

Asymmetric Transportation Costs and the Direction of Capital Flows

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Abstract

This paper incorporates asymmetric inter-regional transportation costs into the two-region endogenous growth model in Martin and Ottaviano (1999) to analyze the relationship between the asymmetry of inter-regional transportation costs and the direction of capital flows between the two locations. We show that if the cost of transporting goods from the South to the North is larger (smaller) than the cost of transporting goods from the North to the South, then net capital flows are from the South (North) to the North (South).

Key words : Asymmetric inter-regional transportation cost, Industrial location, Net capital flows, growth

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I Introduction

The economic literature dealing with geographic space and economic growth is now quite voluminous. See, for example, Martin (1999), Baldwin (1999), Martin and Ottaviano (1999, 2001), Baldwin and Forslid (2000 a), and Baldwin, Martin, and Ottaviano (2001). For instance, Martin and Ottaviano (1999) combine the endogenous growth model in Grossman and Helpman (1991) and the location model in Martin and Rogers (1995) to account for the impact of openness on the world growth rate through the effect on industrial location. However, the models proposed in the literature assume “symmetric” transportation costs. Therefore, all of these models lack a proper adjustment mechanism for the relationship between the geographic space in which a firm operates and asymmetric transportation costs.

A few exceptions are Martin (1999) and Johdo (2013 a), who extend the two-region

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endogenous growth model of Martin and Ottaviano (1999) to incorporate asymmetric transportation costs and study how the asymmetry of transportation costs affects the growth rates through the effect on industrial location.¹ However, in their study, the question remains as to how the asymmetry of inter-regional transport costs affects the net capital flows (or foreign direct investments) between regions.²

To study the relation between asymmetric inter-regional transportation costs and the direction of the net capital flows, we apply the two-region endogenous growth model in Martin and Ottaviano (1999). This particular analysis demonstrates that if the cost of transporting goods from the South to the North is larger (smaller) than the cost of transporting goods from the North to the South, then net capital flows are from the South (North) to the North (South).

The remainder of the paper is structured as follows. Section 2 outlines the features of the model. Section 3 describes the equilibrium location and firm size and Section 4 details the R & D sector. In Section 5, we examine the relation between inter-regional transportation costs and net capital flows. The final section concludes the paper.

II Model Structure

We assume a two-region economy comprising North and South locations. The models for the North and South are identical save their initial stock of capital and transportation costs. We use an asterisk to denote the variables for the South. Henceforth, we mainly focus on a description of the Northern economy given the equivalence with the Southern economy. Unlike owners (households/workers), firms in this model are internationally mobile.

Both North and South households have perfect foresight and share the same utility function. The intertemporal objective of a representative household in the North is to maximize the following lifetime utility :

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- 1 For related works, Leite, Castro and Correia-da-Silva (2009) extend the static model of Krugman (1991) to incorporate asymmetric inter-regional transportation costs and study how the asymmetry of inter-regional transportation costs affects the industrial activities in a region. Kikuchi (2008) studies how the asymmetry of inter-regional transportation costs affects the industrial activities in a region by employing the static model of Martin and Rogers (1995). Johdo (2013 b) also studies the asymmetry of inter-regional transportation costs affects the home market effect by employing a constant returns monopolistic competition model.
 - 2 The main difference between Martin (1999) and Johdo (2013 a) is that the former focuses on the asymmetry of intra-regional transportation costs, whereas the latter focuses on the asymmetry of inter-regional transportation costs.

