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Footloose Capital, Educational Choice, and Wage Inequality

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Abstract

This study investigates wage inequality between high- and low-skilled workers in a two-region footloose capital model with endogenous educational choices. Firms' location decisions are governed by two opposing forces: agglomeration force and dispersion force. Comparative statics are conducted regarding the transportation costs of the differentiated goods sector. When consumers' preference for differentiated goods are weak relative to homogeneous goods, declining transportation costs push firms from the populous region to the peripheral. Furthermore, wage inequality in the core region shrinks, but expands in the peripheral region.

JEL Classification F16, J24, R12
Keywords wage inequality, footloose capital model, home market effect, educational investment

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1 Introduction

1.1 Purpose of the Study

The globalization of economic activity, such as increasing international trade and capital flows, has been blamed as one of the possible causes of wage inequality in many countries. However, wage inequality has many aspects to it and this study focuses on inequality between high-skilled (highly educated) and low-skilled (under educated) workers, which may differ across regions in any given country.

The questions addressed are the following: what types of regions generate large wage inequalities between skill groups? Is the degree of inequality affected by changing the fluidity of interregional trade of goods? If so, what is the underlying mechanism?

Previous research on economic geography and local labor markets has shown that wage inequality between skill groups is greater in more populous regions than in peripheral regions. Behrens and Robert-Nicoud (2015) conducted a comprehensive survey that stressed the sorting of high-skilled workers in large cities. When workers are heterogeneous and there is some distribution of skill levels, the higher the worker's skill, the larger the incentive to enter the metropolitan area[1]. Many empirical studies also point out that wage inequality between skill groups is larger in metropolitan areas (see Glaeser, Resseger, and Tobio, 2009; Duranton and Monastiriotis, 2002 for the U.K.; Combes et al., 2012 for France).

Another possible source of wage inequality is the difference in returns on education across regions. The college wage premium is typically higher in densely populated areas. This gives workers in populous regions a higher incentive to get educated. Consequently, workers in peripheral regions become increasingly reluctant to invest in education, leading to a lower wage premium[2].

It remains to be explained why the return on education is higher in the more populous regions. We address this issue by using a theoretical model of new economic geography, without assuming the mobility of workers across regions. New economic geography emphasizes agglomeration force generated by the increasing returns to scale technology and

1 This mechanism is formally shown in a new economic geography model with heterogeneous agents by Baldwin and Okubo (2006).

2 Using metropolitan data in the U.S., Berry and Glaser (2005) and Lindley and Machin (2014) state that the college wage premium is higher in large cities and the difference across regions has been diverging after the 1990s.

transportation costs. To save on transportation costs to deliver their products, many firms typically prefer to locate in more populous regions (the core). Firms are locked-in to a few metropolitan areas of a country, raising demand for high-skilled labor therein. Under these circumstances, increasing freeness of interregional trade of goods induced by the improving of transportation infrastructure should widen wage inequality between the core and periphery.

We try to point out another mechanism which would reverse the tendency of firms to agglomerate in the core and wages to increase only in metropolitan areas. Our focus is the cost of educational investment. To obtain education, one must incur the costs by themselves. Since the cost differs across workers, some may choose to become highly skilled, while others may not. From a firm's perspective, the cost of increasing employment of high-skilled workers is affected by the workers' educational choice. Although being in a populous region is beneficial for firms concerning standard agglomeration economies, it is also counteracted by the increasing cost (wage) of hiring high-skilled workers. When this dispersion force is stronger than the agglomeration force, firms relocate to peripheral regions where they can hire relatively cheap high-skilled workers.

The process of emerging of industrial clusters are far from monotonic in many developed nations. In Japan, for example, automobiles and heavy industry plants first clustered in coastal metropolitan areas in the mid-20th century. By century end, however, they faced shortage and difficulty of hiring high-skilled workers. Now they have another industrial clusters hundreds of miles away from their original headquarters. This process has contributed to the renaissance of peripheral regions and narrowing of interregional wage inequality. This is what we want to show in the formal model described in the followings.

