovation behaviors and thus their productivity levels, it's of sense to explore the interaction effects between minimum wages and firms' productivity. Moreover, the spatial differences of the impacts of minimum wages on firms' exports deserve more researches.

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Appendix

Proof of Lemma 1

We know that N_l and N_l^* satisfy the following equations:

$$N_l + N_l^* \left(\frac{\kappa_l}{f_l}\rho_l^{\sigma_l-1}\right)^{1-\frac{k_l}{\sigma_l-1}} \left(\frac{\varpi_l}{\varpi_l^*}\right)^{k_l+1-\sigma_l} \left(\frac{\underline{\theta}_l}{\underline{\theta}_l^*}\right)^{-k_l} = \frac{k_l+1-\sigma_l}{k_l}\frac{(1-\rho_l)\beta_l w}{f_l\tau_l^{\sigma_l-1}}, \quad (36)$$

$$N_l^* + N_l \left(\frac{\kappa_l}{f_l}\rho_l^{\sigma_l-1}\right)^{1-\frac{k_l}{\sigma_l-1}} \left(\frac{\varpi_l^*}{\varpi_l}\right)^{\sigma_l-k_l-1} \left(\frac{\underline{\theta}_l}{\underline{\theta}_l^*}\right)^{k_l} = \frac{k_l+1-\sigma_l}{k_l}\frac{(1-\rho_l)\beta_l w^*}{f_l\tau_l^{\sigma_l-1}} \quad (37)$$

from which we can find the equilibrium numbers of firms in both countries as follows:

$$N_l = \frac{\frac{k_l+1-\sigma_l}{k_l}\frac{(1-\rho_l)\beta_l}{f_l\tau_l^{\sigma_l-1}}\left\{w - \left(\frac{\kappa_l}{f_l}\rho_l^{\sigma_l-1}\right)^{\frac{\sigma_l-1-k_l}{\sigma_l-1}}\left(\frac{\varpi_l}{\varpi_l^*}\right)^{k_l+1-\sigma_l}\left(\frac{\underline{\theta}_l}{\underline{\theta}_l^*}\right)^{-k_l} w^*\right\}}{1-\left(\frac{\kappa_l}{f_l}\rho_l^{\sigma_l-1}\right)^{\frac{2(\sigma_l-1-k_l)}{\sigma_l-1}}}, \quad (38)$$

$$N_l^* = \frac{\frac{k_l+1-\sigma_l}{k_l}\frac{(1-\rho_l)\beta_l}{f_l\tau_l^{\sigma_l-1}}\left\{w^* - \left(\frac{\kappa_l}{f_l}\rho_l^{\sigma_l-1}\right)^{\frac{\sigma_l-1-k_l}{\sigma_l-1}}\left(\frac{\varpi_l}{\varpi_l^*}\right)^{\sigma_l-k_l-1}\left(\frac{\underline{\theta}_l}{\underline{\theta}_l^*}\right)^{k_l} w\right\}}{1-\left(\frac{\kappa_l}{f_l}\rho_l^{\sigma_l-1}\right)^{\frac{2(\sigma_l-1-k_l)}{\sigma_l-1}}}. \quad (39)$$

Proof of Lemma 2

First, we know that $N_l\Omega_l$ is decreasing in w according to (38) . Hence $\frac{N_l\Omega_l}{w+w^*}$ is also decreasing in w. Furthermore, from (29), we have

$$\frac{N_l^*}{w+w^*} = \frac{\frac{k_l+1-\sigma_l}{k_l}\frac{(1-\rho_l)\beta_l}{f_l\tau_l^{\sigma_l-1}}}{1-\left(\frac{\kappa_l}{f_l}\rho_l^{\sigma_l-1}\right)^{\frac{2(\sigma_l-1-k_l)}{\sigma_l-1}}}\left\{1-\left[\left(\frac{\kappa_l}{f_l}\rho_l^{\sigma_l-1}\right)^{\frac{\sigma_l-1-k_l}{\sigma_l-1}}\left(\frac{\varpi_l}{\varpi_l^*}\right)^{\sigma_l-k_l-1}\Omega_l+1\right]\frac{w}{w+w^*}\right\}.$$

