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Firm Heterogeneity, Asymmetric Cost and Regional Disparity

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Abstract

This paper explores the effects of international trade with the rest of the world on Chinese regional income disparity within the standard model of product differentiation and heterogeneity in firm productivities. Other things equal, the difference of entry cost results income disparity between regions in both autarky and open economy. When domestic intraregional transport cost between regions is relative low, the same amount of entry cost difference results a wider regional income gap in open economy than that of autarky; and the openness in terms of export over aggregate revenue in the region with a relative lower entry cost is larger than that of the region with a higher entry cost. The extension of different international transportation costs does not change the basic results but exacerbate the productivity disparity between two regions. These results match the facts in Chinese economy well.

Keywords: Firm heterogeneity; Firm exports; Income disparity

JEL classification: F12; F43; L11; O53

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1. Introduction

Regional disparity in income per labor is widely explored by researchers in the traditional approach of investigating the differences in technology and factors of aggregate production function. This paper takes a different approach by focusing on a microeconomic channel that emphasizes the aggregate productivity effects of international trade through the reallocation of production across heterogeneous firms within industries.

The motivation of this research is that the regional income disparity in China has been widening since the Chinese reform and open-door policy in 1978. This paper explains regional income disparity within Melitz's (2003) model of product differentiation and heterogeneity in firm productivities. We find that other things equal, the difference of entry cost results income disparity between regions in both autarky and open economy. Furthermore, when domestic intraregional transport cost between regions is relative low, the same amount of entry cost difference results a wider regional income gap in open economy than that of autarky; and the openness in terms of export over aggregate revenue in the region with a relative lower entry cost is larger than that of the region with a higher entry cost. These results match the facts in Chinese economy well. In this paper we assume that the entry cost is exogenous. However, we will describe some facts below related to the regional difference of entry cost in China.

Policy Difference Chinese economic reform means abandoning the closed-door policy, invigorating the domestic economy and opening to the rest of the world. In the beginning of the open policy, the east coastal provinces had advantage of lots of preferential policies to promote trade with the rest of the world. All preferential policies were limited within the special east coastal cities and provinces. At the same time the west and inland provinces did not have any such policy for more than a decade. "Only in the 1990's, as the population became more optimistic about the reform, was a more balanced strategy of investment between coastal and inland areas adopted" (Litwack and Qian, 1998). For example, beginning in 1979, China central government gave "special policies and flexible measures" to east coastal provinces such as Guangdong and Fujian to encourage trade with the rest of the world especially through Hong Kong, Macau and Taiwan. Four Special Economic Zones (SEZs) were established in 1979, among them three in Guangdong Province

— Shenzhen city (adjacent to Hong Kong), Zhuhai city (adjacent to Macau) and Shantou city (facing toward Taiwan) and one in Fujian Province — Xiamen city (facing toward Taiwan). In 1984, other 14 port cities in 8 coastal provinces were granted similar special privileges to encourage trade and absorb foreign investment. In 1988, Hainan Island which was belong to Guangzhou Province was granted as a new province and the largest SEZ. In 1990, Pudong was established as a new special economic development district in Shanghai. “In the SEZs, local governments had considerable latitude to grant special privileges to exporting firms such as the right to import their intermediate inputs without duty, as well as the right to retain some or all of the resulting foreign exchange earnings” (Jian, Sachs and Warner, 1996). “These regions gained considerable autonomy, enjoyed preferential tax treatment, and received relatively high levels of resources” (Litwack and Qian, 1998).

Market Environment Difference At the same time, China experienced a similar gradualism transition from a planned to a market economy. “Not only did these areas [SEZs] enjoy lower tax rates, but, more important, they enjoyed special institutional and policy environments and gained more authority over economic development. Although the rest of China was still dominated by central planning and public ownership, special economic zones were allowed to become market economies dominated by private ownership” (Qian and Weingast, 1996). The east coastal provinces gradually constructed much better market environment than west and inland provinces. Market barriers and investment thresholds decreased substantially in east coastal provinces. Moreover, the interaction with the rest of the world benefits east coastal provinces not only by physical goods or foreign investment but also by adopting advanced market mechanism, ideas, and rules from the rest of the world. The important effect of international flows of ideas and rules has recently been emphasized by Romer (2010).

Even the Chinese central government gradually pushed the preferential policy to the inland and west provinces from the 1990’s, the advantage of market-oriented reform in east coastal provinces is still persistent. For instance, in the year of 2008, the number of registered firms with foreign investment in 11 east coastal provinces is 350,767, or 80.7 percents of total number in the whole country, which brings a mass of foreign investment of 1901.5 billion dollars, or 84.1 percents of total foreign investment in the whole country; the counterpart number of registered firms with foreign investment in 11 western provinces is 33,407, only 7.7 percents of total

number in the whole country, with a mass of foreign investment of 137.5 billion dollars which is 6.1 percents of total foreign investment.¹ (Data source: China Statistical Yearbook 2009). This implies that the firm entry cost in east coastal provinces is much lower than that of west inland provinces.

Firm Heterogeneity in Data Recent empirical literature suggests that there is great heterogeneity in Chinese firms. Manova and Zhang (2009a) use newly available data on Chinese trade flows to confirm existing stylized facts about firm heterogeneity in trade, and show that firm heterogeneity is central to understanding movements in aggregate trade flows. Manova and Zhang (2009b) use new customs data on the universe of Chinese trading firms to infer the relative importance of production efficiency and product quality for firms' export success. Their findings add additional dimensions of firm heterogeneity than before.

Related Literature Bernard, Eaton, Jensen and Kortum (2003) and Melitz (2003) develop firm heterogeneity models of intra-industry trade that provides substantial insights into the stylized facts of exporting firms.² For instance, these facts suggest that exporting firms are more productive, earn more revenue than non-exporting firms, even in their domestic markets. Helpman, Melitz and Yeaple (2004), Arkolakis (2008), Chaney (2008), Eaton, Kortum and Kramartz (2010) are related developments of the models. Yeaple (2004) presents a model that is consistent with these facts where firm heterogeneity comes from the interaction between trade costs and worker heterogeneity.

Some literature investigates the relationship between trade and income using models of firm heterogeneity. Goksel (2008) develops a heterogeneity firm model to show that the income differences across trade partners act as trade barriers and are key determinant of trade patterns. Baldwin and Robert-Nicoud (2008) explores the growth effects of trade when firms are heterogeneous and finds that freer trade has an ambiguous impact on growth. Gustafsson and Segerstrom (2010), Haruyama and Zhao (2008), and Unel (2010) study the effects of trade on technology progress and spillovers.

Another recent literature including Costinot and Vogel (2010), Davis and Harrigan (2007), Amiti and Davis (2008), Helpman, Itskhoki, and Redding (2010),

¹The 11 east coastal provinces are: Beijing, Tianjin, Liaoning, Shandong, Hebei, Jiangsu, Zhejiang, Shanghai, Fujian, Guangdong, Hainan. The 11 western provinces are: Chongqing, Sichuan, Guangxi, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang.

²Tybout (2003) and Bernard, Jensen, Redding, and Schott (2007) are recent surveys.

Sethupathy (2008), Egger and Kreickemeier (2009), and Davidson, Matusz, and Shevchenko (2008), studies the impact of trade on wage inequality. Costinot and Vogel’s (2010) model can explain the rise of inequality across countries after free trade when there is global skill-biased technological change. However, most of this literature does not focus on the effects of trade on regional income disparity, which is the main focus of this paper.

The remainder of the paper is structured as follows. Section 2 sets up the model under autarkic domestic intraregional trade. Section 3 introduces international trade into the model. Section 4 compares the effect of different entry cost between regions on the regional income disparity under autarky with that of open economy. Section 5 offers extension of the results by considering the different international trade transport costs. This realistic extension leaves the basic results unchanged but exacerbates the regional productivity gap. Section 6 concludes.

2. Autarkic Domestic Intraregional Trade

In this section we only consider domestic intraregional trade in an autarkic country C. A small open economy trade with the rest of the world will be introduced in the next section. Since the models with representative firms like Krugman (1980) can’t explain the differences in regional openness indices, where all firms have the same export status regardless of trade cost, our model is based on Melitz (2003) directly.

2.1. The Basic Setup

There are two regions each with L identical labors in country C. Labors are immobile across regions.³ These two regions 1 and 2 are symmetric except the entry cost f_{ei} , (regional index $i = 1, 2$), which is exogenous determined by central government of the country. (We will not model the behavior of the central government of the country in this paper.) We will relax the assumption of identical iceberg transport cost with the rest of the world.

The preferences of an agent are given by a CES utility function with an elasticity of substitution $\sigma > 1$ over a continuum of goods ξ , with the associated aggregate

³As Au and Henderson (2006) (and reference therein) describe that China strongly restricts internal migration of its population between regions through the hukou system, which is similar to an internal passport system in China.

price index defined over prices of goods $p(\xi)$:

$$U_i = \left(\int_{\xi \in \Xi_i} q_i(\xi)^{\frac{\sigma-1}{\sigma}} d\xi \right)^{\frac{\sigma}{\sigma-1}}, \quad P_i = \left(\int_{\xi \in \Xi_i} p_i(\xi)^{1-\sigma} d\xi \right)^{\frac{1}{1-\sigma}},$$

where Ξ_i is the mass of available goods in region i . The optimal consumption and expenditure for any goods is $q_i(\xi) = R_i p_i(\varphi)^{-\sigma} P_i^{\sigma-1}$, where R_i is aggregate expenditure in region i .

Each firm must pay an sunk entry cost f_{ei} to enter the market to produce a different variety ξ . Then an entrant will draw a productivity coefficient φ from a common distribution $G(\varphi)$. We assume this common distribution is Pareto,⁴ $G(\varphi) = 1 - \left(\frac{b}{\varphi}\right)^\theta$, where $\varphi > b$, $b > 0$ is the minimum productivity value; $\theta > 0$ is a shape parameter, with $\theta > \sigma - 1$. The productivity of a firm is constant after it is known. Firms with the same productivity behave symmetrically in equilibrium, thus we index firms by θ from now onwards.

Labor is the only factor of production of output. A firm will pay additional common fixed f units of labor cost to produce any output q . The cost function is $(f + \frac{q}{\varphi})w_i$, where w_i is the wage in region i . A firm is the only producer of one variety and engages in monopolistic competition with others. A producer from one region can sell its goods to the other region without extra fixed cost, but it has to pay per-unit variable trade cost $\tau \geq 1$, a standard iceberg form. The assumption of no extra fixed cost to sell in the other region in the same country is plausible. Since the marketing effort such as advertising on TV or newspaper in one region is easy to cover the other region without obstacle. And a consumer in one region could order the product directly from a firm in the other region, only need to pay some transport cost. In other words, region 1 and region 2 are in the same country, there should be no tariff or law that can prevent the flows of goods between the regions other than the variable cost.

In this case, the available product variety is same in the two regions, but the prices are different due to the transport cost. A firm with productivity φ from region i sells its product to region j with price $p_{ij}(\varphi)$, a constant markup over marginal cost, and gets revenue $r_{ij}(\varphi)$. For the time being we only consider the case of region

⁴Gabaix (2009) surveys theory and empirics on power laws in economics, Luttmer (2010) surveys general equilibrium models on Pareto distribution of firm size.

1 for that of region 2 is similar. The prices and revenues of a firm from region 1 are:

$$p_{11}(\varphi) = \frac{\sigma}{\sigma - 1} \frac{w_1}{\varphi}, \quad p_{12}(\varphi) = \frac{\sigma}{\sigma - 1} \frac{w_1 \tau}{\varphi}, \quad (1)$$

$$r_{11}(\varphi) = w_1 L \left(\frac{p_{11}(\varphi)}{P_1} \right)^{1-\sigma}, \quad r_{12}(\varphi) = w_2 L \left(\frac{p_{12}(\varphi)}{P_2} \right)^{1-\sigma}. \quad (2)$$

The firm's total domestic revenue is:

$$r_{1d}(\varphi) = r_{11}(\varphi) + r_{12}(\varphi) = \left(1 + \frac{w_2}{w_1} \left(\frac{P_1}{P_2} \right)^{1-\sigma} \tau^{1-\sigma} \right) r_{11}. \quad (3)$$

And its total profit is $\pi_{1d}(\varphi) = \frac{r_{1d}(\varphi)}{\sigma} - f w_1$. It is clear that a firm's revenue and profit are increasing in its productivity φ . A firm exits when its profit is negative. This defines a **zero-profit productivity cut-off** φ_{1d}^* with $r_{1d}(\varphi_{1d}^*) = \sigma f w_1$. An entrant drawing productivity below the threshold exits immediately without producing any product. Only firms drawing productivity above φ_{1d}^* produce for the two regional markets. Since there is no fixed cost needed for a firm to sell from one region to the other region, all firms sell in one region will sell to the other region at same time. This implies that the thresholds relationships are $\varphi_{1d}^* = \varphi_{11}^* = \varphi_{12}^*$ and $\varphi_{2d}^* = \varphi_{21}^* = \varphi_{22}^*$.