Specifically, we analyze the endogenous choice of educational investment by each worker in a two-region "footloose capital" model of Martin and Rogers (1995) without interregional mobility of workers[3]. Additionally, we investigate the effects of declining transportation costs of goods under the assumption of free mobility of capital between regions. This model choice can be justified because the mobility of capital is greater than that of labor. Moreover, a firm's movement is often seen as a fundamental driver of labor demand at the regional level[4]. In turn, a firm's locational choice is affected by its prospects of obtaining sufficient

3 In this sense, the model is complementary to most previous literature, which assumes free mobility of workers across regions.

4 Helpman (2018: 171–172) states that "both migration and capital mobility interact with foreign trade, offshoring, and foreign direct investment; and these interactions have the potential of producing combined effects on inequality that are different from the sum of their separate parts." We try to disentangle this by assuming

adequately skilled workers. Thus, it is natural to investigate the interplay between a firm's movement and a worker's educational choice, focusing on causality in both directions.

1.2 Literature Review

Previous research closest to this study is Toulemonde (2006) and Takatsuka (2011). Both use Martin and Rogers' (1995) footloose capital model in a two-region economy and investigate wage inequality between high- and low-skilled workers.

Toulemonde (2006) analyzes the endogenous educational choices of low-skilled workers and firms' agglomeration. The main mechanism is the income effect on the demand side arising from high-skilled wages. As more workers become educated, their demand for differentiated goods increases and induces more firms to locate in "high-skilled regions." In Toulemonde (2006), education and agglomeration go together, while we abstract from the income effect and focus on another aspect (the cost of educational investment), which is a dispersion force.

Takatsuka (2011) stresses high-skilled wages as a dispersion force. However, the structure of the model differs from ours. Takatsuka (2011) assumes that high-skilled labor is mobile between regions, while total supply is determined exogenously. In contrast, we assume that workers are immobile and can get educated endogenously. Other studies include Pflüger (2004), Picard and Toulemonde (2004), and Takahashi, Takatsuka, and Zeng (2013), among others.

The remainder of this paper is organized as follows: Section 2 establishes the model; Section 3 derives the equilibrium; Section 4 contains comparative statics regarding declining transportation costs; Section 5 introduces an analysis of education subsidies; finally, Section 6 summarizes the study.

2 The Model

First, we define the economic agents and the basic environment of the two-region economy. Second, we introduce consumer behavior, the firms' production structure, and the workers' endogenous educational choice.

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only the movement of capital at once.

2.1 Basic Setup

There are two regions ($j = 1, 2$) in this economy. Homogeneous goods q_0 and differentiated goods $q(i)$ are produced by using high-skilled and low-skilled labor and physical capital. Labor force of region j is fixed at L_j: they are all low-skilled labor *ex-ante* and can get educated to become high-skilled endogenously. Capital endowment of region j is also exogenous and fixed at K_j. Labor is not allowed to move between regions, while capital can move freely.[5] More precisely, capital owners in region j invest their capital wherever the returns are the highest, while all of their capital income is repatriated to the region of their residence.[6]

For simplicity, one unit of homogeneous goods can be produced with only one unit of low-skilled labor. Each agent is endowed with $\bar{q}_0$ units. Under perfect competition, homogeneous goods can be traded between regions without any transportation costs. As we assume imperfect specialization, both regions produce at least some amount of homogeneous goods and hire some low-skilled workers. The wage rate of low-skilled workers in region j, w_{Lj}, is therefore always set to $w_{L1} = w_{L2} = 1$, if we choose homogeneous goods to be the numéraire. The determination of high-skilled wage w_{Hj} is analyzed later.