$$U = \int_0^{\infty} \log[D(t)^\alpha Y(t)^{1-\alpha}] e^{-\rho t} dt, \quad (1)$$

where ρ is the subjective discount rate, which is also identical in both countries, $Y(t)$ is the numeraire good in period t , and the consumption index $D(t)$ is defined as follows :

$$D(t) = \left[\int_{i=0}^{N(t)} D_i(t)^{1-\frac{1}{\sigma}} \right]^{\frac{1}{1-\frac{1}{\sigma}}}, \quad \sigma > 1, \quad (2)$$

where σ is the elasticity of substitution between any two differentiated goods, $D_i(t)$ is the consumption of good i in period t , and $N(t)$ is the total number of differentiated goods produced in both the North and the South. In this model, we introduce transportation costs on the differentiated goods. However, there is no transportation cost on the numeraire good. Here, we assume asymmetric iceberg transport costs in shipping the differentiated goods between countries. Specifically, τ_N ($\tau_N \geq 1$) units of a differentiated good have to be shipped from the South to the North for one unit to arrive at its destination. Similarly, τ_S ($\tau_S \geq 1$) units of a differentiated good have to be shipped from the North to the South for one unit to arrive at its destination. Henceforth, we omit the time subscript. The per capita expenditure of a typical North household E is then :

$$\int_0^n p_i D_i di + \int_0^{n^*} \tau_N p_j^* D_j dj + Y = E. \quad (3)$$

In this model, as shown in (3), the North consists of n firms and the remaining n^* firms are in the South, where n and n^* are endogenous and $n + n^* = N$ holds at each point in time. p_i is the producer price of a typical variety i in the North and p_j^* is its price in the South. The consumption price indices for the differentiated products are then :

$$P = \left(\int_0^n p_i^{1-\sigma} di + \int_0^{n^*} (\tau_N p_j^*)^{1-\sigma} dj \right)^{\frac{1}{1-\sigma}}, \quad (4)$$

$$P^* = \left(\int_0^n (\tau_S p_i)^{1-\sigma} di + \int_0^{n^*} p_j^{*1-\sigma} dj \right)^{\frac{1}{1-\sigma}}, \quad (5)$$

where P (P^*) is the price index in the North (South). In the differentiated goods sector, a patent is required to begin producing each variety of good, and therefore we can interpret this capital requirement as a fixed production cost (along with assuming increasing returns to scale technology). This immaterial capital requirement, however, allows a given patent owner to produce in more than one location at once, in principle. In order to exclude the case where the

patent can be used in more than one location at once, as in Martin (1999), we need to interpret the patent as a fixed cost inclusive of a piece of machinery (or one unit of physical capital). However, in this paper, as in Martin and Ottaviano (1999), we assume that a given patent owner produces a single differentiated good in only one location (a one-to-one correspondence between varieties and locations). Each firm issues equities to finance the fixed cost of the patent and distributes all profits to shareholders as dividends. In addition, each good requires β units of labor. Standard profit optimization by the choice of p_i yields $p_i = w\beta\sigma/(\sigma - 1)$. The profit flow of each firm in the differentiated goods sector is then :

$$\pi_{IRS} = p_i x_i(p_i) - w\beta x_i(p_i) = \frac{w\beta x}{(\sigma - 1)}, \quad (6)$$

where x is the size of output.

The homogeneous good Y is assumed to be produced using some constant returns to scale technology that requires labor as the only input where firms devote one unit of labor to produce one unit of Y . In addition, we assume that some production of the homogeneous good is active in both locations. Hence, we ensure factor-price equalization across locations $w = w^*$ at each instant because of free trade in the homogeneous good. As the numeraire is the homogeneous good, the wage rate in each location is $w = w^* = 1$. Therefore, we obtain $p = p^* = \beta\sigma/(\sigma - 1)$.

Here, we define $\delta_N \equiv \tau_N^{1-\theta} \in (0, 1)$ and $\delta_S \equiv \tau_S^{1-\theta} \in (0, 1)$ for convenience. From standard utility optimization given the choices of D_i , D_j and Y , each household spends a constant fraction α of its consumption expenditure E on the differentiated goods and the remaining $(1 - \alpha)$ of E on good Y :

$$D_i = \frac{\sigma - 1}{\beta\sigma} \frac{\alpha E}{n + n^* \delta_N}, \quad (7a)$$

$$D_j = \frac{\sigma - 1}{\beta\sigma} \frac{\tau_N^{-\alpha} \alpha E}{n + n^* \delta_N}, \quad (7b)$$

