

The Economics of Inter-City Competition in Financial and Distribution Markets

Eddery Lam

Department of Economics, Rochester Institute of Technology, U.S.A.

Chi-Yin Wu*

Department of Economics, Feng Chia University, Taiwan

We introduce a model of inter-city competition within a multidimensional framework. More specifically, we extend a single-sector model to one comprising two sectors, namely, a financial sector and a distribution sector in a three-stage sequential-game framework. There are two types of infrastructure, with one for each sector. The government of each city can build the infrastructure necessary to increase the competitiveness of the relevant sector. However, given that resources are limited, each city has to decide on which type of infrastructure to build, as well as on which elements of that type they wish to invest in. Under this framework, we show that the relative abundance of resources, the initial costs of providing services, and the relative effectiveness of the infrastructure determine the amount of infrastructure the government decides to build, and thus the outcome of the game.

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*Correspondence to: Department of Economics, Feng Chia University, 100 Wenhwa Rd., Seatwen, Taichung, Taiwan, 40724; Tel: +886-4-2451-7250 ext. 4491; e-mail: chiyinwu@fcu.edu.tw.

1 Introduction

Cities constitute an important economic jurisdiction in a country because city and local governments provide the basic infrastructure that facilitates business activities. In general, cities are the most populous and most prosperous areas in a country. Arguably, cities have enabled civilizations to grow and prosper, and have made the world economy what it is today. Interestingly, cities compete in various economic dimensions (e.g., to be a financial center, a distribution headquarters, or an Olympic City), regardless of whether located within the same country and or in different nations. For example, the long-standing competition between Sydney and Melbourne is often quoted as a classic example of inter-city rivalry within a country, regarding both commercial and cultural perspectives. Furthermore, Frankfurt, the headquarters of the European Central Bank, has been competing with London to become Europe's premier financial center. Among the major cities in Asia, Hong Kong and Singapore have been serving as hubs and international gateways, as well as competing to be the largest financial center in East and Southeast Asia.¹ As a result, issues related to inter-city competition across national boundaries have become increasingly important.

Many studies have examined the economics of cities, abstracted from the topics of economic geography.² In general, these studies can be divided into the following two categories: those that study cities that compete with each other and those that study cities that cooperate for mutual benefit. In the case of competition, cities try to undercut rivals by lowering their production costs. The governments of the cities constitute one of the important components when intervening in the competition. Martin and Rogers (1995) state that public infrastructure affects the location of industries and the trade within and between countries. Long and Wong (2009) show that governments provide the infrastructure that lowers the costs of local firms in order to enhance their competitiveness. Moreover, the provision of public inputs is

¹The Global Financial Centres Index (GFCI) ranks New York, London, Hong Kong, and Singapore as the top four global financial centers in 2015.

²For example, see Fujita *et al.* (1999) and Krugman (1991) for discussions of theoretical economic geography models, and Behrens and Thisse (2007) and Bosker *et al.* (2010) for the new economic geography models.

able to enhance the productivity of private inputs and induce an agglomeration effect (see, e.g., Brakman *et al.* (2002, 2008), Fenge *et al.* (2009), and Ott and Soretz (2010)).

In the case of cooperation, cities can trade inputs, intermediate goods, and final goods. In this case, the main concerns are whether cities should diversify their production and how labor should be distributed between cities. Anas and Xiong (2003) show that the transportation costs for inputs and final goods determine whether cities should diversify their production. If the transportation costs of inputs are low, cities should diversify their production. However, if the transportation costs of final goods are low, cities should specialize in terms of production. Cavailhes *et al.* (2007) show that trade costs, communication costs and commuting costs determine the sizes of cities, as well as the allocation of firms within cities. In their model, it is possible for several industrial districts to appear within the same city. Henderson (1974) has developed a theoretical model to analyze the optimal size of cities, and has found that the optimal size is determined by the owners of capital. If the capital owners also form part of the labor force, then the optimal city size tends to be smaller. On the other hand, if the capital owners are purely investors, conflicts of interest between the labor force and investors may lead to an undesirable equilibrium in which the city size is not optimal. Finally, Grajeda and Sheldon (2009) provide an empirical study on the relationship between trade openness and the size of a city. However, their results are not consistent, and depend on the econometric models they estimate and the data they use in the developing countries versus developed countries. It appears that relatively little research has been conducted to analyze the economic geography of inter-city competition between nations. The recent contribution by Long and Wong (2009) is an exception. They develop a spatial model to analyze the strategic rivalry between cities located in different countries trying to become the major distribution center in a region.