Differentiated goods of variety i, $q(i)$, are produced with all three types of production factors, with increasing returns to scale technology under monopolistic competition. In particular, to establish a firm, it is necessary to employ one unit of capital and δ units of high-skilled labor as fixed cost. Variable costs are incurred for low-skilled labor only[7]. To keep the model simple, the marginal product of low-skilled labor is set to one, without loss of any generality. The total varieties N of differentiated goods in this economy is therefore constant and $N = K_1 + K_2$, while how much of them are produced in region 1 or 2 remains to be determined endogenously. To export differentiated goods between regions, firms must pay τ units of homogeneous goods as transportation costs. The main concern is the effects of declining transportation costs τ on the interregional movements of differentiated goods firms.

We abstract from any trade caused by interregional differences in factor proportions (i.e.,

5 This assumption is justified from the following two perspectives: First, the two regions could be interpreted as "countries," where international movement of capital is far easier than that of labor; second, interregional migration within any country is also far less than that of capital.

6 This is a common feature of Martin and Rogers' (1995) footloose capital model. See Pflüger (2004) for the comparison of this assumption and an alternative under which capital owners move with their income to consume in the region they use the capital.

7 This assumption is made to obtain an explicit analytical solution of the model.

K_j/L_j). Without the loss of generality, we assume region 1 is endowed with a fraction $\theta > 1/2$ of the total amount of labor L and capital K: $L_1 = \theta L$, where $L \equiv L_1 + L_2$, and $K_1 = \theta K$, where $K \equiv K_1 + K_2$. We may sometimes refer to region 1 as "the larger region."

2.2 Consumption

There are L_j workers and K_j owners of capital in region j. As a consumer, each of them derives utility according to the function by Ottaviano, Tabuchi, and Thisse (2002):

$$U = \alpha \int_0^N q_j(i)di - \frac{\beta - \gamma}{2} \int_0^N \left[q_j(i)\right]^2 di - \frac{\gamma}{2} \left(\int_0^N q_j(i)di \right)^2 + q_0, \tag{1}$$

where $\alpha > 0$ and $\beta > \gamma > 0$ are parameters that represent the characteristics of consumers' preference. Large values of α indicate strong preference for differentiated goods over homogeneous goods, while a large β captures the strength of "love for variety" in differentiated goods. γ is a parameter of the degree of substitutability among differentiated goods: the larger γ is, the closer substitutes these goods are.

Budget constraint of a consumer in region j with income y is

$$\int_0^N p_j(i)q_j(i)di + q_0 = y + \bar{q}_0. \tag{2}$$

Recall that N is the total available differentiated goods. Utility maximization yields the following demand function for each of the differentiated goods:

$$q_j(i) = a - (b + cN)p_j(i) + cP_j, \tag{3}$$

where parameters a, b, and c in equation (3) are defined such that[8]

$$a \equiv \frac{\alpha}{\beta + (N-1)\gamma}, \; b \equiv \frac{1}{\beta + (N-1)\gamma}, \; c \equiv \frac{\gamma}{(\beta - \gamma)[\beta + (N-1)\gamma]},$$

and P_j is the price index of differentiated goods in region j:

$$P_j \equiv \int_0^N p_j(i)di.$$

Hereafter, we denote the amount of differentiated goods made in region r and consumed in s using q_{rs}, and their corresponding prices using p_{rs}. As firms are symmetric, q_{rs} and

8 These normalizations are made in Ottaviano, Tabuchi, and Thisse (2002) and many studies thereafter: e.g., Fujita and Thisse (2013).