$$Y = (1 - \alpha)E. \quad (7c)$$

Next, we consider the stock market valuation of profit-making firms. Here, we define v as the equity value of a firm and r as the return on a riskless bond. A no-arbitrage condition in capital markets relates the expected return on equity to the return on an equally sized investment in the riskless bond. Therefore, by considering (6), we obtain :

$$\frac{\beta x}{\sigma - 1} + \dot{v} = rv. \quad (8)$$

Next, we solve the intertemporal optimization problem. The maximization of (1) subject to the intertemporal budget constraint and free capital mobility between locations requires that nominal expenditures grow at an instantaneous rate equal to $r - \rho$:

$$\frac{\dot{E}}{E} = \frac{\dot{E}^*}{E^*} = r - \rho. \quad (9)$$

As a result, if a balanced growth path exists, then nominal expenditures must be constant and, consequently, $r = \rho$.

III Firm Sizes and Locations

Here, we determine firm sizes (x, x^*) and locations (n, n^*) for a given level of expenditure (E, E^*). Aggregating the demands in (7 a) and (7 b) across all households worldwide yields the following market-clearing condition for any differentiated product x :

$$x = \frac{\alpha L(\sigma - 1)}{\beta \sigma} \left(\frac{E}{n + n^* \delta_N} + \frac{\delta_S E^*}{n^* + n \delta_S} \right), \quad (10 a)$$

where L is the amount of labor endowment that is equal in both locations. Similarly, for any product x^* , we obtain:

$$x^* = \frac{\alpha L(\sigma - 1)}{\beta \sigma} \left(\frac{\delta_N E}{n + n^* \delta_N} + \frac{E^*}{n^* + n \delta_S} \right). \quad (10 b)$$

The model assumes that firms do not face any relocation costs so relocating does not require any time. For a firm to be indifferent between the North and the South locations following location arbitrage, the operating profits from the two locations must also be equal:

$$\pi_{IRS} = \pi^*_{IRS}. \quad (10 c)$$

Therefore, from equations (6), (10 c) and $w = w^* = 1$, we obtain $x = x^*$. Here, we set K and K^* as the number of firms owned by the North and the South, respectively. In addition, the total stock of capital owned by agents fixes the total number of firms, such that:

$$n + n^* = K + K^* = N. \quad (10 d)$$

Solving (10 a) – (10 d), we obtain the share of firms in the North, where we define γ as :

$$\gamma = \frac{n}{N} = \frac{(1 - \delta_N)E - (1 - \delta_S) \delta_N E^*}{(1 - \delta_N)(1 - \delta_S)(E + E^*)}. \quad (11)$$

The level of output of each firm is :

$$x = \alpha L \frac{\sigma - 1}{\beta \sigma} \frac{E + E^*}{N}. \quad (12)$$

This is identical to that in Martin (1999) and Martin and Ottaviano (1999).

IV R & D Sector with Global Spillovers

Next, we turn to the R & D sector. We assume that forward-looking researchers decide on the amount of R & D investment, and that the R & D technology is linear, whereby the invention of a new good is directly proportional to the labor devoted to the activity. To consider the incentive for researchers to engage in innovative R & D, let v denote the value of a blueprint developed through innovative R & D. As in Martin and Ottaviano (1999), we assume that a researcher that undertakes R & D activities requires η/N units of labor because, under global spillovers, the R & D cost is the same in both locations. In the endogenous growth literature, it has often been assumed that technological knowledge contributed by local R & D is a global public good and the knowledge spillovers augment R & D productivity worldwide.³ Important contributions to this literature include Rivera-Batiz and Romer (1991 a, b), Grossman and Helpman (1991), Baldwin and Forslid (1999, 2000 b) and Peretto (2003).⁴ Free entry into the R & D sector therefore leads to $v = \eta/N$.