As $\frac{w}{w+w^*}$ is increasing in w,[6] $\frac{N_l^*}{w+w^*}$ is also decreasing in w. Therefore, from (29), we know that

$$\underline{\theta}_l^{*k_l} = \frac{\frac{\beta_l b_l^{k_l}}{\delta_l F_{El}}}{N_l\Omega_l/(w+w^*)+N_l^*/(w+w^*)}$$

is increasing in w. This implies that $\underline{\theta}_l^*$ is increasing in w.

[6]This is because that $\left(\frac{\varpi_l}{\varpi_l^*}\right)^{\sigma_l-k_l-1}$ and Ω_l are both decreasing in $\frac{\varpi_l}{\varpi_l^*}$.

Proof of Lemma 3

First, from (38) and (39), we have

$$\frac{N_l}{N_l^*} = \frac{w - \left(\frac{\kappa_l}{f_l}\rho_l^{\sigma_l-1}\right)^{\frac{\sigma_l-1-k_l}{\sigma_l-1}} \omega_l^{k_l+1-\sigma_l}\Omega_l^{-1}w^*}{w^* - \left(\frac{\kappa_l}{f_l}\rho_l^{\sigma_l-1}\right)^{\frac{\sigma_l-1-k_l}{\sigma_l-1}} \omega_l^{\sigma_l-1-k_l}\Omega_l w}. \quad (40)$$

Second, equation (30) can be rewritten as

$$h(\omega_l) = \left(\frac{w}{w^*}\right)^{1-\alpha_l}\left(\frac{\bar{K}_l^*}{\bar{K}_l}\right)^{\alpha_l},$$

where

$$h(\omega_l) = \omega_l\left(\frac{w\Omega_l - \left(\frac{\kappa_l}{f_l}\rho_l^{\sigma_l-1}\right)^{\frac{\sigma_l-1-k_l}{\sigma_l-1}} \omega_l^{k_l+1-\sigma_l}w^*}{w^* - \left(\frac{\kappa_l}{f_l}\rho_l^{\sigma_l-1}\right)^{\frac{\sigma_l-1-k_l}{\sigma_l-1}} \omega_l^{\sigma_l-1-k_l}\Omega_l w}\right)^{-\alpha_l}. \quad (41)$$

As

$$g(\omega_l) = \frac{w\Omega_l - \left(\frac{\kappa_l}{f_l}\rho_l^{\sigma_l-1}\right)^{\frac{\sigma_l-1-k_l}{\sigma_l-1}} \omega_l^{k_l+1-\sigma_l}w^*}{w^* - \left(\frac{\kappa_l}{f_l}\rho_l^{\sigma_l-1}\right)^{\frac{\sigma_l-1-k_l}{\sigma_l-1}} \omega_l^{\sigma_l-1-k_l}\Omega_l w}$$

is decreasing in ω_l, $h(\omega_l)$ is increasing in ω_l. This implies that equation (30) has a unique solution, which is increasing in $\frac{w}{w^*}$.

Table 1: Descriptive statistics of variables

Variable	Unit	Definition	Mean
w	Yuan	Urban minimum wage standard	532.5 [150.7]
DX	*100%	A dummy measures whether or not a firm exports, with 1 if the firm exports and 0 if it does not	0.276 [0.44]
ln X		The natural logarithm of a firm's exporting sale	9.62 [1.72]
ln $\bar{K}$		The natural logarithm of the total capital stock in an industry	19.62 [1.16]
ln K		The natural logarithm of a firm's capital stock	9.76 [1.47]
RCD		A firm's total capital/its total debt	8.11 [498]
RInv	*100%	A firm's value of inventories/its total output value	0.325 [21.84]
RP		A firm's sale profit/its total output value	-0.038 [11.9]
DF	*100%	A dummy measures whether or not a firm's capitals are all from home\footnoteThis concept includes state-owned firms, collective firms, joint-equity cooperative enterprises, private firms (including sole proprietorship firms and private partnership firms), etc. with 1 for yes and 0 for no.	0.754 [0.430]
SC	*100%	It's 1 if a firm's capitals are all or partly from the state and 0 if not	0.109 [0.31]
UGdp	10^8 yuan	The GDP of the urban a firm locates	1140 [1326]
UPop	10^4 people	The population of the urban a firm locates	228.4 [205.6]
UW	Yuan	The average annual wage of the urban the firm locates	21414 [8580]
UE	10^4 people	The employment of the urban a firm locates	51.56 [58.16]