p_{rs} are common for all firms in region j. To clarify, if we denote by n the number of firms in region 1 and by remaining $N - n$ that in region 2, price indices of each region are

$$P_1 = np_{11} + (N - n)p_{21}, \tag{4}$$

$$P_2 = np_{12} + (N - n)p_{22}. \tag{5}$$

Demand functions (3) for each type of differentiated goods q_{rs} are thus

$$q_{11} = a - (b + cN)p_{11} + cP_1,$$

$$q_{21} = a - (b + cN)p_{21} + cP_1,$$

$$q_{22} = a - (b + cN)p_{22} + cP_2,$$

$$q_{12} = a - (b + cN)p_{12} + cP_2.$$

2.3 Production

Firms producing differentiated goods in region 1 maximize the following profit function:

$$\pi_1 = (p_{11} - 1)q_{11}(L_1 + K_1) + (p_{12} - 1 - \tau)q_{12}(L_2 + K_2) - \delta w_{H1} - r_1. \tag{6}$$

The first term on the right-hand side is the firms' profit from sales in region 1. Note that individuals' demand does not depend on their income y. The total sales in region 1 firms in (6) are, therefore, unaffected by educational choices of workers in either region. The second term is their counterpart in region 2, where transportation costs τ marginal costs $w_{L1} = 1$ are subtracted. Factor Prices w_{H1} and r_1 are determined endogenously.

The first order condition concerning p_{11} and p_{12} for this profit function π_1 yields

$$p_{11} = \frac{1}{2} + \frac{a + cP_1}{2(b + cN)}, \tag{7}$$

$$p_{12} = \frac{1 + \tau}{2} + \frac{a + cP_2}{2(b + cN)}. \tag{8}$$

Similarly, profits of firms in region 2 are

$$\pi_2 = (p_{22} - 1)q_{22}(L_2 + K_2) + (p_{21} - 1 - \tau)q_{21}(L_1 + K_1) - \delta w_{H2} - r_2, \tag{9}$$

maximization of which yields:

$$p_{21} = \frac{1 + \tau}{2} + \frac{a + cP_1}{2(b + cN)}, \tag{10}$$

$$p_{22} = \frac{1}{2} + \frac{a + cP_2}{2(b + cN)}. \tag{11}$$

By inserting (7) and (10) into the definition of price index (4), we can show P_1 as a function of the number of firms n in region 1 (that of region 2 follows analogously).

$$P_1 = \frac{b + cN}{2b + cN} [N + \tau(N - n)] + \frac{aN}{2b + cN},$$
$$P_2 = \frac{b + cN}{2b + cN} (N + \tau n) + \frac{aN}{2b + cN}.$$

It is straightforward to represent prices p_{rs} also in the following way:[9]

$$p_{11} = \frac{1}{2} + \frac{a}{2b + cN} + \frac{c\,[N + \tau(N - n)]}{2(2b + cN)},$$
$$p_{21} = p_{11} + \frac{\tau}{2},$$
$$p_{22} = \frac{1}{2} + \frac{a}{2b + cN} + \frac{c(N + \tau n)}{2(2b + cN)},$$
$$p_{12} = p_{22} + \frac{\tau}{2}.$$

2.4 Educational Choice and the Labor Market

Each low-skilled worker has an opportunity to get skilled; we call this "education." Specifically, by paying as cost of education ϵ units of homogeneous goods, they can become high-skilled workers. The costs ϵ differ by person and are distributed according to the uniform distribution defined over some finite range $\epsilon \in [\check{\epsilon},\ \hat{\epsilon}]$. The range is assumed to be identical for both regions[10]. There is no uncertainty regarding the costs and results of education.

In equilibrium, low-skilled workers correctly expect their wages if they get educated w_{Hj} and rationally choose whether to become high-skilled. Those with education costs below ϵ_j^*

9 Their corresponding demands q_{rs} also follow immediately:

$$q_{11} = \frac{b + cN}{2(2b + cN)} [2a - (2b + cN) + c\,\{N + \tau(N - n)\}],$$
$$q_{21} = q_{11} - \frac{\tau(b + cN)}{2},$$
$$q_{22} = \frac{b + cN}{2(2b + cN)} [2a - (2b + cN) + c(N + \tau n)],$$
$$q_{12} = q_{22} - \frac{\tau(b + cN)}{2}.$$