This study extends the single-sector model of city competition developed by Long and Wong (2009). In our analysis, we explicitly consider the resource constraints facing two city governments across multiple dimensions. Specifically, each government maximizes its objective function by strategically distributing limited resources within two different sectors: a financial sector and a distribution sector. Governments can assist firms in these sectors by expending resources to

build the infrastructure relevant to the sector. These infrastructures reduce the service costs of the respective sectors and increase the competitiveness of firms in the sectors. Here, we analyze inter-city competition in terms of the two sectors using the sequential game structure. While it would be desirable to use the simultaneous game structure, as in Long and Wong (2009), the complexity and intractability of the resulting mathematics prevents us from doing so. Therefore, we solve this model under the sequential game structure. We show that if the resources of one city are more abundant than those in the other city, *ceteris paribus*, this city tends to dominate both the financial and distribution sectors. Given that a city's resources may reflect its size and prosperity, our analysis implies that larger and wealthier cities are more likely to become both distribution and financial centers. In addition, we derive the conditions under which one city dominates the financial sector, while the other dominates the distribution sector.

The remainder of this paper is organized as follows. Section 2 presents the analytical framework of competition between two cities in the financial and distribution markets. In Section 3, we examine the case in which one city captures both markets. Sections 4 and 5 analyze duopolistic competition in the financial market and in the distribution market, respectively. Then, in Section 6, we discuss how government resource constraints affect the dominance of local firms in the financial and distribution markets. Lastly, Section 7 concludes the paper.

2 The Model

Following Long and Wong (2009), we analyze the competition between two cities, denoted as city N (North) and city S (South),³ where the distance between the two is normalized to unity. City S is located at point 0 and city N is located at point 1. There exists a continuum of investors/producers who are uniformly distributed between the two cities. Each city is assumed to have a single distribution firm. To allow for inter-city competition in multiple dimensions, we also incorporate a financial sector into our model by considering that each investor has to acquire a

³It is possible that cities coordinate to produce a better outcome. For example, New York City is the financial capital, while Washington is the main political center in the United States. We exclude this type of coordination in this study.

loan from a financial firm (located in city S or N) to finance production. For analytical simplicity, there is a single financial firm in each city. Assuming that each investor produces one unit of a homogeneous good, the investor has to decide whether to sell the product locally or to export it. If an investor decides to export the good, he has to hire a distribution firm (referred to as distributor S or N) to distribute it to the rest of the world. The world price of this homogeneous good is taken to be higher than its local price.⁴

In offering a production loan to each investor, financial firm S or N charges α_i , and incurs a service cost $C_i^F (< \alpha_i)$, where $i = S$ or N. It is costly for an investor to collect information about financial services, and this cost is positively related to where the investor is located. For instance, investors have to travel to a city for negotiations or to sign contracts. If an investor is located at point x , the cost of traveling to city S is $(C/2)x^2$. This can be regarded as the cost of acquiring or researching information about the financial firm in city S. This cost is $(C/2)(1-x)^2$ if investor x obtains information about financial firm N.

In providing the service of distributing the good for an investor, distributor S or N charges θ_i and incurs a cost $C_i^D (< \theta_i)$, where $i = S$ or N. If an investor is located at point y , the shipment cost to city S is $(b/2)y^2$ and to city N is $(b/2)(1-y)^2$.