Note: The value in "[]" is the standard of the corresponding mean.

Table 2: Estimation results of capital-output elasticities: OLS method

Industry code	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
06	0.50	0.45	0.51	0.50	0.47	0.57	0.63	0.67	0.66	0.62
07	0.73	0.67	0.98	0.97	1.14	0.93	0.80	0.83	0.85	0.82
08	0.51	0.40	0.34	0.39	0.37	0.43	0.54	0.46	0.52	0.48
09	0.32	0.22	0.32	0.44	0.37	0.43	0.61	0.57	0.63	0.55
10	0.29	0.26	0.27	0.29	0.35	0.39	0.46	0.51	0.48	0.50
13	0.52	0.46	0.44	0.41	0.45	0.45	0.47	0.47	0.49	0.49
14	0.70	0.62	0.58	0.55	0.53	0.56	0.56	0.52	0.50	0.50
15	0.63	0.55	0.54	0.51	0.47	0.49	0.50	0.52	0.52	0.50
16	0.77	0.79	0.75	0.82	0.97	1.06	0.85	0.91	0.97	0.92
17	0.57	0.46	0.45	0.46	0.48	0.50	0.53	0.51	0.53	0.50
18	0.58	0.45	0.47	0.45	0.45	0.46	0.51	0.49	0.50	0.48
19	0.62	0.45	0.51	0.52	0.56	0.58	0.61	0.61	0.60	0.61
20	0.41	0.37	0.35	0.31	0.32	0.37	0.43	0.42	0.44	0.41
21	0.48	0.35	0.31	0.37	0.41	0.39	0.38	0.38	0.43	0.42
22	0.59	0.50	0.48	0.46	0.49	0.49	0.49	0.46	0.48	0.47
23	0.80	0.75	0.76	0.72	0.68	0.69	0.65	0.61	0.57	0.45
24	0.58	0.45	0.45	0.44	0.41	0.49	0.51	0.50	0.50	0.48
25	0.60	0.64	0.71	0.76	0.67	0.73	0.69	0.77	0.73	0.63
26	0.64	0.58	0.58	0.57	0.55	0.57	0.58	0.60	0.60	0.58
27	0.67	0.59	0.60	0.55	0.53	0.53	0.43	0.42	0.43	0.38
28	0.43	0.43	0.41	0.43	0.46	0.49	0.48	0.53	0.58	0.56
29	0.44	0.39	0.42	0.46	0.46	0.55	0.50	0.50	0.53	0.49
30	0.58	0.52	0.53	0.50	0.49	0.51	0.53	0.54	0.57	0.55
31	0.50	0.44	0.46	0.47	0.45	0.52	0.53	0.54	0.56	0.52
32	0.55	0.48	0.51	0.48	0.51	0.57	0.59	0.60	0.58	0.58
33	0.60	0.48	0.52	0.45	0.53	0.57	0.62	0.70	0.74	0.70
34	0.62	0.50	0.51	0.51	0.51	0.51	0.55	0.56	0.59	0.57
35	0.61	0.50	0.51	0.47	0.48	0.50	0.51	0.51	0.50	0.49
36	0.70	0.60	0.60	0.55	0.54	0.54	0.52	0.52	0.51	0.49
37	0.73	0.63	0.61	0.57	0.55	0.55	0.53	0.54	0.56	0.53