10 Alternatively, Sato and Yamamoto (2012) analyzed another setup under which education costs are identical for all workers, while their endowment of "high-skilled labor" differs according to their respective abilities. In their formulation, the supply of high-skilled labor increases more than proportionately as more low-skilled labor chooses to become educated. This adds another mechanism to lower the wage of high-skilled labor w_H through excess supply. Our scenario was selected for the sake of simplicity.

get educated, while those above ϵ_j^* choose to stay uneducated, where ϵ_j^* is defined as:

$$w_{Hj} - \epsilon_j^* = w_{Lj} = 1.$$

The market clearing condition for high-skilled labor in region 1 is

$$n\delta = L_1 \frac{\epsilon_1^* - \check{\epsilon}}{\hat{\epsilon} - \check{\epsilon}} = L_1 \frac{w_{H1} - 1 - \check{\epsilon}}{\hat{\epsilon} - \check{\epsilon}}. \tag{12}$$

The left-hand side of (12) shows the demand for high-skilled labor while the right-hand side is their supply. It is readily verified that the number of firms n is positively associated with high-skilled wage w_{H1}. Intuitively, as more firms operate in region 1, the demand for high-skilled workers increases as fixed input for firms' setup. These demands must be met by a corresponding supply of high-skilled workers. However, to entice those who did not get educated to alter their mind, some incentive like higher wage w_{H1} is needed. The equilibrium condition for the high-skilled labor market in region 2 follows analogously:

$$(N - n)\,\delta = L_2 \frac{w_{H2} - 1 - \check{\epsilon}}{\hat{\epsilon} - \check{\epsilon}}. \tag{13}$$

3 Equilibrium

3.1 Arbitrage of Footloose Capital

In the equilibrium, differentiated goods firms can enter the market freely in both regions under monopolistic competition. This situation is described by zero-profit conditions, that is, profits in both (6) and (9) are set equal to zero. Furthermore, in an economy with no impediments to interregional capital movements, capital owners may seek locations where returns are the highest. Effectively, returns on capital are equalized between regions ($r_1 = r_2$). Specifically, the following equation must hold in equilibrium:

$$\begin{aligned}&(p_{11} - 1)q_{11}(L_1 + K_1) + (p_{12} - 1 - \tau)q_{12}(L_2 + K_2)\\ &- [(p_{22} - 1)q_{22}(L_2 + K_2) + (p_{21} - 1 - \tau)q_{21}(L_1 + K_1)] = \delta\,(w_{H1} - w_{H2})\,.\end{aligned} \tag{14}$$

Note that in any standard footloose capital model with only one type of labor, the right-hand side of (14) is set to zero. However, this model has two types of labor. As high-skilled labor is assumed to be used for fixed costs in setting up firms, the right-hand side of (14) is the distinguishing feature.

3.2 Analytical Solution

We can calculate the left-hand side of (14) by substituting for p_{rs} and q_{rs} as derived in subsection 2.3. The right-hand side can be represented with n by the usage of (12) and (13). After some calculations, (14) becomes

$$\frac{\tau}{2}(b+cN)(L+K)\left[(2\theta-1)\left(\frac{2a+cN}{2b+cN}-\frac{2+\tau}{2}\right)+\frac{c\tau(\theta N-n)}{2b+cN}\right]$$
$$=\frac{\delta^2}{L}(\hat{\epsilon}-\check{\epsilon})\left(\frac{n}{\theta}-\frac{N-n}{1-\theta}\right). \tag{15}$$

Intuitively, the equilibrium condition of the footloose capital models of this kind means the arbitrage of capital (firms), i.e., whether to invest in the more populous region or the other. Locating in the core region yields two opposing effects[11]. On the one hand, there is the *market-access* advantage of serving their goods to the larger market without incurring transportation costs; expressed in the first term of the square bracket of (15). On the other hand, there is the *market-competition* disadvantage of locating near the large number of rival firms. As firms in a region increase, the markup price of monopolistic competition goes down, which is the well-known feature of the utility function of Ottaviano, Tabuchi, and Thisse (2002). Hence, the number of firms in region 1, n, partially diminishes the attractiveness of the core; expressed in the second term of the square bracket of (15). The sum of these two effects is a decreasing function of n.