Finally, there is a government in each of the two cities. A city government (referred to as government S or N) can help its financial and distribution firms become more competitive by building the necessary infrastructure. By infrastructure, we do not limit ourselves to physical infrastructure, such as a new airport. Sophisticated legal and financial systems can certainly help reduce the operating costs of a financial firm. Thus, improvements to these systems are also considered to be part of the relevant infrastructure. We consider two types of infrastructure: I_i^F and I_i^D . Infrastructure I_i^F helps to reduce the financial firm's service cost, while infrastructure I_i^D helps to reduce the distribution firm's service cost. Specifically, we assume that:

$$C_i^F = \overline{C}_i^F - \frac{\psi_i^F (I_i^F)^2}{2}, \quad (1)$$

⁴We assume that the financial and distribution services provided by city N and city S are identical. The only difference is the costs of the various services.

$$C_i^D = \overline{C_i^D} - \frac{\psi_i^D (I_i^D)^2}{2}, \quad (2)$$

where C_i^j is the service cost of firm j ($= F, D$) in city i ($= N, S$), and $\overline{C_i^j}$ is firm j 's service cost in the absence of any infrastructure. Symbol ψ_i^j denotes the effectiveness of infrastructure I_i^j in reducing the cost to firm j of providing its service in city i . Another interpretation of ψ_i^j is that it reflects the comparative advantage of one sector over other sectors. Equations (1) and (2) indicate that each city government is capable of reducing the operating costs of local firms by building a more efficient infrastructure. However, given the limited resources available, each government has to decide which type of infrastructure to build, as well as which elements of that type they wish to invest in.

2.1 The Three-Stage Game

We consider a three-stage sequential-move game. We provide more detailed explanations of each stage of the game in the following subsections. Note that if an investor decides to export his product to the rest of the world, he has to hire both a financial and a distribution firm. However, if the costs of hiring these firms outweigh the benefits, he decides not to undertake the investment. It is possible for an investor to hire a financial firm only. In this case, the investor decides to sell his goods locally.

(i) First Stage

At the beginning of this game, each city government determines which type of infrastructure to build and the elements of the type in which they intend to invest. We assume that the main objective of government S or N is to maximize the total profit of its financial and distribution firms. As mentioned earlier, a city government can help both types of firms become more competitive by building the relevant infrastructure for each firm. The infrastructure helps reduce the service costs of the respective firms, allowing them to offer lower prices to investors. However, each government has limited resources. Denote R_i as the (exogenous)⁵ amount of

⁵Given that this is a one-time game, we assume that the amount of resources available to each city is exogenous. In a repeated game, one can argue that the amount of resources is endogenous. In other words, the prosperity of each sector will affect the amount of resources each city has in the next period.

resources available to government i ($= S, N$). The objective of government i is to choose I_i^F and I_i^D to maximize the following constrained optimization problem:

$$\max_{\{I_i^F, I_i^D\}} (\pi_i^F + \pi_i^D) \quad (3)$$

subject to

$$R_i \geq I_i^F + I_i^D, \quad (4)$$

where π_i^j is the profit of firm j in city i . Here, R_i can be used to reflect the size of a city. If the cities are similar in terms of their size and the effectiveness of their respective infrastructures, it is likely that cities S and N will share the financial and distribution markets equally. However, if one city is much larger than the other and, thus, has more resources, it is likely that the larger city will capture both markets. In a later section, we derive the conditions that determine which of these scenarios will emerge.

(ii) Second Stage

In the second stage of the game, each financial firm decides how many investors to serve, as well as an optimal price to charge. Recall that an investor has to acquire a loan from a financial firm to finance production. If an investor finds that production is unprofitable, he will not apply for a loan. This condition limits the maximum price the financial firm can charge to investors and, hence, constitutes a constraint on the firm's profit maximization decision. Denote α_s as the price financial firm S charges to investors, and x_s as the number of investors served by the firm. Let P be the competitive price at which investors can sell their goods locally. The objective of financial firm S is to choose α_s and x_s to solve the following problem:

$$\max_{\{\alpha_s, x_s\}} \pi_s^F = \int_0^{x_s} (\alpha_s - C_s^F) dx = (\alpha_s - C_s^F) x_s \quad (5)$$

subject to

$$P \geq \alpha_s + \frac{C}{2} x_s^2. \quad (6)$$

For analytical simplicity, we assume that the financial firm's service cost, C_s^F , is independent of the number of investors served by the firm. However, this service

cost is a function of infrastructure I_s^F , as described by equation (1). Note that $(C/2)x_s^2$ in equation (6) is the cost to the investor at location x_s of obtaining information about financial firm S.

Similarly, we can express the profit maximization problem faced by financial firm N by replacing x_s with $(1-x_s)$ and changing the subscript to N.

(iii) Third Stage

In the third and last stage of the game, distributor S or N has to decide how many investors to serve, and at what prices. In our setting, the number of investors is dependent on the equilibrium outcome of the second stage. If an investor decides not to obtain any loan from a financial firm, he will not hire any distributor either, simply because he is not producing.

Let P^* be the competitive price of the homogeneous good in the world market. Under the assumption that $P^* > P$, there is an incentive for the investors to export. Given the service prices charged by the distributors, the investors will not hire the distribution firms if they realize that exporting is unprofitable. This condition imposes a constraint on the price that a distributor can charge. The constrained profit maximization problem that distributor S solves is:

$$\max_{\{\theta_s, y_s\}} \pi_s^D = \int_0^{y_s} (\theta_s - C_s^D) dy = (\theta_s - C_s^D) y_s \quad (7)$$

subject to

$$P^* - (\alpha_s + \frac{C}{2} x_s^2) \geq \theta_s + \frac{b}{2} y_s^2. \quad (8)$$

Similarly, we can set up the constrained profit maximization problem for distributor N by replacing y_s with $(1-y_s)$ and by changing the subscript to N.

Note that y_s is the number of investors served by distributor S. We also assume that a distributor's service cost, C_s^D , is independent of y_s . However, this service cost is a function of infrastructure I_s^D as given by equation (2). The term θ_s is the price that distributor S charges. The term $(b/2)y_s^2$ is the cost of shipping the good to city S. The budget constraint in (8) is slightly different from that for a financial firm as discussed earlier. Since an investor has to acquire a loan from a financial firm for production, the investor has to subtract the cost of hiring a financial firm, $(\alpha_i + (C/2)x_i^2)$, in calculating the profit from exporting. The budget

constraint holds only when an investor hires distributor S or otherwise the investor will just sell his product locally.

3 Monopolistic Financial Firm and Distribution Firm

As in game theory, we use backward induction to solve the three-stage game. We focus our analysis temporarily on a single city case by assuming that the financial and distribution firms in city N are inefficient to the point where they do not offer any services. In this case, financial firm S and distributor S become monopolistic service providers. Three possibilities of interest to our analysis are as follows:

- 1) Both financial firm S and distributor S serve their respective markets completely;
- 2) Financial firm S serves its market completely, but distributor S serves its market partially;
- 3) Both financial firm S and distributor S serve their respective markets partially.⁶

In what follows, we discuss the whole market case and the partial market case separately. We begin our analysis with distributor S at stage three and then financial firm S at stage two.

(iii.s)Third stage: distributor S

Distributor S is able to serve the entire distribution market if and only if:

$$\frac{3b}{2} \leq P^* - C_s^D - \frac{C}{2} x_s^2 - \alpha_s. \quad (9a)$$

This is the scenario where $y_s = 1$. Given this condition, we derive the price that distributor S charges to the investor by solving the constrained profit optimization problem (see equations (7) and (8)):

$$\theta_s = P^* - \frac{C}{2} x_s^2 - \alpha_s - \frac{b}{2}. \quad (9b)$$

Distributor S serves the market only partially if and only if:

⁶Note that, under this setting, it is not possible to have a case in which the distribution firm serves the whole market and the financial firm serves only a part of the market. Investors are required to hire a financial firm if they want to start producing. However, since the financial firm decides to serve only a part of the market, some investors must be left out and, thus, will not hire a distribution firm because they are not producing anything.

$$\frac{3b}{2} \geq P^* - C_s^D - \frac{C}{2} x_s^2 - \alpha_s. \quad (9c)$$

In this scenario, Distributor S determines θ_s and y_s that maximize profit in equation (7) subject to the constraint in equation (8). The solutions are:

$$\theta_s = \frac{2}{3}[P^* - \alpha_s] + \frac{1}{3}[C_s^D - Cx_s^2], \quad (9d)$$

$$y_s = \sqrt{\frac{1}{b} \left[\frac{2}{3}(P^* - \alpha_s - C_s^D) - \frac{1}{3} x_s^2 \right]}. \quad (9e)$$

In the above two cases, service price θ_s depends on x_s , the number of investors who are served by distributor S. The distributor has to take into account the service price that financial firm S charges, α_s , in the second stage of the three-stage game.

(ii.s) Second stage: financial firm S

Financial firm S is able to serve the entire financial market if and only if:

$$\frac{3C}{2} \leq P - C_s^F. \quad (10a)$$

This is the scenario in which $x_s = 1$. Given this condition, we solve the constrained profit maximization problem (see equations (5) and (6)) for the price that financial firm S charges to the investors:

$$\alpha_s = P - \frac{C}{2}. \quad (10b)$$

Financial firm S serves the market only partially if and only if:

$$\frac{3C}{2} \geq P - C_s^F. \quad (10c)$$

Financial firm S determines α_s and x_s that maximize profit in equation (5) subject to the constraint in equation (6). The solutions are:

$$\alpha_s = \frac{2}{3}P + \frac{C_s^F}{3}, \quad (10d)$$

$$x_s = \sqrt{\frac{2}{3C}(P - C_s^F)}. \quad (10e)$$

Case I: Both firms in city S serve their respective markets completely

In this case, $x_s = 1$ and $y_s = 1$. The service price charged by financial firm S is given in equation (10b). To determine the service price θ_s charged by distributor S, we substitute equation (10b) into equation (9b) and set $x_s = 1$ to obtain:

$$\theta_s = P^* - P - \frac{b}{2}.$$

We calculate profits for financial firm S and distributor S which are given, respectively, as:

$$\pi_s^F = P - \frac{C}{2} - C_s^F \quad \text{and} \quad \pi_s^D = P^* - P - \frac{b}{2} - C_s^D. \quad (11)$$

Case II: Only financial firm S serves its market completely

In this case $x_s = 1$ and equation (10b) also defines α_s . To obtain θ_s , we substitute equation (10b) into equation (9d) and set $x_s = 1$ to obtain:

$$\theta_s = \frac{2}{3}[P^* - P] + \frac{1}{3}C_s^D. \quad (12)$$

To obtain y_s , we first set x_s to be 1 in equation (9e). We then substitute equation (12) into equation (9e) to get:

$$y_s = \sqrt{\frac{1}{b} \left[\frac{2}{3}(P^* - P) + \frac{C}{3} - \frac{1}{3} \right]}. \quad (13)$$

We calculate the profit for distributor S as follows:

$$\pi_s^D = \frac{2}{3}(P^* - P - C_s^D) \sqrt{\frac{1}{b} \left[\frac{2}{3}(P^* - P) + \frac{C}{3} - \frac{1}{3} \right]}. \quad (14)$$

In this case, the profit for financial firm S is identical to that in the previous case:

$$\pi_s^F = P - \frac{C}{2} - C_s^F. \quad (15)$$

Case III: Both firms in city S serve their respective markets partially

In this case, α_s is given from equation (10d) and x_s is given from equation (10e). The profit for financial firm S is:

$$\pi_s^F = \frac{2}{3}(P - C_s^F) \sqrt{\frac{2}{3C}(P - C_s^F)}. \quad (16)$$

To derive y_s , we substitute equations (10d) and (10e) into equation (9e) to get:

$$y_s = \sqrt{\frac{1}{b} \left(\frac{2}{3} [P^* - P - C_s^D] + \frac{4}{9} C_s^F \right)}.$$