39	0.92	0.87					0.58	0.60	0.64	0.62
40	0.72	0.64	0.60	0.56	0.55	0.59	0.62	0.62	0.64	0.64
41	0.75	0.71	0.70	0.63	0.61	0.65	0.60	0.60	0.62	0.60
42	0.81	0.70	0.68	0.59	0.60	0.51	0.52	0.54	0.55	0.55
43	0.64	0.57	0.52	0.47			0.76	0.65	0.60	0.65
44	0.70	0.71	0.69	0.63	0.66	0.68	0.70	0.70	0.65	0.58
45	0.73	0.81	0.86	0.84	0.79	0.77	0.62	0.65	0.66	0.66
46	0.63	0.62	0.63	0.63	0.63	0.64	0.66	0.67	0.67	0.65

Note: Refer to Table 3 for the name of the industries.

Table 3: Estimation results of capital-output elasticities: fixed-effect model

Industry code	Industry name	1998 -1999	2000 -2001	2002 -2003	2004 -2005	2006 -2007
06	Extraction coal	0.58	0.37	0.54	0.57	0.48
07	Petroleum and natural gas extraction	0.72	1.15	1.00	0.72	0.93
08	ferrous metals mining and dressing	0.73	0.45	0.52	0.58	0.56
09	Extraction non-ferrous metal	0.61	0.54	0.49	0.57	0.57
10	Extraction nonmetallic ore	0.61	0.44	0.50	0.47	0.53
13	Food processing	0.54	0.43	0.52	0.51	0.55
14	Food manufacturing	0.62	0.63	0.49	0.58	0.56
15	Beverage Manufacturing	0.55	0.44	0.53	0.55	0.58
16	Tobacco processing	0.58	0.66	0.57	0.52	0.80
17	Textile	0.62	0.51	0.48	0.56	0.58
18	Garments and other Fiber Products manufacturing	0.67	0.55	0.45	0.55	0.52
19	Leather Furs Down and Related Products	0.77	0.55	0.50	0.53	0.52
20	Timber Processing, Bamboo, Cane, Palm Fiber and Straw Products	0.50	0.44	0.44	0.54	0.51
21	Furniture Manufacturing	0.55	0.42	0.52	0.50	0.52
22	Papermaking and Paper Products	0.63	0.38	0.51	0.49	0.56
23	Printing Industry and Recording Media	0.55	0.45	0.51	0.64	0.54
24	Cultural Educational and Sports Goods	0.70	0.61	0.53	0.63	0.57
25	Petroleum Refining and Cok	0.57	0.42	0.63	0.55	0.53
26	Chemical materials and chemical products	0.65	0.52	0.53	0.58	0.58
27	Pharmaceutical manufacturing	0.66	0.45	0.44	0.57	0.52
28	Chemical Fiber manufacturing	0.66	0.32	0.37	0.49	0.62
29	Rubber Products	0.62	0.43	0.43	0.56	0.54
30	Plastic product industry	0.65	0.55	0.49	0.59	0.60
31	Nonmetal Mineral Products	0.60	0.43	0.44	0.52	0.56
32	Ferrous metal smelting and rolling processing	0.63	0.44	0.44	0.52	0.61

33	Non-Ferrous Metals Smelting and Rolling	0.58	0.48	0.51	0.54	0.59
34	Metal product industry	0.65	0.51	0.46	0.60	0.59
35	Machine building industry	0.64	0.55	0.54	0.52	0.59
36	General Equipment manufacturing	0.70	0.56	0.54	0.55	0.60
37	Transport Equipment manufacturing	0.68	0.50	0.49	0.59	0.56
39	Arms and ammunition manufacturing	0.98			0.59	0.61
40	Electric Equipment and Machinery manufacturing	0.64	0.50	0.12	0.65	0.65
41	Electronic and Telecommunication Equipment manufacturing	0.71	0.52	0.55	0.64	0.59
42	Instrumentation and culture, office machinery manufacturing	0.73	0.67	0.19	0.57	0.53
43	Recovery and processing of waste resources and materials	0.71	0.30		0.72	0.56
44	Production and supply of electric power and heat power	0.58	0.46	0.45	0.45	0.55
45	Production and supply of gas	0.69	0.62	0.41	0.30	0.52
46	Production and supply of water	0.45	0.27	0.35	0.19	0.35