In turn, the right-hand side of (15) is an increasing function of n. This can be interpreted as the *labor-supply* effect which indicates that "to hire more high-skilled workers in region 1, firms must pay higher wages to them." In other words, without giving workers incentives to get education, firms of differentiated goods sector cannot setup their plants.

As the left-hand side of (15) is decreasing in n and the right-hand side is increasing, we have a unique solution of the equilibrium number of differentiated goods firms in region 1 under some parameter restriction described later:

$$n^* = \theta N + \frac{(b+cN)(L+K)}{2}\frac{A(\tau)}{B(\tau)}(2\theta-1), \tag{16}$$

11 Fujita and Thisse (2013: 358–360) give a clear-cut explanation to these effects.

where $A(\tau)$ and $B(\tau) > 0$ are some constants including transportation costs τ, specified as:

$$A(\tau) \equiv \tau \left(\frac{2a + cN}{2b + cN} - \frac{2 + \tau}{2} \right), \tag{17}$$

$$B(\tau) \equiv \frac{\delta^2}{L} (\hat{\epsilon} - \check{\epsilon}) \frac{1}{\theta(1-\theta)} + \frac{c\tau^2(b + cN)}{2(2b + cN)}(L + K). \tag{18}$$

Since we have an explicit solution for n^*, the number of firms in region 1, it is readily verified that if $A(\tau) > 0$, we have *the home market effect*. In other words, if region 1 has more than half of the total labor force and total capital ($\theta > 1/2$), the number of firms located in region 1 is larger than its endowment[12] ($n^* > \theta N$). The proposition below confirms this, as long as the transportation costs are not prohibitively high from the beginning.

Proposition 1. As long as there are some positive amounts of interregional trade, the number of differentiated goods firms in region 1 is larger than its endowment of capital ($n^* > \theta N$).

Proof. Apparently, the trade flow of differentiated goods q_{12} is always smaller than the counterpart q_{21}. Furthermore, the amount q_{12} is an increasing function of n:

$$q_{12} = (b + cN) \left[\frac{a}{2b + cN} - \frac{2 + \tau}{2} + \frac{c(N + \tau n)}{2(2b + cN)} \right].$$

A sufficient condition for positive interregional trade is hence $q_{12} > 0$, when n is the smallest, $n = 0$. After some calculations, the condition is:

$$\frac{2a + cN}{2(2b + cN)} > \frac{2 + \tau}{2}. \tag{19}$$

By comparing (19) and (17), we can verify that $A(\tau) > 0$, whenever (19) holds.

With the number of firms n, we can compare the high-skilled wage in both regions w_{H1} and w_{H2} from (12) and (13). It can be shown that $w_{H1} > w_{H2}$, if condition (19) is met. We can, thus, conclude that wage inequality between high- and low-skilled workers is larger in region 1. This result complements previous empirical studies, such as Behrens and Robert-Nicoud (2015).

Proposition 2. As long as there are some positive amounts of interregional trade, wage inequality in region 1 is larger than that in region 2 ($w_{H1} > w_{H2}$).

12 That is, capital flows from a smaller region to a larger region.

Lastly, we check the condition for interior equilibrium under which the full agglomeration of differentiated goods firms in region 1 does not occur ($n^* < N$). From equation (16), this condition is

$$\frac{b+cN}{2b+cN}(L+K)\tau\left[\left\{(2\theta-1)b+\frac{cN}{2}\right\}\tau+2(2\theta-1)(b-a)\right]+\frac{2N\delta^2}{\theta L}(\hat{\epsilon}-\check{\epsilon})>0. \tag{20}$$

A sufficient condition for this to hold is $b > a$, which is equivalent to $\alpha < 1$ in the original utility function (1). This condition states that the utility from differentiated goods is relatively weaker than that from homogeneous goods. Intuitively, if $\alpha < 1$, then the home market effects generated by differentiated goods sector, i.e., the advantage of proximity to the larger market, is not too strong. It is profitable for some firms to locate in region 2, accordingly.