The average productivity above threshold φ_{1d}^* is:

$$\tilde{\varphi}_{1d}(\varphi_{1d}^*) = \left[\frac{1}{1 - G(\varphi_{1d}^*)} \int_{\varphi_{1d}^*}^{\infty} \varphi^{1-\sigma} g(\varphi) d\varphi \right]^{\frac{1}{1-\sigma}}. \quad (4)$$

From the Pareto distribution we know that:

$$k = \left(\frac{\tilde{\varphi}_{1d}}{\varphi_{1d}^*} \right)^{\sigma-1} = \frac{\theta}{\theta - \sigma + 1}. \quad (5)$$

This property about Pareto distribution suggests that the ratio of average productivity to the threshold is a constant determined by the shape parameter θ and elasticity of substitution between varieties σ . The expected revenue and profit from entry are given by, $\bar{r}_{1d}(\tilde{\varphi}_{1d}) = k \sigma f w_1$ and $\bar{\pi}_{1d}(\tilde{\varphi}_{1d}) = (k - 1) f w_1$.

There are unbounded potential entrants, and the free entry is balanced by the

sunk entry cost. All firms have a common exogenous rate of death δ . In equilibrium the expected profit will be zero:

$$\frac{[1 - G(\varphi_{1d}^*)]\bar{\pi}_{1d}}{\delta} - f_{e1}w_1 = 0. \quad (6)$$

As in Bernard, Redding and Schott (2007), the **free entry condition** and the **zero-profit condition** imply that the threshold productivity φ_{1d}^* is pinned down uniquely,

$$\frac{b^\theta}{\varphi_{1d}^*{}^\theta} f(k-1) = \delta f_{e1}. \quad (7)$$

The threshold productivity φ_{1d}^* is determined by the exogenous parameters of the model. It is decreasing in entry cost f_{e1} . Higher entry cost implies that the expected value of entry, the ex-ante probability of successful entry multiplied by the expected profitability of operation until death, must be higher in units of labor cost. Since the expected profitability from successful entry $\bar{\pi}_{1d}$ is a constant of $(k-1)f$ in units of labor cost, the ex-ante probability of successful entry $1 - G(\varphi_{1d}^*)$ in equation (6) must be higher, which suggests that the threshold productivity φ_{1d}^* must be lower.

In equilibrium the aggregate revenue of region 1, R_1 , is the total wage revenue Lw_1 since the inelastic supply of labor. And the mass of success entrants is balanced by the mass of exogenous death firms. The mass of active firms in region 1, M_1 , is constant, $M_1 = \frac{R_1}{\bar{r}_{1d}(\tilde{\varphi}_{1d})} = \frac{L}{k\sigma f}$. The case of region 2 is similar. Thus the price index in region 1 is:

$$P_1^{1-\sigma} = M_1 p_{11}(\tilde{\varphi}_{1d})^{1-\sigma} + M_2 p_{21}(\tilde{\varphi}_{2d})^{1-\sigma} \quad (8)$$

The welfare per labor in region 1 is $\omega_1 = \frac{w_1}{P_1}$.

The intraregional trade balance condition between region 1 and region 2 is $M_1 \bar{r}_{12}(\tilde{\varphi}_{1d}) = M_2 \bar{r}_{21}(\tilde{\varphi}_{2d})$. That is, total sales to one region from the other are equal.

2.2. Properties of Autarkic Domestic Intraregional Trade

After setting up the basic framework, we can analysis the properties of the autarkic domestic intraregional trade between two regions in country C. Our main interest is

the effect of the change of entry cost of one region, f_{e1} , on the changes of productivity and welfare in both regions. We assume that the two regions in country C are symmetric except for entry cost. When region 1 gets an exogenous preferential policy from the central government, which is unmodeled in the present paper, its entry cost decreases, i.e., $f_{e1} < f_{e2}$. Then we could get the following results, proofs are in the appendix:

Lemma 1 *In the autarkic domestic intraregional trade environment, the productivity threshold in one region is independent to the cost parameters in the other region.*

From equation (7) we know that φ_{1d}^* is not related to the cost parameters of region 2, and vice versa. The firm with zero-profit cut-off productivity gets revenue of σf units of labor cost, and the firm with average productivity $\tilde{\varphi}_{id}$ gets revenue of $k\sigma f$ with a constant profit of $(k-1)\sigma f$ units of labor cost. Therefore the expected value of entry in one region balanced by its own entry cost implies that the cost parameters of one region have no effect on the productivity threshold in the other region. The intuition is that, when entry cost in region 1 decreases, more entry is induced and the wage in region 1 is bid up. Accordingly, the aggregated revenue w_1L and average productivity of firms from region 1 increase, while the price indices in both regions decrease. This results two opposite effects on firms from region 2: **market potential effect** and **market competition effect**. Each firm from region 2 earns lower revenue from region 2 because of competition of firms with more productivity from region 1. At the same time, each of them gets larger revenue from region 1 due to a larger aggregated revenue w_1L . These two effects cancel each other out. Therefore, the survival productivity threshold in region 2 remains unchanged when f_{e1} changes.

Lemma 1 suggests that the policy in one region does not influence the firm productivity in the other region. That is, when one region has a better policy to enhance its own firms' productivity, the average productivity of firms in the other region can't benefit from that better policy.⁵ This is not the case in the next section when regions trade with the rest of world. Since the prices of a product imported from the rest of the world are same in both regions due to identical international

⁵As we will show below, welfare in one region does benefit from better policy in the other region.

transport costs, region 2 is at a disadvantage with a higher entry cost than that of region 1.

Proposition 1 Region 1 vs. Region 2 in Autarky *In the autarkic intraregional trade environment, other things equal, if entry cost in region 1 decreases, $f_{e1} < f_{e2}$, then*

1. *Region 1 has a higher survival productivity, higher average productivity, higher wage, and larger average size (revenue) of firms than that of region 2: $\varphi_{1d}^* > \varphi_{2d}^*$, $\tilde{\varphi}_{1d} > \tilde{\varphi}_{2d}$, $w_1 > w_2$, $\bar{r}_{1d}(\tilde{\varphi}_{1d}) > \bar{r}_{2d}(\tilde{\varphi}_{2d})$;*
2. *Both regions have higher welfare per labor than before, however, the welfare gain in region 1 is larger than that of region 2: $\omega_1 > \omega_2$;*
3. *Welfare in both regions are decreasing in the transport cost, τ , the welfare gap between two regions, $\frac{\omega_1}{\omega_2}$, as well as wage gap, $\frac{w_1}{w_2}$ is increasing in the transport cost.*

If $f_{e1} = f_{e2}$, the two regions are identical, the wage per labor, average size per firm, the average productivity and welfare per labor are equalized. When f_{e1} is lowered exogenously while f_{e2} remains unchanged, there are more potential entrants in region 1 than that of region 2, the competition for labor raises the wage in region 1. The revenue of firms at margin level can not cover their cost since the rise of wage, hence the firms exit the market when they no longer make profit. Therefore the threshold productivity in region 1 increases and the average productivity increases proportionally. The average revenue and the average profit of firms in region 1 become larger due to the relative high wage than that of region 2.

The welfare per labor is wage over price index. The decrease of f_{e1} raises the threshold productivity and average productivity of firms from region 1, but wage in region 1 rises proportionally short of the increase of the threshold productivity (see the proof in the Appendix), thus the price indices P_1 and P_2 decrease. Consequently, the welfare per labor in two regions are both higher after the decrease of f_{e1} . Moreover, the price index P_1 is lower than P_2 , and the wage in region 1 is relative higher than that in region 2 as shown above. Therefore, the welfare gain per labor in region 1 is higher than that of region 2. Proposition 1 suggests that the aggregate income and productivity gaps between two regions are the results of the

entry cost disparity. The lower the entry cost in a region, the higher the income and productivity in that region. Although the policy in one region does not influence the firm productivity in the other region as shown in Lemma 1, the decrease of entry cost in one region does benefit labor's welfare not only in local region but also in the other region through intraregional trade. However, the direct welfare gain through the increase of wage and productivity in region 1 is larger than the indirect welfare gain in region 2 through the decrease of price index.

The third point in Proposition 1 is the welfare gains from trade. It says that if the transport cost rises, or the market segregation increases in two regions, then both regions have a welfare loss and the welfare gap between them becomes larger. On the contrary, welfare enhances in both regions and their welfare gap decreases when they become more integration due to the smaller trade cost. Although their welfare gap does not vanish even there is no transport cost, i.e. $\tau = 1$, because of different entry costs in two regions, the less friction of two regions the closer becomes their welfare. In other words, there is a trend of welfare equalization to some extent between regions with higher regional integration.

Corollary 1 Home Market Share *In the autarkic intraregional trade environment, other things equal, except $f_{e1} < f_{e2}$, then the home market share of firms from region 1 is greater than that of firms from region 2, $\frac{M_1 \bar{r}_{11}(\bar{\varphi}_{1d})}{R_1} > \frac{M_2 \bar{r}_{22}(\bar{\varphi}_{2d})}{R_2}$.*

When f_{e1} decreases, there are more entrants in region 1, wage is raised by the fiercer competition for labor, the aggregate revenue rises proportionally to the wage. Then there are two effects. One is the *income effect in region 1*: as the aggregate revenue increases, labor in region 1 will consume more of each product from both regions than before. The other is the *substitution effect in both regions*: since the average price of products from region 1 is lower than that of region 2, labor in both regions consume more of each product from region 1 to substitute that with relative high price from region 2. In other words, while labor love variety, they demand more products with higher productivity (quality) than that with lower productivity (quality).⁶ As a result, *in region 1*, the average consumption of products from region 2 increases proportionally short of the rise of the average consumption of products

⁶ Arkolakis, Demidova, Klenow, and Rodríguez-Clare (2008) emphasize a similar effect of relative change of productivities on consumers' welfare. Arkolakis, Costinot and Rodríguez-Clare (2009) compare the gains from trade with different models.

from region 1; *in region 2*, the average consumption of products from region 1 increases while the average consumption of products from region 2 decreases.⁷ The net effect is therefore an increase of expenditure share on products from region 1 of aggregate revenue in region 1, and decrease of expenditure share on products from region 2 of aggregate revenue in region 2. That's to say, the home market share of firms from region 1 is greater than that of firms from region 2, $\frac{M_1 \bar{r}_{11}(\bar{\varphi}_{1d})}{R_1} > \frac{M_2 \bar{r}_{22}(\bar{\varphi}_{2d})}{R_2}$. The lower entry cost in region 1, the higher aggregate revenue of region 1, the larger the home market share of firms in region 1, and the smaller the home market share of firms in region 2.

3. Open to the Rest of the World

In this section we let the country C open to the rest of the world, firms in two regions of the country can trade with the rest of the world and make domestic intraregional trade simultaneously. After drawing productivity parameter φ , firms decide whether to export or not. If a firm decide to sell its product to the rest of the world, then it must pay fixed exporting cost f_x in units of labor in the rest of the world in each period as in Arkolakis, Costas, Demidova, Klenow and Rodríguez-Clare (2008). The fixed export cost f_x and iceberg international trade cost $\tau_x > 1$ are common in two regions. The difference between domestic intraregional trade and international trade is whether there is fixed export cost; while a firm need not require any extra fixed cost to sell in the other domestic region, it must incur fixed export cost f_x to sell in the world market in addition to the fixed production cost f .

The product price of a firm from region i export to the world market is $p_{ix}(\varphi)$, and revenue is $r_{ix}(\varphi)$. Again, let's focus on firms from region 1 at present; the case of region 2 is similar. A firm from region 1 selling in the rest of the world sets price $p_{1x}(\varphi) = \frac{\sigma}{\sigma-1} \frac{w_1 \tau_x}{\varphi}$ and gets revenue $r_{1x}(\varphi) = A(p_{1x}(\varphi))^{1-\sigma}$, where A is an exogenously constant that remains unaffected by country C as does in Demidova and Rodríguez-Clare (2009).⁸ The domestic profit (including profits from selling

⁷The increase in region 1 and the decrease in region 2 of the average consumption of products from region 2 cancel each other out as shown in Lemma 1, thus the aggregate revenue of region 2, $w_2 L$, remains unchanged in autarkic domestic intraregional trade environment.