V Asymmetric Transportation Costs, Location and Growth

In this section, we derive the solution for a steady state in which the share of firms in the North and the growth rate of N do not change (i.e., $\gamma = n/N$ and $g (= \dot{N}/N)$ are constants). As

3 Lee et al. (2004) attempt to provide a justification for the relationship between openness and growth empirically.

4 Grossman and Helpman (1995) present a survey of the relationship between international trade and endogenous growth in more detail

the equity value of each firm equals that of the blueprint it owns, the equity value of any firm v is determined by the free-entry condition in the R & D sector: $v = \eta/N$. If a balanced growth path exists, this implies that v decreases at rate $g = \dot{N}/N = \dot{n}/n$. The world labor market-clearing condition is the same as that in Martin and Ottaviano (1999):

$$\eta g + \left(\frac{\sigma - \alpha}{\sigma}\right)L(E + E^*) = 2L. \quad (13)$$

If g is constant in the steady state, then equation (13) implies that expenditures must be constant. This leads to $r = \rho$. Then, substituting equation (12), $v = \eta/N$, and $r = \rho$ into equation (8) and considering (13) yields the following equilibrium growth rate:

$$g = \frac{2L}{\eta} \frac{\alpha}{\sigma} - \left(\frac{\sigma - \alpha}{\sigma}\right)\rho. \quad (14)$$

Here, for simplicity, we assume that each North and South household owns an equal number of firms (i.e., $K = K^*$) so that they receive an equal per capita dividend income from capital investment. Then, the respective steady-state levels of per capita expenditure for each location are:

$$E = E^* = 1 + \frac{\rho\eta}{2\gamma L}. \quad (15)$$

Substituting (15) into the equilibrium share of firms in the North given by equation (11) yields:

$$\gamma = \frac{n}{N} = \frac{1}{2} \left[\frac{1 - \delta_N - (1 - \delta_S)\delta_N}{(1 - \delta_N)(1 - \delta_S)} \right]. \quad (16)$$

From (16), we obtain the parametric condition required for γ to lie between 0 and 1 (an interior equilibrium):

$$1 - \delta_N > (1 - \delta_S)\delta_N, \quad 1 - \delta_S > (1 - \delta_N)\delta_S \quad (17)$$

Here, following Martin and Ottaviano (1999), we define the scale of net capital flows as $I \equiv (dn/dt) - (dK/dt)$, where the former is the change in the number of firms operating in a location and the latter is the change in the number of firms owned by households in the same location. Therefore, $I > (<) 0$ implies that net capital flows will be from the South (North) to

the North (South). Then, from (10 d), (16) and $K = K^*$, the scale of net capital flows is :

$$I \equiv \frac{dn}{dt} - \frac{dK}{dt} = g(n - K) = g \left[\frac{\delta_s - \delta_N}{(1 - \delta_N)(1 - \delta_s)} \right] K. \quad (18)$$

Equation (18) shows that the direction of net capital flows depends on the relative transportation cost between the North and the South :

$$I > 0, \text{ if } \delta_s > \delta_N, \quad (19 \text{ a})$$

$$I = 0, \text{ if } \delta_s = \delta_N, \quad (19 \text{ b})$$

$$I < 0, \text{ if } \delta_s < \delta_N. \quad (19 \text{ c})$$

Equation (19 a) implies that net capital flows will be from the South to the North over time if $\delta_s > \delta_N$ holds. On the contrary, from (19 c), net capital flows will be from the North to the South if $\delta_s < \delta_N$ holds. Equation (19 b) shows that when $\delta_s = \delta_N$, no capital flow takes place between the North and South locations. In sum, the above results indicate that if the cost of transporting goods from the South to the North is larger (smaller) than the cost of transporting goods from the North to the South, then net capital flows are from the South (North) to the North (South).

VI Conclusion

This paper analyzed the relationship between asymmetric inter-regional transportation costs and the direction of capital flows between the two locations given global spillovers in R & D by applying the two-region endogenous growth model in Martin and Ottaviano (1999). The results indicate that if the cost of transporting goods from the South to the North is larger (smaller) than the cost of transporting goods from the North to the South, then net capital flows are from the South (North) to the North (South).

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