4 Declining Transportation Costs

In standard models of new economic geography, the home market effect is generally strengthened by declining transportation costs. For example, Fujita and Thisse (2013: 350–360) show that in a footloose capital model, the number of firms in the larger region 1 (n in our model) increases as τ declines. In contrast, we added the educational choice of workers and assumed that high-skilled workers are required to establish differentiated goods firms. This acts as a dispersion force, which would partially offset the home market effect under some conditions.

Since we have an explicit solution n^* for the number of firms in region 1, comparative statics for transportation costs τ can be shown.

Proposition 3. As long as $b > a$, the number of differentiated goods firms in region 1 decreases when transportation costs τ decline. If $b > a$ does not hold, the effect is ambiguous.

Proof. By inspecting (16), we see that the effect of τ on n^* is entirely through $A(\tau)/B(\tau)$. Its sign can be calculated as:

$$\begin{aligned}&\operatorname{sign}\frac{d}{d\tau}\frac{A(\tau)}{B(\tau)}\\ &=\operatorname{sign}\left(\frac{2a+cN}{2b+cN}-1-\tau\right)\frac{\delta^2}{L}\frac{\hat{\epsilon}-\check{\epsilon}}{\theta(1-\theta)}+\frac{c\tau^2(b+cN)}{2(2b+cN)^2}(L+K)(b-a)\end{aligned} \tag{21}$$

The first parenthesis of (21) is positive, if the trade condition (19) holds. The second term of (21) is also positive when $b > a$. In contrast, the sign of (21) is ambiguous and can be negative when $b > a$ does not hold.

This model contains both agglomeration and dispersion forces for firms. Agglomeration force is the standard home market effect. Locating in larger market is beneficial for firms because they can serve their differentiated goods to many consumers without incurring transportation costs (the market-access advantage). When transportation costs τ are high, two regions in this economy are isolated, and interregional trade of differentiated goods is scarce, not if impossible. The market-access advantage, therefore, is stronger when τ is high. Hence having $A'(\tau) > 0$ in (21).

The dispersion forces are twofold. First, the utility function of Ottaviano, Tabuchi, and Thisse (2002) captures the competition effect of differentiated goods firms. As firms in one region increase, they must set lower prices in equilibrium (the market-competition disadvantage). When transportation costs τ are high, this competition becomes severer in the larger region 1: $B'(\tau) > 0$ in (21)[13]. Both the market-access advantage and market-competition disadvantage are stronger under high τ.

Second, is the dispersion force coming from the educational choice of workers (labor-supply effect). As more firms agglomerate in one region, it is necessary to employ high-skilled workers to set up new differentiated goods firms. Highly skilled workers, in turn, are available only through costly educational investments, which are self-paid. To induce someone, lacking education, to alter their mind, incentives like higher wages w_H are necessary. High firm setup costs gradually make it difficult for firms to agglomerate and choose to hire high-skilled workers more cheaply in the smaller regions. This effect is independent of transportation costs τ: see the first term of $B(\tau)$ in (18). However, this effect acts as another dispersion force which is absent in most previous studies[14]. This is why declining

13 For some intuition, think of the other extreme case of $\tau = 0$. There, the competition pressure is identical in the core region 1 and periphery 2. Thus, increasing the number of firms n in region 1 does not make any disadvantage to region 1. Note also that the home market effect vanishes and each region attracts exactly the same number of firms as their own endowment of capital. Factor price equalization prevails and $w_{H1} = w_{H2}$. Takahashi, Takatsuka, and Zeng (2013) show that interregional difference in wage rate emerges only when transportation costs are positive and finite (not equal to zero nor infinity) in footloose capital models.