Table 4: Firms' export choices: LPM-FE model

	Dependant: DX			
	(1)	(2)	(3)	(4)[7]
ln w	**-0.015**	**-0.016**	**-0.011**	**-0.011**
	[3.37]***	**[4.09]*****	**[2.70]*****	**[2.76]*****
ln θ	**0.013**	**0.016**	**0.016**	**0.011**
	[16.96]***	**[26.17]*****	**[25.96]*****	**[19.58]*****
ln $\bar{K}$	**0.003**	**0.002**	**0.002**	**0.001**
	[1.85] **	**[1.58] ****	**[1.26]**	**[0.60]**
ln K		0.028	0.028	0.027
		[38.23]***	[38.22]***	[37.14]***
RCD		-0.000	-0.000	-0.000
		[1.31]	[0.60]	[0.63]
RInv		-0.000	-0.000	-0.000
		[4.20]***	[4.18]***	[4.70]** *
RP		0.000	0.000	0.000
		[0.80]	[0.79]	[0.83]
DF		-0.035	-0.035	-0.035
		[10.14]***	[9.85]***	[9.87]***
SC		0.005	0.004	0.004
		[1.79] *	[1.71] *	[1.62] *
lnUGdp			-0.003	-0.004
			[1.16]	[1.45]
lnUPop			0.024	0.025
			[10.24]***	[10.48]***
lnUW			-0.023	-0.022
			[6.84]***	[6.62]***
lnUE			-0.018	-0.017
			[6.84]***	[6.81]**
TimeDum	Yes	Yes	Yes	Yes
Const	0.290	0.074	0.221	0.251
	[7.49]***	[2.35]**	[5.27]***	[5.99]***

Obs	954603	948983	934346	934346
R2̂	0.00	0.01	0.01	0.01

Note: The value in "[]" is the "t-statistics" of the corresponding estimated value[ff0c]"***", "**", "*" represent, respectively, that the corresponding estimated value are significant at 1%, 5% and 10%, respectively.

Table 5: Firms' exporting sales: fixed-effect model

Dependant: ln X				
	(1)	(2)	(3)	(4)[8]
ln w	**-0.042**	**-0.100**	**-0.086**	**-0.108**
	[1.59]*	**[4.05]*****	**[3.39]*****	**[4.09]*****
lnθ	**0.691**	**0.754**	**0.756**	**0.522**
	[162.66] ***	**[185.01]*****	**[183.23]*****	**[143.50]*****
ln $\bar{K}$	**0.053**	**0.041**	**0.041**	**0.022**
	[7.41]***	**[5.99]*****	**[5.98]*****	**[3.01]*****
ln K		0.646	0.646	0.625
		[141.33] ***	[139.70]***	[130.22]***
RCD		-0.000	-0.000	-0.000
		[0.45]	[0.42]	[0.73]
RInv		-0.016	-0.015	-0.033
		[6.04]***	[5.63]***	[12.10]***
RP		-0.017	-0.017	-0.024
		[3.61]***	[3.42]***	[4.81]***
DF		-0.019	-0.023	-0.023
		[1.07]	[1.26]	[1.23]
SC		0.047	0.047	0.030
		[2.84]***	[2.79]***	[1.74] *
lnUGdp			-0.105	-0.122
			[6.88]***	[7.72]***
lnUPop			0.006	0.014
			[0.57]	[1.25]
lnUW			0.029	0.066
			[1.31]	[2.85]***
lnUE			0.170	0.179
			[10.34]***	[10.50]***
TimeDum	Yes	Yes	Yes	Yes
Const	7.118	1.179	0.782	1.750
	[36.33]***	[6.21]***	[2.87]***	[6.19]***

Obs	263215	262227	258515	258515
R2̂	0.22	0.31	0.32	0.26

Note: The value in "[]" is the "t-statistics" of the corresponding estimated value. "***", "**", "*" represent, respectively, that the corresponding estimated value are significant at 1%, 5% and 10%, respectively.