⁸Antràs and Staiger (2010) study the trade agreements in the presence of offshoring using a two-small-country trade model.

to region 1 and region 2) of a firm from region 1 is $\pi_{1d}(\varphi) = \frac{r_{1d}(\varphi)}{\sigma} - fw_1$, where $r_{1d}(\varphi) = r_{11}(\varphi) + r_{12}(\varphi)$, and the export profit is $\pi_{1x}(\varphi) = \frac{r_{1x}(\varphi)}{\sigma} - f_x w_1$. Since revenue and profit are increasing in productivity φ , **zero-profit conditions** result two productivity cutoffs, φ_{1d}^* and φ_{1x}^* , which sort the firms into exit, domestic selling, and export. The latter is greater than the former in accordance to the empirical evidence. Firms drawing a productivity below φ_{1d}^* exit immediately otherwise they will incur loss for any produce; only firms with productivity above φ_{1d}^* produce for the domestic market; firms lucky enough with productivity above φ_{1d}^* not only produce for the domestic market but also export to the rest of the world.

From the zero-profit conditions in domestic and export markets, the two productivity thresholds are:

$$\varphi_{1d}^{*\sigma-1} = \frac{\sigma f \left(\frac{\sigma}{\sigma-1} w_1\right)^{\sigma-1}}{L \left(P_1^{\sigma-1} + \left(\frac{w_2}{w_1}\right) P_2^{\sigma-1} \tau^{1-\sigma} \right)}, \quad \varphi_{1x}^{*\sigma-1} = \frac{\sigma f_x w}{A \left(\frac{\sigma}{\sigma-1} w_1 \tau_x\right)^{1-\sigma}}. \quad (9)$$

where w is the exogenous wage in the rest of the world. The equations above suggest that the survival productivity φ_{1d}^* is related to the relative wage and relative price indices between two regions. And the export productivity φ_{1x}^* is increasing proportionally in the wage in region 1.

Let $H_1 = \frac{\varphi_{1x}^*}{\varphi_{1d}^*}$ denotes the ratio of export productivity threshold to survival productivity threshold in region 1. The ex-ante probability of exporting conditional on successful entry in the Pareto distribution is $H_1^{-\theta} = \frac{1-G(\varphi_{1x}^*)}{1-G(\varphi_{1d}^*)}$. H_1 can be rewritten from equation (9) as:

$$H_1^{\sigma-1} = \frac{f_x w L}{A f \tau_x^{1-\sigma}} \left(P_1^{\sigma-1} + \left(\frac{w_2}{w_1}\right) P_2^{\sigma-1} \tau^{1-\sigma} \right). \quad (10)$$

The ex-ante expect revenue of entry in region 1 is the average revenue from domestic sales and the average revenue from exporting times the probability of exporting,

$$\bar{r}_1(\tilde{\varphi}_{1d}) = k\sigma f w_1 + H_1^{-\theta} k\sigma f_x w, \quad (11)$$

where $\tilde{\varphi}_{1d}$ is the ex-post average productivity of active firms from region 1 as in

equation (4). The ex-ante expected profit of entry in region 1 is thus:

$$\bar{\pi}_1(\tilde{\varphi}_{1d}) = (k-1)fw_1 + H_1^{-\theta}(k-1)f_xw. \quad (12)$$

In equilibrium the mass of active firms from region 1 is,

$$M_1 = \frac{R_1}{\bar{r}_1(\tilde{\varphi}_{1d})} = \frac{w_1L}{k\sigma fw_1 + H_1^{-\theta}k\sigma f_xw}. \quad (13)$$

As in the autarkic intraregional trade case, there are potential unbounded entrants, the expected profit of entry is zero: $\frac{[1-G(\varphi_{1d}^*)]\bar{\pi}_{1d}}{\delta} - f_{e1}w_1 = 0$. Combining the **free entry condition** with the **zero-profit condition**, we can get the function below:

$$\frac{b^\theta}{\varphi_{1d}^{*\theta}} \left[f + H_1^{-\theta} f_x \frac{w}{w_1} \right] (k-1) = \delta f_{e1}. \quad (14)$$

Firms from **the rest of the world** are similar to that at domestic regions. They draw productivity parameter φ from the Pareto distribution identical to that of country C. They have to pay a fixed exporting cost of labor input F to sell in country C. After paying the fixed exporting cost F , a firm can sell its product in region 1 or region 2, or both in the country C. That is to say, a firm from the rest of the world who wants to export to country C only needs to pay one fixed exporting cost each period, whichever regions it decides to enter. This assumption is accordance with the assumption of no extra fixed cost except the variable transportation cost to sell from one region to the other in the autarkic domestic intraregional trade. Therefore, when a firm from the rest of the world decides to export to the country C, it will sell in both regions. The variable cost from the rest of the world to each region is symmetric iceberg transport cost, τ_x , which is greater than 1.

The prices of products from the rest of the world exported to region 1 and 2 are equal due to the identical transport cost:

$$p_{x1}(\varphi) = p_{x2}(\varphi) = \frac{\sigma}{\sigma-1} \frac{w\tau_x}{\varphi}. \quad (15)$$

The revenues from sales in region 1 and region 2 are $r_{x1}(\varphi)$ and $r_{x2}(\varphi)$ respectively:

$$r_{x1}(\varphi) = w_1 L \left(\frac{p_{x1}(\varphi)}{P_1} \right)^{1-\sigma}, \quad r_{x2}(\varphi) = w_2 L \left(\frac{p_{x2}(\varphi)}{P_2} \right)^{1-\sigma}. \quad (16)$$

The total exporting revenues $r_x(\varphi)$ of a firm from the rest of the world are $r_x(\varphi) = r_{x1}(\varphi) + r_{x2}(\varphi)$. The export productivity threshold for firms from the rest of the world, φ_x^* , is determined by **zero-profit productivity condition**, $r_x(\varphi_x^*) = \sigma F$:

$$\varphi_x^{*\sigma-1} = \frac{\sigma F}{(w_1 L P_1^{\sigma-1} \tau_x^{1-\sigma} + w_2 L P_2^{\sigma-1} \tau_x^{1-\sigma}) \left(\frac{\sigma w}{\sigma-1} \right)^{1-\sigma}}. \quad (17)$$

Assume the mass of active firms from the rest of the world, M , which is normalized to 1, is exogenous and not affected by the country C as in Demidova and Rodríguez-Clare (2009). Then the mass of firms who can export to the country C, M_x , is: $M_x = \frac{b^\theta}{\varphi_x^{*\theta}}$. Thus, the price index in region 1 and region 2 can be rewritten as,

$$\begin{aligned} P_1^{1-\sigma} &= M_1 p_{11}(\tilde{\varphi}_{1d})^{1-\sigma} + M_2 p_{21}(\tilde{\varphi}_{2d})^{1-\sigma} + M_x p_{x1}(\tilde{\varphi}_x)^{1-\sigma}, \\ P_2^{1-\sigma} &= M_1 p_{12}(\tilde{\varphi}_{1d})^{1-\sigma} + M_2 p_{22}(\tilde{\varphi}_{2d})^{1-\sigma} + M_x p_{x2}(\tilde{\varphi}_x)^{1-\sigma}, \end{aligned} \quad (18)$$

where $\tilde{\varphi}_x$ defined as in equation (4), is the ex-post average productivity of firms from the rest of the world who export to country C.

In equilibrium, the total export revenues earned by firms from region 1, or total sales from region 1 to region 2 plus export to the rest of the world, must be equal to the value of imports from the rest of the world plus the value from region 2. This relationship is also hold for firms from region 2. The **trade balance conditions** for region 1 and region 2 respectively can be written as:

$$\begin{aligned} &M_1 w_2 L \left(\frac{p_{12}(\tilde{\varphi}_{1d})}{P_2} \right)^{1-\sigma} + H_1^{-\theta} M_1 A (p_{1x}(\tilde{\varphi}_{1x}))^{1-\sigma} \\ &= M_2 w_1 L \left(\frac{p_{21}(\tilde{\varphi}_{2d})}{P_1} \right)^{1-\sigma} + M_x w_1 L \left(\frac{p_x(\tilde{\varphi}_x)}{P_1} \right)^{1-\sigma}, \end{aligned} \quad (19)$$

and

$$\begin{aligned}
& M_2 w_1 L \left(\frac{p_{21}(\tilde{\varphi}_{2d})}{P_1} \right)^{1-\sigma} + H_2^{-\theta} M_2 A (p_{2x}(\tilde{\varphi}_{2x}))^{1-\sigma} \\
& = M_1 w_2 L \left(\frac{p_{12}(\tilde{\varphi}_{1d})}{P_2} \right)^{1-\sigma} + M_x w_2 L \left(\frac{p_x(\tilde{\varphi}_x)}{P_2} \right)^{1-\sigma}.
\end{aligned} \tag{20}$$

Proposition 2 Unique Equilibrium *When the country is open to trade with the rest of the world, there is a unique trade equilibrium referenced by the equilibrium vectors, $\{\varphi_{1d}^*, \varphi_{1x}^*, \varphi_{2d}^*, \varphi_{2x}^*, \varphi_x^*, P_1, P_2, w_1, w_2\}$.*

4. Properties of Open Economy

In this section, we derive a number of results concerning the effects of international trade with the rest of the world on the productivity and welfare gap between two regions in country C.

Lemma 2 *In the open economy environment, the productivity threshold in one region is related to the cost parameters in the other region.*

The survival and exporting threshold productivities in region 1 are connected by H_1 in the equation (14). We know from equation (10) that H_1 is related to the relative wage, $\frac{w_2}{w_1}$, and price indices of region 1 and region 2, P_1 and P_2 , which are determined by the prices of all available product variety including that from region 2 and from the rest of the world. The aggregate revenue, $w_1 L$, increasing in the decrease of entry cost in region 1, induces more entrants of firms from the rest of the world that can sell in both regions. Moreover, the prices of a product imported from the rest of the world are same in both regions due to identical international transport costs, region 2 is at a disadvantage with a higher entry cost than that of region 1. Thus, as in the case of autarkic intraregional trade, when entry cost in region 1 decreases, each firm from region 2 earns lower revenue from region 2 because of competition of firms with more productivity from region 1; and, each of them gets larger revenue from region 1 due to a larger aggregated revenue, $w_1 L$. However, these two effects cannot cancel each other out due to the existence of the importing products from the rest of the world. Lemma 2 is a contrary counterpart

to the Lemma 1 in the autarkic intraregional trade environment. Lemma 2 suggests that open to the rest of the world results a link, through which productivity in one region is related to the policy in the other region in the international trade environment.

Proposition 3 Autarky vs. Open *After open to the rest of the world, both regions have higher survival productivity threshold, higher average productivity, higher average revenue, higher welfare, and lower number of firms than that in autarkic domestic intraregional trade.*

Proposition 3 compares both regions in autarky with themselves in open economy. The results of Proposition 3 show the basic gains from international trade. After the country C is open to the rest of the world, the average revenue in units of labor wage from domestic markets (including region 1 and region 2) is $k\sigma f$, which is same to the case of autarky. Moreover, $H_i^{-\theta}$ fraction of all active firms from each region earn average revenue of $k\sigma fw$ from export, which is the average revenue gains from international trade. Hence, the average revenue from domestic and export is larger than before. Comparing equation (14) to equation (7), we can find that there is an additional term reflecting the expected profits from exporting to the rest of the world in equation (14). This induces more labor demand by the more productivity firms who have new exporting profit opportunities. Thus the wage in both regions is raised up. At the same time, entry of firms from the rest of the world competes for domestic markets. The least productivity firms cannot survive any more and exit thereafter. Therefore the survival productivity threshold increases, so does the average productivity proportionally. The rise of average productivity and the entry of variety from the rest of the world improve the labor's welfare of both regions in the country C. The number of active firms from each region decreases in the rise of average revenue per firm. However, the total variety, which is same in both regions, could be larger than, equal to, or smaller than that of autarky.⁹

⁹When two regions are symmetric, if fixed export cost of firms from the rest of the world, $F <, =, \text{ or } > w_1f$, the total variety in each region in open economy is larger than, equal to, or smaller than that in autarky respectively. When $f_{e1} < f_{e2}$, if $F > w_1f$, the total variety in each region in open economy is smaller than that in autarky; if $F < w_2f$, the total variety is larger than that in autarky. As Arkolakis, Demidova, Klenow, and Rodríguez-Clare (2008), Baldwin and Forslid (2010), Bernard, Redding and Schott (2007) and Melitz (2003) among others point out that the welfare effect of possible changes of total variety with trade is dominated by the productivity gain.