14 To verify this, consider a special case of this model with $\delta = 0$. If differentiated goods firms do not need high-skilled workers, there is no incentive to get educated and this model degenerates to the one with only 1 type of labor; showing that n^* is *decreasing* in τ, i.e., the agglomeration of firms in region 1 is strengthened as transportation costs decline.

transportation costs τ leads to *smaller* agglomerations in the larger region[15].

Here, wage inequality between high- and low-skilled workers in region 1 shrinks while expanding in region 2. As transportation costs decline, both the market-access advantage and market-competition disadvantage of region 1 are mitigated. When $b > a$, the disadvantage dominates and some firms relocate themselves to region 2. Demand for high-skilled labor in region 1 declines accordingly, while increasing in region 2.

5 Education Subsidies

For a smaller region, it is natural to attract differentiated goods firms by supporting educational investments of residents. The government in region 2 offers some education subsidy $s > 0$ for the homogeneous goods to all those who choose to invest in their education. This is financed by incurring some income tax t levied on all workers L_2 and capital owners K_2 in region 2. For simplicity, the tax rate is the same whether the worker gets an education. The government budget constraint for this tax and subsidy scheme is

$$t\,(L_2 + K_2) = sL_2 \frac{\epsilon_2^* - \check{\epsilon}}{\hat{\epsilon} - \check{\epsilon}}, \tag{22}$$

where the local government chooses the level of s. Note that the tax rate t is set according to (22) after the education cutoff ϵ_2^* is determined in equilibrium.

Workers' educational choices in region 2 are now determined according to

$$w_{H2} - \epsilon_2^* + s - t = 1 - t,$$

where those who have education costs lower than ϵ_2^* become high-skilled and those above ϵ_2^* stay uneducated. The labor market clearing condition for region 2 is

$$(N - n)\,\delta = L_2 \frac{(w_{H2} + s) - 1 - \check{\epsilon}}{\hat{\epsilon} - \check{\epsilon}}, \tag{23}$$

instead of (13).

The only difference from the previous model is the right-hand side of (14), where we have to substitute for w_{H2} by using (23) instead of (13). After some calculations, we arrive at

15 Notice that the condition $b > a$ of proposition 1 means low intensity of preference for the differentiated goods for the homogeneous goods. When differentiated goods are not that important in consumers' utility, the home market effect is weak and firms have little incentive to locate in the larger market. Takatsuka and Zeng (2018) also obtain similar results.

the solution for the number of differentiated goods firms in region 1, $n^*_{(s)}$ with education subsidy in region 2:

$$n^*_{(s)} = \theta N + \frac{(b + cN)(L + K)}{2} \frac{A(\tau)}{B(\tau)}(2\theta - 1) - \frac{\delta s}{B(\tau)}. \tag{24}$$

Since education subsidy s is some positive constant, $n^*_{(s)}$ is *smaller* than n^* without subsidy. This is a reasonable result, because the government in region 2 intended to attract more firms by promoting education. Note also that the byproduct of firms' relocation is the higher wage in region 2, w_{H2}.

6 Conclusions

Wage inequality between high- and low-skilled workers is investigated in a two-region footloose capital model with the endogenous educational choice of workers. The agglomeration force induces firms to be located in a region with a large population, while hiring many high-skilled workers requires costly educational investments. When consumers' preference for differentiated products is weak, the latter force dominates the former. Furthermore, declining transportation costs push firms to the peripheral region. The wage inequality in the core region shrinks, while expanding in the peripheral region.

The present model can explain why some manufacturing firms in developed nations sometimes create new plants in rural areas rather than in existing industrial clusters. Further studies should explore policy instruments to promote both firms' relocation and the redistribution of regional income.

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