Proposition 4 Region 1 vs. Region 2 in Open Economy *Other things equal after open to the rest of the world, if entry cost in region 1 decreases, $f_{e1} < f_{e2}$, then*

1. *Region 1 has a higher wage, higher average productivity, higher average exporting productivity, and larger average size (revenue) of firms than region 2: $w_1 > w_2$, $\tilde{\varphi}_{1d} > \tilde{\varphi}_{2d}$, $\tilde{\varphi}_{1x} > \tilde{\varphi}_{2x}$, and $\bar{r}_{1d}(\tilde{\varphi}_{1d}) > \bar{r}_{2d}(\tilde{\varphi}_{2d})$;*
2. *The fraction of firms who export is higher in region 1: $H_1^{-\theta} < H_2^{-\theta}$. And, the number of firms who export from region 1 is greater than that of region 2: $H_1^{-\theta} M_1 > H_2^{-\theta} M_2$;*
3. *Both regions have higher welfare per labor than before, but the welfare gain in region 1 is larger than that in region 2: $\omega_1 > \omega_2$.*

Proposition 4 compares region 1 with region 2 after they are open to the rest of the world. It shows that the gap of entry costs still results the regional productivity disparity after country C open to the rest of the world. The logic is same to the case of autarkic domestic intraregional trade. The lower entry cost in region 1 encourages more entrants and their competition for the labor raises the real wage. Thus the survival productivity threshold and the exporting productivity threshold in region 1 rise, so do the two average productivities, $\tilde{\varphi}_{1d}$ and $\tilde{\varphi}_{1x}$.

As in the autarkic domestic intraregional trade, when the country opens to the rest of the world, the decrease of entry cost f_{e1} increases entrants in region 1. The competition raises the wage w_1 and reduces the price index P_1 . On the one hand, by equation (9), exporting productivity threshold φ_{1x}^* rises proportionally with the wage since the exporting profits decreases due to larger labor cost of production so that marginal firms who export before can not make profits any more and exit from the world market. On the other hand, the survival productivity φ_{1d}^* also rises proportionally with the wage, but there is another effect raises φ_{1d}^* at the same time by the reductions of the price indices P_1 , P_2 and the relative wage $\frac{w_2}{w_1}$ due to the rising of the average productivity in region 1, which appear in the denominator of the first equation of equation (9). In other words, the rise of exporting productivity threshold φ_{1x}^* falls short of the increase of the survival productivity φ_{1d}^* . The net effect is therefore reduction in H_1 . Thus, there are a larger fraction of firms who export to the rest of the world from region 1 than from region 2. Moreover, total

number of exporting firms from region 1, which equals the mass of the active firms times the ex-ante probability of exporting, $H_1^{-\theta} M_1$, is greater than that of region 2. In this sense, region 1 is more open than region 2.

The average revenue of firms from region 1 consists of two parts as shown in equation (11), one is domestic revenue (including sales from region 1 and region 2) which increases proportionally with w_1 , and the other is export revenue which also rises due to the increase of the fraction of firms who can export, $H_1^{-\theta}$. Two terms in the right hand side of equation (11) and equation (12) both become larger. Therefore the average revenue and average profit earned by active firms from region 1 are higher than that of region 2.

The price indices in region 1 and 2, P_1 and P_2 , are both reduced by the more proportional increase of average productivity than wage in region 1, the welfare in both regions enhances. However, since wage in region 1 increases in the decrease of entry cost, f_{e1} , and P_2 decreases proportionally less than the decrease of P_1 as in the case of autarky, welfare per labor in region 1 is larger than that in region 2.

Proposition 5 Change of τ *Other things equal in open economy, as entry cost in region 1 decreases a same amount as that in autarky, $f_{e1} < f_{e2}$, then there exists a $\tau^* > 1$ such that,*

1. if $\tau^* > \tau \geq 1$, then
 - a. *The openness index in terms of export over aggregate revenue in region 1 is larger than that of region 2: $O_1^{ex} > O_2^{ex}$;*
 - b. *The regional productivity gap becomes wider in open economy than that of autarky: $\left(\frac{\tilde{\varphi}_{1d}}{\tilde{\varphi}_{2d}}\right)^{open} > \left(\frac{\tilde{\varphi}_{1d}}{\tilde{\varphi}_{2d}}\right)^{autarky}$.*
2. *If $\tau > \tau^*$, then the directions of inequalities above are reversed. And, the equalities hold when $\tau = \tau^*$.*

The reason that the productivity disparity gap between two regions changes with transport cost is that in open economy the decrease of f_{e1} always raises the average productivity of firms from region 1, however, it reduces the average productivity of firms from region 2 when τ is low but raises it when τ is high. The reduction of f_{e1} increases entry in region 1 as in autarky. Furthermore, after the country is open to the rest of the world, firms with productivity above export productivity threshold

can export to the world market. The decrease of entry cost raises the fraction of firms who can export to the world market from region 1, $H_1^{-\theta}$, as shown in Proposition 4, thus it induces more entry as the potential profit is larger associated with a good productivity draw than that without the increase of fraction of export. As a result, the proportional rise of survival threshold productivity and the average productivity of firms in region 1 is bigger in open economy than that in autarky.

However, the effects of change of f_{e1} on the productivity of firms from region 2 depend on the intraregional transport cost. When the intraregional transport cost is low, the threshold productivity in region 2 can be lower than before with the decrease of f_{e1} . The decrease of f_{e1} raises the wage and aggregate revenue of region 1, the **market potential** of region 1 becomes larger than before, hence firms from region 2 get higher revenue in region 1. The amount of sales revenue rise in region 1 by firms from region 2 is larger than the amount of revenue decrease in region 2 due to the more **market competition** by relative high productivity firms from region 1 and potential greater mass of firms from the rest of the world, $\Delta r_{21} > \Delta r_{22}$. Therefore, the average domestic revenue of firms from region 2, $r_{2d} = r_{21} + r_{22}$, is larger than before, this relaxes the **zero-profit condition** in region 2, firms with lower productivity can survive now. Thus, the threshold productivity in region 2 decreases and the productivity disparity between two regions becomes larger. In the same time, larger average revenue induces more entrants who bid up wage in region 2 to some extent.

When the intraregional transport cost is high, the threshold productivity in region 2 becomes higher with the decrease of f_{e1} . The rise of sales revenue in region 1 by firms from region 2 is less than the decrease of revenue in region 2, $\Delta r_{21} < \Delta r_{22}$. The average domestic revenue of firms from region 2 is smaller than before, marginal firms with the least productivity are forced to exit. Thus, the threshold productivity in region 2 increases and the productivity disparity between two regions decreases. Lower average revenue discourages less entrants and wage in region 2 decreases. In the intermediate critical point of $\tau = \tau^*$, the percentage increase of the threshold productivity in region 1 equals to the percentage increase of the threshold productivity in region 2, thus the productivity disparity between two regions remains unchanged.

Therefore, the effects of decrease of f_{e1} on the average productivity of firms from region 2 depends on the two contrary effects: the **market potential effect**

of region 1 and the **market competition effect** in region 2. The **market potential effect** of region 1 raises r_{21} but the **market competition effect** in region 2 reduces r_{22} . When $\tau > \tau^*$, the decrease of r_{22} overwhelms the rise of r_{21} , the threshold productivity in region 2 increases more than that in region 1 and the average productivity disparity between two regions becomes narrower. When $\tau = \tau^*$, the decrease of r_{22} is greater than the rise of r_{21} , but the threshold productivity in region 2 goes up by the same percentage points as that in region 1 and the average productivity disparity between two regions remains unchanged in open economy as well as in autarky. When τ is lower than τ^* within some extent, the decrease of r_{22} is still greater than the rise of r_{21} , but the threshold productivity in region 2 rises proportionally short of the increase of the threshold productivity in region 1, the average productivity disparity between two regions becomes wider. On the contrary, when τ is lower much more than τ^* , the rise of r_{21} is large enough to make less productivity firms who can't survive before can survive now. The threshold productivity in region 2 decreases and the average productivity disparity between two regions becomes much wider.

The logic of relative openness indices in two regions is similar to above. The openness index in terms of export over GDP in region 1 is $O_1^{ex} = \frac{H_1^{-\theta} M_1 k \sigma f_x w}{w_1 L}$. The decrease of f_{e1} raises the wage and threshold productivity of region 1, but the rise of the wage proportionally short of the increase of the threshold productivity, the O_1^{ex} increases as a result, since the export productivity φ_{1x}^* is increasing proportionally in the wage in region 1 as shown in the left equation of equation (9). When τ is low, the decrease of f_{e1} reduces the threshold productivity of region 2 and raises the wage of region 2 as shown above, so the O_2^{ex} decreases. Thus, $O_1^{ex} > O_2^{ex}$. On the contrary, when τ is high, the decrease of f_{e1} raises the threshold productivity in region 2 but reduces the wage of region 2, O_2^{ex} increases more than the rise of O_1^{ex} , i.e., $O_1^{ex} < O_2^{ex}$.

Proposition 5 compares the gap between region 1 and region 2 in autarky with that in open economy when f_{e1} reduces the same amount. It is an important result in the present paper that matches two prominent features in China: one is the fact that productivity disparity between east coastal provinces and west provinces became wider after open policy; the other is that the openness index was much

larger in east coastal region than that in west.¹⁰ Although the actual data shows the openness indices in terms of export, import, and export plus import, over GDP are all larger in east coastal provinces than that in west provinces, we can match part of those facts: when the transport cost is low, export over GDP is larger in east coastal provinces.¹¹

Corollary 2 Home Market Effect *Other things equal in open economy, as entry cost in region 1 decreases, $f_{e1} < f_{e2}$, then*

1. *Region 1 has an international trade surplus with the rest of the world while region 2 has an international trade deficit;*
2. *Furthermore, if $\tau^* > \tau \geq 1$, then the ratio of the number of exporting firms in region 1 to that of region 2 is greater than the ratio of aggregate revenue of region 1 to that of region 2, $\frac{H_1^{-\theta} M_1}{H_2^{-\theta} M_2} > \frac{R1}{R2}$.*

Home market effect (HME) proposed by Krugman (1980) and Helpman and Krugman (1985) states that an industry with increasing returns to scale in a larger country will run a trade surplus and the larger country's share of firms exceeds its share of demand. HME is found to be a robust prediction in many different trade models (Freenstra, Markusen and Rose 2001, Head, Mayer and Ries 2002). Although Davis (1998) finds that the HME disappears when the differentiated and homogeneous goods have identical transport costs, Crozet and Trionfetti (2008) show that the HME survives when the homogeneous goods are differentiated by countries (Armington good) with trade cost of iceberg form. Using a difference-in-difference gravity specification, Hanson and Xiang (2004) find that in a model with a continuum of differentiated-product industries the ratio of country pairs exports to the third country is increasing in relative GDP for industries with high transport costs, low substitution elasticities. However, HME does not generally survive in a multi-country model (Behrens, Lamorgese, Ottaviano and Tabuchi 2009). The market size in the more-than-proportional relationship is traditionally defined in terms of labor endowment, or consumer type (Krugman, 1980, Davis and Weinstein,

¹⁰Frankel and Romer (1999) documents the positive correlation between income and openness across countries.

¹¹When the transport cost is very low, the export plus import over GDP is larger in east coastal provinces, since when $\tau = 1$, the openness index in terms of import over aggregate revenue in region 1 is equal to that of region 2: $O_1^{im} = O_2^{im}$, so within some extent of τ near 1, $O_1^{im} + O_1^{ex} > O_2^{im} + O_2^{ex}$.

2003). In the present paper, we regard GDP (total expenditure or aggregate revenue, R_i) as the market size. When aggregate revenue in region 1 becomes greater than that of region 2, $R_1 > R_2$, due to the decrease of entry cost of region 1, region 1 has an international trade surplus with the rest of the world while region 2 has an international trade deficit. This is a kind of HME somewhat like a multi-country case without “outside good”—a homogeneous good with zero trade cost produced by perfectly competitive sector under constant returns to scale.

When f_{e1} decreases, export from region 1 to the rest of the world is larger than import from the rest of the world, $H_1^{-\theta} M_1 A (p_{1x}(\tilde{\varphi}_{1x}))^{1-\sigma} > M_x w_1 L (\frac{p_x(\tilde{\varphi}_x)}{P_1})^{1-\sigma}$, i.e., region 1 has an international trade surplus. In the meantime, region 2 has a same amount of international trade deficit to balance the trade between country C and the rest of the world in equilibrium. The logic is very simple. As the average productivity of firms from region 1 rises, they become more competitive and hence sell more on world market; in the meanwhile, the rise of aggregate revenue in region 1 induces more entry of firms from the rest of the world to both regions, which raises region 2’s import surpassing its export. Thus there are both international trade deficit in region 2 and international trade surplus in region 1 with the rest of the world; and region 1 has an intraregional trade deficit with region 2 accordingly. This implies that country C takes advantage of the relative high productivity in region 1 to promote export. It is accordance with the fact that the most major part of total export in China is from east coastal provinces. For instance, export to world from 11 east coastal provinces in the year of 2000 is 226.9 billion dollars which is 91 percent of total export of the country, while export to world from 11 western provinces in the same year is 9 billion dollars which is only 3.6 percent of total export of the country. (Data source: China Statistical Yearbook 2009).

Moreover, if domestic transport cost between two regions is less than the critical value defined by Proposition 5, $\tau^* > \tau \geq 1$, the more-than-proportional relationship between production and demand—another kind of HME stated by the second part of Corollary 2—emerges, i.e., the increase of the number of exporting firms in region 1 relative to that of region 2 is greater than the increase of aggregate revenue of region 1 relative to that of region 2.

5. Extension: Different Transportation Costs

In this section, we relax the assumption of equal international transportation costs to explore the effect of geographic features of China on the regional income disparity. The international trade cost of east coastal provinces, which have a much advantage of geographic location to trade with the rest of the world, is much lower than that of west and inland provinces. Considering the realistically different transport cost in the model, we could find that the different international transport costs between regions does not change our basic results but exacerbate the productivity disparity between two regions. Region 1 has advantages of lower international transport cost and lower entry cost, this can result that region 1 has a much higher average productivity and income than region 2.

We assume that the international trade cost between region 1 and the rest of the world is still τ_x . However, the international trade cost between region 2 and the rest of the world is the product of intraregional transport cost and the international trade cost between region 1 and the rest of the world, $\tau\tau_x$. That's to say, when firms from region 2 export to the rest of the world, they must pay intraregional transport cost, τ , and international trade cost between region 1 and the rest of the world, τ_x . This is accordance to the fact that most of the western regions in China have to export or import goods via the main port cities located in east coastal regions. When they export, firms from region 2 first transport goods to the main port cities in east, then from these ports they transport goods to the world market. This procession is the same as region 2 imports goods from the rest of the world. A firm from region 2 sets price selling to the rest of the world market $p_{2x}(\varphi) = \frac{\sigma}{\sigma-1} \frac{w_2\tau\tau_x}{\varphi}$ and gets revenue $r_{2x}(\varphi) = A(p_{2x}(\varphi))^{1-\sigma}$. Therefore, the two productivity thresholds in region 2 are:

$$\varphi_{2d}^{*\sigma-1} = \frac{\sigma f \left(\frac{\sigma}{\sigma-1} w_2\right)^{\sigma-1}}{L \left(P_2^{\sigma-1} + \left(\frac{w_1}{w_2}\right) P_1^{\sigma-1} \tau^{1-\sigma}\right)}, \quad \varphi_{2x}^{*\sigma-1} = \frac{\sigma f_x w}{A \left(\frac{\sigma}{\sigma-1} w_2 \tau \tau_x\right)^{1-\sigma}}. \quad (21)$$

The ratio of export productivity threshold to survival productivity threshold in region 2, H_2 , can be written as:

$$H_2^{\sigma-1} = \frac{f_x w L}{A f (\tau \tau_x)^{1-\sigma}} \left(P_2^{\sigma-1} + \left(\frac{w_1}{w_2}\right) P_1^{\sigma-1} \tau^{1-\sigma} \right). \quad (22)$$

The prices of products from the rest of the world export to region 1 and 2 are not equal due to the different transport costs:

$$p_{x1}(\varphi) = \frac{\sigma}{\sigma - 1} \frac{w\tau_x}{\varphi}, \quad p_{x2}(\varphi) = \frac{\sigma}{\sigma - 1} \frac{w\tau\tau_x}{\varphi}. \quad (23)$$

The export productivity threshold for firms from the rest of the world, φ_x^* , is still determined by **zero-profit productivity condition**, $r_x(\varphi_x^*) = r_{x1}(\varphi) + r_{x2}(\varphi) = \sigma F$:

$$\varphi_x^{*\sigma-1} = \frac{\sigma F}{\left(w_1 L P_1^{\sigma-1} \tau_x^{1-\sigma} + w_2 L P_2^{\sigma-1} (\tau\tau_x)^{1-\sigma}\right) \left(\frac{\sigma w}{\sigma-1}\right)^{1-\sigma}}. \quad (24)$$

The variables in region 1 are the same as in Section 3. Thus, when two regions have different international transportation costs with the rest of the world, we can get the results below:

Proposition 6 Region 1 vs. Region 2 with Equal Entry Cost in Open *In open economy with different international transportation costs, the ratios of average productivity, wage, welfare per labor, import and export openness indices in region 1 to that of region 2 are greater than 1; moreover, the ratios are increasing in τ .*

Proposition 6 shows that different international transportation costs alone can result the regional productivity disparity in open economy with equal entry cost. When $\tau > 1$, region 2 has a geographic disadvantage of international trade with the rest of the world, firms from region 2 have to pay $\tau > 1$ times of the transportation cost firms from region 1 have to pay when they export to the rest of the world market. The case of import is similar, firms from the rest of the world exporting to region 2 have to pay $\tau > 1$ times of the transportation cost they export to region 1. More goods from region 2 have to be melted away than that from region 1, and the consumers in region 2 have to pay higher price than that in region 1 to buy the same foreign goods. Thus, region 2 has lower income and lower welfare per labor than region 1. The marginal export firms from region 2 can no longer make profit from the rest of the world hence exit foreign market, the fraction of firms from region 2 who can export decreases. At the same time, total sales of foreign goods to region 2 decreases due to the higher prices. Thus, import and export openness indices in region 2 are smaller than that in region 1. When τ rises, the disadvantage of higher

international transportation cost of region 2 becomes worse, hence the productivity gap between two regions increases.

It is worth pointing out that the different international transportation costs model degenerates to the identical transportation costs model in autarky as shown in the above sections, since firms from any one region selling goods to the other region have to pay the same amount of transportation cost, τ ; the different transportation costs can not affect domestic intraregional trade but only affect international trade with the rest of the world. When two regions have equal entry cost in autarky, they are symmetric whatever the value of transportation cost, τ , is. Proposition 1 shows that there is no productivity disparity between two regions in autarky when two regions have equal entry cost even if they have potential different international transportation costs in the future. In fact, Jian, Sachs and Warner (1996) and Kanbur and Zhang (2005) among others demonstrate that there is strong evidence for regional productivity disparity in China before 1978, the year the open policy began. Therefore, it suggests that it is *not* different international transportation costs *but* the different entry costs are the fundamental root of the regional disparity in China. Although different transportation costs result no regional productivity disparity in autarky, they do cause and aggravate the regional productivity gap in open economy as shown below.

Proposition 7 Region 1 vs. Region 2 with Different Entry Cost in Open

In open economy with different international transportation costs, if $f_{e1} < f_{e2}$, the ratios of average productivity, wage, welfare per labor in region 1 to that of region 2 are greater than 1 and these ratios are greater with different transport costs than without.

When there are both different international transportation costs and different entry cost in open economy, Proposition 7 shows that region 1 has higher productivity and welfare per labor than region 2, and these regional disparities in open economy are greater than that in autarky, since the different international transportation costs affect region 2 adversely in open economy. Accordingly, the regional productivity gap in open economy is broadened when region 2 has these two disadvantages simultaneously.

Corollary 3 Home Market Effect with Different Transport Costs

In open economy the ratio of the number of exporting firms in region 1 to that of region

2 is greater than the ratio of aggregate revenue of region 1 to that of region 2, $\frac{H_1^{-\theta} M_1}{H_2^{-\theta} M_2} > \frac{R_1}{R_2}$, when $\tau > 1$ or $f_{e1} < f_{e2}$.

Corollary 3 shows that the more-than-proportional relationship between production and demand still exists when two regions have different international transportation costs or when two regions have different entry costs or both. When two regions have different entry costs without different international transportation costs, that's $\tau = 1$, it's just the second part of Corollary 2. When two regions have different international transportation costs (international transportation cost between region 1 and the rest of the world is τ_x while international transportation cost between region 2 and the rest of the world is $\tau\tau_x$ with $\tau > 1$) without different entry costs, H_1 decreases but H_2 increases when τ rises. Thus, region 1 has more proportional firms export to the rest of the world than region 2. As in the case of Corollary 2, this effect dominates the effect of relative smaller amount of active firms from region 1 than that of region 2. Therefore, the more-than-proportional relationship, HME, emerges again when the assumption of equal international transportation costs is relaxed.

6. Conclusions

The regional income disparity in China has been widening since the Chinese reform and open-door policy in 1978. This paper explores the effects of international trade with the rest of the world on Chinese regional income disparity within the standard model of product differentiation and heterogeneity in firm productivities. Other things equal, the difference of entry cost results income disparity between regions in both autarky and open economy. When domestic intraregional transport cost between regions is relative low, the same amount of entry cost difference results a wider regional income gap in open economy than that of autarky; and the openness in terms of export over aggregate revenue in the region with a relative lower entry cost is larger than that of the region with a higher entry cost. These results match the facts in Chinese economy well. The relaxation of the assumption of equal international transportation costs to explore the effect of geographic features of China on the regional income disparity does not change the basic results but exacerbate the productivity disparity between two regions.

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Appendix: Proofs

This appendix contains outlines of the proofs of the results reported in the paper.

Proof of Lemma 1, Independence

From equation (7) we know that φ_{1d}^* is not related to the cost parameters of region 2, and vice versa. QED.

Proof of Proposition 1, Region 1 vs. Region 2 in Autarky

(1) From equation (7) we get that $\left(\frac{\varphi_{1d}^*}{\varphi_{2d}^*}\right)^\theta = \frac{f_{e2}}{f_{e1}}$, if $f_{e2} > f_{e1}$, then $\varphi_{1d}^* > \varphi_{2d}^*$. From equation (5), it follows immediately that $\tilde{\varphi}_{1d} > \tilde{\varphi}_{2d}$.

The trade balance condition between two regions in the autarky is $M_1 \bar{r}_{12}(\tilde{\varphi}_{1d}) = M_2 \bar{r}_{21}(\tilde{\varphi}_{2d})$, since $M_1 = M_2 = \frac{L}{k\sigma f}$, and price index is determined by equation (8), we can get

$$\frac{w_2 w_1^{1-\sigma}}{w_1^{1-\sigma} \tau^{1-\sigma} + w_2^{1-\sigma} \left(\frac{\varphi_{1d}^*}{\varphi_{2d}^*}\right)^{1-\sigma}} = \frac{w_1 w_2^{1-\sigma}}{w_2^{1-\sigma} \tau^{1-\sigma} + w_1^{1-\sigma} \left(\frac{\varphi_{1d}^*}{\varphi_{2d}^*}\right)^{\sigma-1}}. \quad (25)$$

Let $A = \frac{w_1}{w_2} > 0$ and $B = \frac{\varphi_{1d}^*}{\varphi_{2d}^*} > 1$, equation (25) can be written as

$$(A - 1)\tau^{1-\sigma} = A^{1-\sigma} B^{1-\sigma} (B^{2\sigma-2} - A^{2\sigma-1}). \quad (26)$$

If $A = 1$, the LHS of equation (26) is 0, but the RHS of equation (26) is greater than 0, it's a contradiction; if $A < 1$, the LHS of equation (26) is less than 0, so the RHS of equation (26) also need to be less than 0, i.e., $A > B^{\frac{2(\sigma-1)}{2\sigma-1}} > 1$, it's a contradiction. Thus, A must greater than 1 and $B > A$ from the RHS of equation (26). That's to say, $w_1 > w_2$ when $f_{e2} > f_{e1}$.

Since $\bar{r}_{1d}(\tilde{\varphi}_{1d}) = k\sigma f w_1$ and $\bar{r}_{2d}(\tilde{\varphi}_{2d}) = k\sigma f w_2$, so $\bar{r}_{1d}(\tilde{\varphi}_{1d}) > \bar{r}_{2d}(\tilde{\varphi}_{2d})$.

(2) The welfare per labor in region 1 $\omega_1 = \frac{w_1}{P_1}$, we can write

$$\omega_1^{1-\sigma} = \frac{w_1^{1-\sigma}}{P_1^{1-\sigma}} = \frac{k\sigma f}{L\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \left(\tilde{\varphi}_{1d}^{\sigma-1} + \tau^{1-\sigma} \left(\frac{w_1}{w_2}\right)^{\sigma-1} \tilde{\varphi}_{2d}^{\sigma-1}\right)}, \quad (27)$$

we have known that $\tilde{\varphi}_{1d}$ and $\frac{w_1}{w_2}$ are greater than before when f_{e1} decreases, or $f_{e2} > f_{e1}$, but $\tilde{\varphi}_{2d}$ remains unchanged, so the welfare per labor in region 1, ω_1 ,

becomes larger than before.

The proof of the increase of the welfare per labor in region 2, ω_2 , is as below,

$$\omega_2^{1-\sigma} = \frac{w_2^{1-\sigma}}{P_2^{1-\sigma}} = \frac{k\sigma f}{L\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \left(\tilde{\varphi}_{2d}^{\sigma-1} + \tau^{1-\sigma} \left(\frac{w_2}{w_1}\right)^{\sigma-1} \tilde{\varphi}_{1d}^{\sigma-1} \right)}, \quad (28)$$

from equation (26), we know that $B > A > 1$, i.e., $\frac{w_2}{w_1} > \frac{\tilde{\varphi}_{2d}}{\tilde{\varphi}_{1d}}$, so the welfare per labor in region 2, ω_2 , becomes larger than before as well.

From equation (27) we can get the ratio of the welfare per labor in region 1 to region 2 as below,

$$\left(\frac{\omega_1}{\omega_2}\right)^{\sigma-1} = \frac{\tilde{\varphi}_{1d}^{\sigma-1} + \tau^{1-\sigma} \left(\frac{w_1}{w_2}\right)^{\sigma-1} \tilde{\varphi}_{2d}^{\sigma-1}}{\tilde{\varphi}_{2d}^{\sigma-1} + \tau^{1-\sigma} \left(\frac{w_1}{w_2}\right)^{1-\sigma} \tilde{\varphi}_{1d}^{\sigma-1}} > 1, \quad (29)$$

since

$$\begin{aligned} & \left(\tilde{\varphi}_{1d}^{\sigma-1} + \tau^{1-\sigma} \left(\frac{w_1}{w_2}\right)^{\sigma-1} \tilde{\varphi}_{2d}^{\sigma-1} \right) - \left(\tilde{\varphi}_{2d}^{\sigma-1} + \tau^{1-\sigma} \left(\frac{w_1}{w_2}\right)^{1-\sigma} \tilde{\varphi}_{1d}^{\sigma-1} \right) \\ &= \tilde{\varphi}_{1d}^{\sigma-1} \left(1 - \tau^{1-\sigma} \left(\frac{w_1}{w_2}\right)^{1-\sigma} \right) - \tilde{\varphi}_{2d}^{\sigma-1} \left(1 - \tau^{1-\sigma} \left(\frac{w_1}{w_2}\right)^{\sigma-1} \right) \\ &> (\tilde{\varphi}_{1d}^{\sigma-1} - \tilde{\varphi}_{2d}^{\sigma-1}) \left(1 - \tau^{1-\sigma} \left(\frac{w_1}{w_2}\right)^{1-\sigma} \right) > 0. \end{aligned} \quad (30)$$

Below is the proof of decreases of price indices P_1 and P_2 when f_{e1} decreases. We need to prove the wage in region 1 rises proportionally short of the increase of the threshold productivity. From equation (3) and **zero-profit condition** $r_{1d}(\varphi_{1d}^*) = \sigma f w_1$, we know that

$$\begin{aligned} r_{1d}(\varphi_{1d}^*) &= r_{11}(\varphi_{1d}^*) + r_{12}(\varphi_{1d}^*) = \left(1 + \frac{w_2}{w_1} \left(\frac{P_1}{P_2}\right)^{1-\sigma} \tau^{1-\sigma} \right) r_{11} \\ &= \left(\frac{1}{P_1^{1-\sigma}} + \frac{w_2}{w_1} \frac{1}{P_2^{1-\sigma}} \tau^{1-\sigma} \right) w_1 L \left(\frac{\sigma}{\sigma-1} \frac{w_1}{\varphi_{1d}^*} \right)^{1-\sigma} = \sigma f w_1 \\ &\Rightarrow \left(\frac{1}{P_1^{1-\sigma}} + \frac{w_2}{w_1} \frac{1}{P_2^{1-\sigma}} \tau^{1-\sigma} \right) L \left(\frac{\sigma}{\sigma-1} \frac{w_1}{\varphi_{1d}^*} \right)^{1-\sigma} = \sigma f. \end{aligned} \quad (31)$$

If percentage change of threshold productivity, $\hat{\varphi}_{1d}^*$, equals percentage change of wage in region 1, \hat{w}_1 , $\hat{\varphi}_{1d}^* = \hat{w}_1$, then $\hat{p}_{11} = \hat{p}_{12} = \hat{P}_1 = \hat{P}_2 = 0$ since the number of active firms remains unchanged. The left hand side of the last line of equation above is less than the right hand side since $w_1 > w_2$ when $f_{e2} > f_{e1}$ as shown in the first part above. It's a contradiction. Thus the wage in region 1 must rise proportionally short of the increase of the threshold productivity in region 1 since a firm's revenue is increasing in its productivity.

(3) From equation (26), we can get,

$$\frac{\partial A}{\partial \tau} = \frac{\tau^{-\sigma}(\sigma - 1)(A - 1)}{\tau^{1-\sigma} + \sigma B^{1-\sigma} A^{\sigma-1} + (\sigma - 1)B^{\sigma-1} A^{-\sigma}} > 0, \quad (32)$$

so the wage gap between two regions, $\frac{w_1}{w_2}$, is increasing in transport cost, τ .

Since

$$\frac{\partial \left(\frac{A}{\tau}\right)}{\partial \tau} = \frac{\tau \frac{\partial A}{\partial \tau} - A}{\tau^2}, \quad (33)$$

inserting the equation (32) into above and using the equation (26), we can get

$$\begin{aligned} \frac{\partial \left(\frac{A}{\tau}\right)}{\partial \tau} &= \frac{\tau^{1-\sigma}(\sigma - 1)(A - 1) - \tau^{1-\sigma} A - \sigma B^{1-\sigma} A^{\sigma} - (\sigma - 1)B^{\sigma-1} A^{1-\sigma}}{\tau^2(\tau^{1-\sigma} + \sigma B^{1-\sigma} A^{\sigma-1} + (\sigma - 1)B^{\sigma-1} A^{-\sigma})} \\ &= \frac{\tau^{1-\sigma} ((\sigma - 1)(A - 1) - A) - B^{1-\sigma} A^{1-\sigma} (\sigma A^{2\sigma-1} + (\sigma - 1)B^{2\sigma-2})}{\tau^2(\tau^{1-\sigma} + \sigma B^{1-\sigma} A^{\sigma-1} + (\sigma - 1)B^{\sigma-1} A^{-\sigma})} \\ &= \frac{-A\tau^{-2-\sigma} - (2\sigma - 1)A^{\sigma} B^{1-\sigma}}{\tau^2(\tau^{1-\sigma} + \sigma B^{1-\sigma} A^{\sigma-1} + (\sigma - 1)B^{\sigma-1} A^{-\sigma})} \\ &< 0. \end{aligned} \quad (34)$$

Combining equation above and equation (27), we know that welfare per labor in region 1, ω_1 , is decreasing in τ .

Since

$$\frac{\partial A\tau}{\partial \tau} = \tau \frac{\partial A}{\partial \tau} + A > 0, \quad (35)$$

combining equation above and equation (28), we know that welfare per labor in region 2, ω_2 , is decreasing in τ as well.

Differentiating equation (29) with respect to τ and using $B = \frac{\varphi_{1d}^*}{\varphi_{2d}^*} = \frac{\tilde{\varphi}_{1d}}{\tilde{\varphi}_{2d}} > A =$

$\frac{w_1}{w_2} > 1$, $B^\theta = \frac{f_{e2}}{f_{e1}}$ is independent of τ and $A' = \frac{\partial A}{\partial \tau} > 0$ from equation (32) yields

$$\begin{aligned}
& \frac{\partial \left(\frac{w_1}{w_2} \right)^{\sigma-1}}{\partial \tau} \\
&= \frac{(\sigma-1)\tau^{-\sigma}A^{\sigma-1}(\tau A^{-1}A' - 1)(1 + \tau^{1-\sigma}A^{1-\sigma}B^{\sigma-1})}{(1 + \tau^{1-\sigma}A^{1-\sigma}B^{\sigma-1})^2} \\
&\quad - \frac{(1-\sigma)\tau^{-\sigma}A^{-\sigma}B^{\sigma-1}(A + \tau A')(B^{\sigma-1} + \tau^{1-\sigma}A^{\sigma-1})}{(1 + \tau^{1-\sigma}A^{1-\sigma}B^{\sigma-1})^2} \\
&= \frac{(\sigma-1)\tau^{-\sigma}A^{1-\sigma}((B^{2\sigma-2} - A^{2\sigma-2}) + \tau A^{-1}A'(A^{2\sigma-2} + B^{2\sigma-2}) + 2\tau^{2-\sigma}A^{\sigma-2}A'B^{\sigma-1})}{(1 + \tau^{1-\sigma}A^{1-\sigma}B^{\sigma-1})^2} \\
&> 0.
\end{aligned} \tag{36}$$

Thus, the welfare ratio between two regions, $\frac{w_1}{w_2}$, is increasing in τ . QED.

Proof of Corollary 1, Home Market Share

Using the fact that $R_1 = M_1\bar{r}_{11}(\tilde{\varphi}_{1d}) + M_1\bar{r}_{12}(\tilde{\varphi}_{1d})$, $R_2 = M_2\bar{r}_{22}(\tilde{\varphi}_{2d}) + M_2\bar{r}_{21}(\tilde{\varphi}_{2d})$, $M_1 = M_2$, and the trade balance condition between two regions in the autarky $M_1\bar{r}_{12}(\tilde{\varphi}_{1d}) = M_2\bar{r}_{21}(\tilde{\varphi}_{2d})$, we get $\frac{M_1\bar{r}_{11}(\tilde{\varphi}_{1d})}{R_1} = \frac{w_1L - M_1\bar{r}_{12}(\tilde{\varphi}_{1d})}{w_1L} = 1 - \frac{M_1\bar{r}_{12}(\tilde{\varphi}_{1d})}{w_1L} > 1 - \frac{M_2\bar{r}_{21}(\tilde{\varphi}_{2d})}{w_2L} = \frac{w_2L - M_2\bar{r}_{21}(\tilde{\varphi}_{2d})}{w_2L} = \frac{M_2\bar{r}_{22}(\tilde{\varphi}_{2d})}{R_2}$. QED.

Proof of Proposition 2, Unique Equilibrium

This proof is similar to the proof of proposition 3 in Bernard, Redding and Schott (2007). Suppose that the equilibrium wage vector $\{w_1, w_2\}$ is known, and the wage in the rest of the world w is an exogenous parameter. The aggregate revenue $\{R_1, R_2\}$ is pinned down in two regions. The equilibrium variety prices are determined as a function of the wage vector: $\{p_{11}(\varphi), p_{12}(\varphi), p_{1x}(\varphi), p_{21}(\varphi), p_{22}(\varphi), p_{2x}(\varphi), p_{x1}(\varphi), p_{x2}(\varphi)\}$. With wages, variety prices, and aggregate revenue known, the equilibrium zero-profit cut-off productivities and export cut-off productivities $\{\varphi_{1d}^*, \varphi_{1x}^*, \varphi_{2d}^*, \varphi_{2x}^*, \varphi_x^*\}$, and price indices $\{P_1, P_2\}$ are the solution to the system of seven simultaneous equations defined by equations (10), (14), (18), and (17). We substitute out for the equilibrium mass of firms, $M_1 = \frac{w_1L}{k\sigma f w_1 + H_1^{-\theta} k\sigma f_x w}$, $M_2 = \frac{w_2L}{k\sigma f w_2 + H_2^{-\theta} k\sigma f_x w}$, and $M_x = \frac{b^\theta}{\varphi_x^* \theta}$, ratio of export productivity threshold to survival productivity threshold $H_1 = \frac{\varphi_{1x}^*}{\varphi_{1d}^*}$ and $H_2 = \frac{\varphi_{2x}^*}{\varphi_{2d}^*}$. Thus, given the wage vector, we have solved for all elements of the equilibrium vector $\{\varphi_{1d}^*, \varphi_{1x}^*, \varphi_{2d}^*, \varphi_{2x}^*, \varphi_x^*, P_1,$

$P_2, M_1, M_2, M_x, R_1, R_2\}$. The equilibrium wage vector itself is pinned down by the requirement the trade balance conditions for region 1 and region 2 with the rest of the world by equations (19) and (20). QED.

Proof of Lemma 2, Dependence

The survival and exporting threshold productivities in region 1 are connected by H_1 in the equation (14). We know from equation (10) that H_1 is related to the relative wage, $\frac{w_2}{w_1}$, and price indices of region 1 and region 2, P_1 and P_2 , which are determined by the parameters of two regions and the rest of the world. So the productivity threshold in region 1 is related to the cost parameters in region 2, and vice versa. QED.

Proof of Proposition 3, Autarky vs. Open

Comparing equation (14) $\frac{b^\theta}{\varphi_{1d}^{*\theta}} \left[f + H_1^{-\theta} f_x \frac{w}{w_1} \right] (k - 1) = \delta f_{e1}$ to equation (7) $\frac{b^\theta}{\varphi_{1d}^{*\theta}} f (k - 1) = \delta f_{e1}$, we can find that there is an additional term reflecting the expected profits from exporting to the rest of the world in equation (14). So the survival productivity threshold φ_{1d}^* in open economy is higher than that in autarky. And the average productivity $\tilde{\varphi}_{1d}$ becomes higher as well.

The average revenue in region 1 in *autarky* is $\bar{r}_{1d}(\tilde{\varphi}_{1d}) = k\sigma f w_1$, while average revenue in region 1 in *open* is determined by equation (11): $\bar{r}_1(\tilde{\varphi}_{1d}) = k\sigma f w_1 + H_1^{-\theta} k\sigma f_x w$. So the average revenue in region 1 in *open* is greater than that in *autarky*. The case of region 2 is similar to region 1.

$H_i^{-\theta}$ fraction of active firms from each region earn average revenue of $k\sigma f w$ from export, this induces more labor demand by the more productivity firms who have new exporting profit opportunities. Thus the wage in both regions is raised up. Average productivity rises in both regions, which reduces the price index for each good. As Bernard, Redding and Schott (2007) point out, other things equal, the potential to import rest of the world varieties expands the range of varieties available to consumers in both regions, which reduces consumer price indices. Thus, the welfare rises in both regions after open to the rest of the world.

The mass of firms in region 1 in *autarky* is $M_1 = \frac{L}{k\sigma f}$, while mass of firms in region 1 in *open* is determined by equation (13): $M_1 = \frac{R_1}{\bar{r}_1(\tilde{\varphi}_{1d})} = \frac{w_1 L}{k\sigma f w_1 + H_1^{-\theta} k\sigma f_x w}$. So mass of firms in region 1 in *open* is smaller than that in *autarky*. The case of region 2 is similar to region 1. QED.

Proof of Footnote 9, Comparing Total Varieties in Open with Autarky

(1) When two regions are symmetric, ie., $f_{e1} = f_{e2}$, then $w_1 = w_2$, in autarky, $M_1^{autarky} = M_2^{autarky} = \frac{L}{k\sigma f}$; after open to the rest of the world, $M_1^{open} = M_2^{open} = \frac{Lw_1}{k\sigma fw_1 + H_1^{-\theta} k\sigma f_x w}$. From trade balance $2H_1^{-\theta} M_1^{open} A\tilde{p}_{1x}^{1-\sigma} = 2H_1^{-\theta} M_1^{open} k\sigma f_x w = M_x k\sigma F$ we can get $M_x = \frac{2H_1^{-\theta} M_1^{open} f_x w}{F}$. So the change of total variety is

$$\begin{aligned}
& 2M_1^{autarky} - (2M_1^{open} + M_x) \\
&= \frac{2L}{k\sigma f} - \left(\frac{2Lw_1}{k\sigma fw_1 + H_1^{-\theta} k\sigma f_x w} + \frac{2H_1^{-\theta} M_1^{open} f_x w}{F} \right) \\
&= \frac{2H_1^{-\theta} M_1^{open} f_x w}{w_1 f} - \frac{2H_1^{-\theta} M_1^{open} f_x w}{F} \\
&= 2H_1^{-\theta} M_1^{open} f_x w \left(\frac{F - w_1 f}{w_1 f F} \right) \\
&\Rightarrow \begin{cases} < 0, & \text{if } F < w_1 f \\ = 0, & \text{if } F = w_1 f \\ > 0, & \text{if } F > w_1 f \end{cases} \tag{37}
\end{aligned}$$

Thus, in the case of $f_{e1} = f_{e2}$, when $F <, =, \text{ or } > w_1 f$, the total variety in each region in open economy is larger than, equal to, or smaller than that in autarky respectively.

(2) When region 1 has a lower entry cost, ie., $f_{e1} < f_{e2}$, then $w_1 > w_2$, in autarky, $M_1^{autarky} = M_2^{autarky} = \frac{L}{k\sigma f}$; after open to the rest of the world, $M_i^{open} = \frac{Lw_i}{k\sigma fw_i + H_i^{-\theta} k\sigma f_x w}$, $i = 1, 2$. From trade balance $H_1^{-\theta} M_1^{open} k\sigma f_x w + H_2^{-\theta} M_2^{open} k\sigma f_x w = M_x k\sigma F$ we can get $M_x = \frac{H_1^{-\theta} M_1^{open} f_x w + H_2^{-\theta} M_2^{open} f_x w}{F}$. So the change of total variety is

$$\begin{aligned}
& (M_1^{autarky} + M_2^{autarky}) - (M_1^{open} + M_2^{open} + M_x) \\
&= \frac{H_1^{-\theta} M_1^{open} f_x w}{fw_1} + \frac{H_2^{-\theta} M_2^{open} f_x w}{fw_2} - \frac{H_1^{-\theta} M_1^{open} f_x w + H_2^{-\theta} M_2^{open} f_x w}{F} \\
&= H_1^{-\theta} M_1^{open} f_x w \left(\frac{F - w_1 f}{w_1 f F} \right) + H_2^{-\theta} M_2^{open} f_x w \left(\frac{F - w_2 f}{w_2 f F} \right) \\
&\Rightarrow \begin{cases} > 0, & \text{if } F > w_1 f \\ < 0, & \text{if } F < w_2 f \end{cases} \tag{38}
\end{aligned}$$

Thus, in the case of $f_{e1} < f_{e2}$, if $F > w_1 f$, the total variety in each region in open economy is smaller than that in autarky; if $F < w_2 f$, the total variety is larger than that in autarky. QED.

Proof of Proposition 4, Region 1 vs. Region 2 in Open Economy

(1) The lower entry cost in region 1 encourages more entrants and their competition for the labor raises the wage in region 1, so $w_1 > w_2$. The marginal firms in region 1 exit due to the rise of labor cost. Thus the survival productivity threshold and the exporting productivity threshold in region 1 rise, $\varphi_{1d}^* > \varphi_{2d}^*$ and $\varphi_{1x}^* > \varphi_{2x}^*$. So do the two average productivities, $\tilde{\varphi}_{1d} > \tilde{\varphi}_{2d}$ and $\tilde{\varphi}_{1x} > \tilde{\varphi}_{2x}$. The increase of average productivity of firms from region 1 relative to region 2 reduces the price index in region 1 more than that in region 2, $P_1 < P_2$.

From equation (11) $\bar{r}_1(\tilde{\varphi}_{1d}) = k\sigma f w_1 + H_1^{-\theta} k\sigma f_x w$, we write the ratio of average revenue,

$$\frac{\bar{r}_1(\tilde{\varphi}_{1d})}{\bar{r}_2(\tilde{\varphi}_{2d})} = \frac{k\sigma f w_1 + H_1^{-\theta} k\sigma f_x w}{k\sigma f w_2 + H_2^{-\theta} k\sigma f_x w} > 1, \quad (39)$$

since $w_1 > w_2$ and $H_1^{-\theta} > H_2^{-\theta}$ as shown in part 2 below.

(2) When $\tau = 1$, $P_1 = P_2$, so $\left(\frac{H_1}{H_2}\right)^{\sigma-1} = \frac{1+\frac{w_2}{w_1}}{1+\frac{w_1}{w_2}} < 1$, since $w_1 > w_2$. When $\tau = \infty$, $\left(\frac{H_1}{H_2}\right)^{\sigma-1} = \left(\frac{P_1}{P_2}\right)^{\sigma-1} < 1$, since $P_1 < P_2$. From equation (10) we know that H_i , $i = 1, 2$ are decreasing in τ . Thus, $H_1 < H_2$, and $H_1^{-\theta} > H_2^{-\theta}$.

The ratio of the number of firms who export from region 1 to that of region 2 is: $\frac{H_1^{-\theta} M_1}{H_2^{-\theta} M_2} = \frac{f H_2^\theta + \frac{f_x w}{w_2}}{f H_1^\theta + \frac{f_x w}{w_1}} > 1$, since $H_1 < H_2$ and $w_1 > w_2$.

(3) As shown in above, average productivity of firms from region 1 is higher; this reduces the price indices in both regions, the welfare in both regions rise as a result. However, average productivity of firms from region 1 is higher than that of region 2, so the price index in region 1 decreases more than that in region 2, $P_1 < P_2$. Combining this and $w_1 > w_2$ as shown above, we get $\omega_1 > \omega_2$, which proves the part 3 of the proposition. QED.

Proof of Proposition 5, Change of τ

(1) Import openness index in terms of import over GDP in region i is $O_i^{im} = \frac{M_x w_i L (\frac{\tilde{p}_{xi}}{P_i})^{1-\sigma}}{w_i L} = M_x (\frac{\tilde{p}_{xi}}{P_i})^{1-\sigma}$. From the assumption in text, $\tilde{p}_{x1} = \tilde{p}_{x2}$, $i = 1, 2$.

Export openness index in terms of export over GDP in region i is $O_i^{ex} = \frac{H_i^{-\theta} M_i k \sigma f_x w}{w_i L}$.

We can write

$$\frac{O_1^{ex}}{O_2^{ex}} = \frac{w_2 L H_1^{-\theta} M_1 k \sigma f_x w}{w_1 L H_2^{-\theta} M_2 k \sigma f_x w} = \frac{\bar{r}_2}{\bar{r}_1} \left(\frac{H_2}{H_1} \right)^\theta. \quad (40)$$

First, we show that if $\tau = 1$, $O_1^{ex} > O_2^{ex}$. When $\tau = 1$, the ratio of two import openness indices is

$$\frac{O_1^{im}}{O_2^{im}} = \left(\frac{P_1}{P_2} \right)^{\sigma-1} = 1, \quad (41)$$

since $P_1 = P_2$ due to $\tau = 1$.

If $O_1^{ex} = O_2^{ex}$, the intraregional trade must be balanced, that is to say, $R_{12} = R_{21}$. Since $R_{ij} = M_i w_j L \left(\frac{\tilde{p}_i}{P_j} \right)^{1-\sigma}$, $i, j = 1, 2$, we can write

$$\begin{aligned} \frac{R_{12}}{R_{21}} &= \frac{M_1}{w_1 L} \frac{w_2 L}{M_2} \left(\frac{w_1}{w_2} \right)^{1-\sigma} \left(\frac{\varphi_{1d}^*}{\varphi_{2d}^*} \right)^{\sigma-1} = \frac{\bar{r}_2}{\bar{r}_1} \left(\frac{w_1}{w_2} \right)^{1-\sigma} \left(\frac{\varphi_{1d}^*}{\varphi_{2d}^*} \right)^{\sigma-1} \\ &= \frac{\bar{r}_2}{\bar{r}_1} \left(\frac{\varphi_{1x}^* \varphi_{2d}^*}{\varphi_{2x}^* \varphi_{1d}^*} \right)^{1-\sigma} = \frac{\bar{r}_2}{\bar{r}_1} \left(\frac{H_2}{H_1} \right)^{\sigma-1} < \frac{\bar{r}_2}{\bar{r}_1} \left(\frac{H_2}{H_1} \right)^\theta = \frac{O_1^{ex}}{O_2^{ex}} = 1, \end{aligned} \quad (42)$$

using $\theta > \sigma - 1$ and equation (40). It's a contradiction.

If $O_1^{ex} < O_2^{ex}$, then region 2 has a relative greater trade surplus with the rest of the world than that of region 1. Region 2 must has an intraregional trade deficit with region 1, i.e., $R_{12} > R_{21}$. However, it's a contradiction similar to equation above,

$$\frac{R_{12}}{R_{21}} = \frac{\bar{r}_2}{\bar{r}_1} \left(\frac{H_2}{H_1} \right)^{\sigma-1} < \frac{\bar{r}_2}{\bar{r}_1} \left(\frac{H_2}{H_1} \right)^\theta = \frac{O_1^{ex}}{O_2^{ex}} < 1. \quad (43)$$

Thus, if $\tau = 1$, $O_1^{ex} > O_2^{ex}$.

Second, we show that if $\tau = \infty$, $O_1^{ex} < O_2^{ex}$. When $\tau = \infty$, in equilibrium, both regions must keep a trade balance condition with the rest of the world,

$$\frac{O_1^{ex}}{O_2^{ex}} = \frac{O_1^{im}}{O_2^{im}} = \left(\frac{P_1}{P_2} \right)^{\sigma-1} < 1, \quad (44)$$

since $P_1 < P_2$ as shown in Proposition 4.

Third, monotonicity, from $O_i^{ex} = \frac{H_i^{-\theta} M_i k \sigma f_x w}{w_i L} = \frac{f_x w}{f w_i H_i^\theta + f_x w}$, we know that O_i^{ex} is decreasing in τ . Since the domestic revenue decreases when τ increase, the firms with survive threshold productivity φ_{id}^* can no longer survive anymore, φ_{id}^* must rise. At the same time, lower revenue discourages entry, wages, w_i , are bid down. Thus, H_i and w_i are monotonically decreasing in τ .

Therefore, there must exist a $\infty > \tau^* > 1$ such that

$$\begin{cases} \frac{O_1^{ex}}{O_2^{ex}} > 1, & \text{if } \tau^* > \tau \geq 1 \\ \frac{O_1^{ex}}{O_2^{ex}} = 1, & \text{if } \tau = \tau^* \\ \frac{O_1^{ex}}{O_2^{ex}} < 1, & \text{if } \tau > \tau^* > 1 \end{cases} \quad (45)$$

(2) Survival productivity cutoff (equation 14) in open economy can be written as $\frac{b^\theta}{\varphi_{id}^{*\theta}} \left[f + \frac{f_x w}{H_i^\theta w_i} \right] (k-1) = \delta f_{ei}$, $i = 1, 2$, which shows that other things equal, survival productivity cutoffs in both regions φ_{id}^* are monotonically increasing in transport cost τ , since H_i and w_i are monotonically decreasing in τ shown as above.

In autarky, the ratio of survival productivity cutoffs in two regions is $\left(\frac{\varphi_{1d}^*}{\varphi_{2d}^*} \right)^\theta = \frac{f_{e2}}{f_{e1}}$. In open economy, we can write the ratio $\left(\frac{\varphi_{1d}^*}{\varphi_{2d}^*} \right)^\theta = \frac{f + \frac{f_x w}{H_1^\theta w_1}}{f + \frac{f_x w}{H_2^\theta w_2}}$.

From equation (45), we can get

$$\Rightarrow \begin{cases} \left(\frac{\varphi_{1d}^*}{\varphi_{2d}^*} \right)^{open} > \left(\frac{\varphi_{1d}^*}{\varphi_{2d}^*} \right)^{autarky}, & \text{if } \tau^* > \tau \geq 1 \\ \left(\frac{\varphi_{1d}^*}{\varphi_{2d}^*} \right)^{open} = \left(\frac{\varphi_{1d}^*}{\varphi_{2d}^*} \right)^{autarky}, & \text{if } \tau = \tau^* \\ \left(\frac{\varphi_{1d}^*}{\varphi_{2d}^*} \right)^{open} < \left(\frac{\varphi_{1d}^*}{\varphi_{2d}^*} \right)^{autarky}, & \text{if } \tau > \tau^* > 1 \end{cases} \quad (46)$$

since

$$\begin{cases} \frac{H_1^\theta w_1}{H_2^\theta w_2} < 1, & \text{if } \frac{O_1^{ex}}{O_2^{ex}} > 1 \\ \frac{H_1^\theta w_1}{H_2^\theta w_2} = 1, & \text{if } \frac{O_1^{ex}}{O_2^{ex}} = 1 \\ \frac{H_1^\theta w_1}{H_2^\theta w_2} > 1, & \text{if } \frac{O_1^{ex}}{O_2^{ex}} < 1. \end{cases} \quad (47)$$

(3) Comparing the **market potential effect** and the **market competition effect**.

When $\tau = 1$, the **market potential effect** is greater than the **market competition effect**, i.e., the rise of sales revenue in region 1 by firms from region 2 is greater than the decrease of revenue in region 2, $\Delta r_{21} > \Delta r_{22}$. Suppose it's not the case. If $\Delta w_2 = 0$, $\Delta H_2 = 0$, then $\Delta \varphi_{2d}^* = 0$, $\Delta EX_{2x} = 0$, $\Delta IM_{x1} > 0$, $\Delta IM_{x2} < 0$, $\Delta IM_{x1} + \Delta IM_{x2} = 0$, it's the same as $\Delta r_{21} > 0$, $\Delta r_{22} < 0$ with $\Delta r_{21} + \Delta r_{22} = 0$, so $\Delta \varphi_x^* = 0$. However, $\Delta EX_{1x} > 0$ since H_1 decreases when f_{e1} decreases. Then $\Delta EX_{1x} + \Delta EX_{2x} > \Delta IM_{x1} + \Delta IM_{x2} = 0$, there is trade surplus between Country C and the rest of the world. It can't be an equilibrium. There must be an improvement of terms of trade in region 1 or region 2 or both. If w_1 increases, Δr_{21} will be larger; if w_2 increases, R_2 will be larger. In either case, the domestic revenue of region 2 becomes larger, i.e., $\Delta r_{21} + \Delta r_{22} > 0$. Thus, the less productivity firms from region 2 can't survive before can survive now, φ_{2d}^* decreases. At the meantime, larger revenue induces more entry in region 2, w_2 is bid up.

When $\tau = \infty$, the **market potential effect** is zero, the **market competition effect** resulted by greater mass of firms from the rest of the world reduces the domestic revenue, r_{2d} . Therefore, φ_{2d}^* is raised up and w_2 is bid down by less entry. QED.

Proof of Corollary 2, Home Market Effect

(1) We know from the proof of Proposition 5 that

$$\frac{O_1^{im}}{O_2^{im}} = \left(\frac{P_1}{P_2}\right)^{\sigma-1} \Rightarrow \begin{cases} = 1, & \text{if } \tau = 1, \text{ since } P_1 = P_2 \\ < 1, & \text{if } \tau > 1, \text{ since } P_1 < P_2. \end{cases} \quad (48)$$

Comparing equation above with equation (45), and using the fact that H_i and w_i are monotonically decreasing in τ , we can get that the trade balance of region $i = 1, 2$ with the rest of the world $TB_i = H_i^{-\theta} M_i A (p_{ix}(\tilde{\varphi}_{ix}))^{1-\sigma} - M_x w_i L \left(\frac{p_x(\tilde{\varphi}_x)}{P_i}\right)^{1-\sigma}$ is

$$\Rightarrow \begin{cases} TB_1 > 0, TB_2 < 0, & \text{if } \infty > \tau \geq 1 \\ TB_1 = TB_2 = 0, & \text{if } \tau = \infty. \end{cases} \quad (49)$$

Thus, region 1 has an international trade surplus with the rest of the world while region 2 has an international trade deficit when $\tau < \infty$.

(2) The ratio of the number of exporting firms in region 1 to that of region 2 is

$$\frac{H_1^{-\theta} M_1}{H_2^{-\theta} M_2} = \frac{f H_2^\theta + \frac{f_x w}{w_2}}{f H_1^\theta + \frac{f_x w}{w_1}} = \frac{f w_2 H_2^\theta + f_x w w_1}{f w_1 H_1^\theta + f_x w w_2} \Rightarrow \begin{cases} > \frac{w_1}{w_2}, & \text{if } \tau^* > \tau \geq 1 \\ = \frac{w_1}{w_2}, & \text{if } \tau = \tau^* \\ < \frac{w_1}{w_2}, & \text{if } \tau > \tau^* > 1 \end{cases} \quad (50)$$

using equations (45) and (47). QED.

Proof of Proposition 6, Region 1 vs. Region 2 with Equal Entry Cost in Open

First, when $\tau = 1$, two regions are symmetric and have identical average productivity, wage, welfare, openness indices.

When τ rises, the domestic revenues r_{id} , $i = 1, 2$, decrease, the least productivity firms can't survive and exit, hence, φ_{id}^* rise. Lower revenue discourages entry in both regions, wages, w_i , are bid down. Hence φ_{1x}^* decreases. However, φ_{2x}^* increases due to the rise of τ , so H_1 decreases but H_2 increases accordingly. The opposite effects on H_i of the rise of τ can be seen from equations (10) and (22), which can be rewritten as below:

$$H_1^{\sigma-1} = \frac{f_x w L}{A f \tau_x^{1-\sigma}} \left(P_1^{\sigma-1} + \left(\frac{w_2}{w_1} \right) \left(\frac{P_2}{\tau} \right)^{\sigma-1} \right), H_2^{\sigma-1} = \frac{f_x w L}{A f \tau_x^{1-\sigma}} \left((\tau P_2)^{\sigma-1} + \left(\frac{w_1}{w_2} \right) P_1^{\sigma-1} \right).$$

Since firms from region 1 have higher possibility of getting profit from the rest of the world, more entry is induced to region 1, wage is bid up, $w_1 > w_2$. The survival productivity threshold in region 1 rises more than that in region 2, $\varphi_{1d}^* > \varphi_{2d}^*$. And the price index in region 1 is lower than that in region 2, $P_1 < P_2$. Thus, welfare per labor in region 1 is higher than that in region 2, $\omega_1 > \omega_2$.

Second, when $\tau = \infty$, region 2 becomes autarky and can't trade with the rest of the world or region 1. Thus, $O_1^{ex} > O_2^{ex} = 0$, $O_1^{im} > O_2^{im} = 0$, $H_1 < H_2 = \infty$, $w_1 > w_2$, $P_2 > P_1$, $\omega_1 > \omega_2$.

Third, as results above, O_1^{ex} is monotonically increasing in τ while O_2^{ex} is mono-

tonically decreasing in τ . Therefore,

$$\left\{ \begin{array}{l} \frac{O_1^{ex}}{O_2^{ex}} > 1, \quad \text{if } \tau > 1 \\ \frac{O_1^{ex}}{O_2^{ex}} = 1, \quad \text{if } \tau = 1 \end{array} \right. \Leftrightarrow \left\{ \begin{array}{l} \frac{H_1^\theta w_1}{H_2^\theta w_2} < 1, \\ \frac{H_1^\theta w_1}{H_2^\theta w_2} = 1. \end{array} \right. \Leftrightarrow \left\{ \begin{array}{l} \frac{\varphi_{1d}^*}{\varphi_{2d}^*} > 1, \\ \frac{\varphi_{1d}^*}{\varphi_{2d}^*} = 1. \end{array} \right. \Leftrightarrow \left\{ \begin{array}{l} \frac{\tilde{\varphi}_{1d}}{\tilde{\varphi}_{2d}} > 1, \\ \frac{\tilde{\varphi}_{1d}}{\tilde{\varphi}_{2d}} = 1. \end{array} \right. \quad (51)$$

From the proof of Proposition 5 above, we can write the ratio of import openness indices in two regions as below,

$$\frac{O_1^{im}}{O_2^{im}} = \tau^{\sigma-1} \left(\frac{P_1}{P_2} \right)^{\sigma-1} > 1,$$

since $\frac{P_1^{\sigma-1}}{P_2^{\sigma-1}} > \tau^{1-\sigma}$ from equation (18) when $\tau > 1$.

The ratios are increasing in τ are the results of the monotonicity of H_i , w_i . QED.

Proof of Proposition 7, Region 1 vs. Region 2 with Different Entry Cost in Open

First, the proofs of that the ratios are greater than 1 and ratios in open are larger than that in autarky are similar to the proofs of Proposition 5 and 6.

Second, the relationship of ratios of survival productivity cutoffs in two regions with and without different entry costs is

$$\left(\frac{\varphi_{1d}^*}{\varphi_{2d}^*} \right)_{dec}^\theta = \frac{f_{e2} f + \frac{f_x w}{H_1^\theta w_1}}{f_{e1} f + \frac{f_x w}{H_2^\theta w_2}} = \frac{f_{e2}}{f_{e1}} \left(\frac{\varphi_{1d}^*}{\varphi_{2d}^*} \right)_{eec}^\theta > \left(\frac{\varphi_{1d}^*}{\varphi_{2d}^*} \right)_{eec}^\theta > 1, \quad (52)$$

here, subscripts of *dec* and *eec* denote the *different entry costs* and *equal entry costs* respectively.

Since average revenue is increasing in the average productivity, $\left(\frac{R_1}{R_2} \right)_{dec} > \left(\frac{R_1}{R_2} \right)_{eec}$
 $\Leftrightarrow \left(\frac{w_1}{w_2} \right)_{dec} > \left(\frac{w_1}{w_2} \right)_{eec}$. The ratio of two regional price indices becomes larger with larger productivity gap, thus, $\left(\frac{\omega_1}{\omega_2} \right)_{dec} > \left(\frac{\omega_1}{\omega_2} \right)_{eec}$. QED.

Proof of Corollary 3, Home Market Effect with Different Transport Costs

The ratio of the number of exporting firms in region 1 to that of region 2 is

$$\frac{H_1^{-\theta} M_1}{H_2^{-\theta} M_2} = \frac{f H_2^\theta + \frac{f_x w}{w_2}}{f H_1^\theta + \frac{f_x w}{w_1}} = \frac{f w_2 H_2^\theta + f_x w w_1}{f w_1 H_1^\theta + f_x w w_2} > \frac{w_1}{w_2}, \quad (53)$$

using equation (51) when $\tau > 1$ or (52) when $f_{e1} < f_{e2}$. QED.