Similarly, to obtain θ_s , we substitute equations (10d) and (10e) into equation (9d) to get:

$$\theta_s = \frac{2}{3}(P^* - P) + \frac{4}{9} C_s^F + \frac{1}{3} C_s^D.$$

We calculate the profit for distributor S as follows:

$$\pi_s^D = \left[\frac{2}{3}(P^* - P) + \frac{4}{9} C_s^F - \frac{2}{3} C_s^D \right] \sqrt{\frac{1}{b} \left(\frac{2}{3} [P^* - P - C_s^D] + \frac{4}{9} C_s^F \right)}. \quad (17)$$

(i.s) *First stage*

Here we only consider Case I in which financial firm S and distributor S serve their respective markets totally. Recall that their profit functions are given, respectively, as:

$$\pi_s^F = P - \frac{C}{2} - C_s^F, \quad (18)$$

$$\pi_s^D = P^* - P - \frac{b}{2} - C_s^D, \quad (19)$$

where C_s^D and C_s^F are the costs of providing services by the firms as defined in equations (1) and (2).

The objective of government S is to choose I_s^F and I_s^D that solve the following profit maximization problem:

$$\max_{\{I_s^F, I_s^D\}} (\pi_s^F + \pi_s^D) \quad \text{subject to} \quad R_s \geq I_s^F + I_s^D,$$

where π_s^F and π_s^D are given in equations (18) and (19). Solving the above problem yields:

$$I_s^F = R_s \left(\frac{\psi_s^D}{\psi_s^F + \psi_s^D} \right), \quad (20)$$

$$I_s^D = R_s \left(\frac{\psi_s^F}{\psi_s^F + \psi_s^D} \right). \quad (21)$$

The equilibrium service costs for financial firm S and distributor S are given, respectively, as:

$$C_s^F = \overline{C_s^F} - \frac{\psi_s^F}{2} \left(\frac{R_s \psi_s^D}{\psi_s^F + \psi_s^D} \right)^2,$$

$$C_s^D = \overline{C_s^D} - \frac{\psi_s^D}{2} \left(\frac{R_s \psi_s^F}{\psi_s^F + \psi_s^D} \right)^2.$$

We can use above equations to calculate α_s and θ_s .

4 Duopoly in the Financial Market

We proceed to examine the case in which the financial firms of two cities compete in the financial market. We consider the whole market scenario where every investor is completely served by the same financial firm (either S or N). It is necessary to determine the critical investor who is indifferent between financial firm S and financial firm N. The investor, denoted as x_d , will be indifferent if:

$$\alpha_s + \frac{C}{2} x_d^2 = \alpha_N + \frac{C}{2} (1 - x_d)^2. \quad (22)$$

Solving for x_d yields:

$$x_d = \frac{1}{C} (\alpha_N - \alpha_s) + \frac{1}{2}. \quad (23)$$

This equation is similar to equation (19) for the case of distribution firms discussed in Long and Wong (2009). There are three possibilities:

- 1) Case I: If $\alpha_N - \alpha_s \geq C/2$, then $x_d = 1$ and financial firm S serves the entire financial market. Financial firm S charges the service price, $\alpha_s = \alpha_N - (C/2)$ if $\alpha_N < P$, and $\alpha_s = P - (C/2)$ if $\alpha_N > P$.

- 2) Case II: If $\alpha_s - \alpha_N \geq C/2$, then $x_d = 0$ with financial firm N serving the entire financial market. Financial firm N charges the service price, $\alpha_N = \alpha_s - (C/2)$ if $\alpha_s < P$, and $\alpha_N = P - (C/2)$ if $\alpha_s > P$.
- 3) Case III: If $|\alpha_N - \alpha_s| < C/2$, then financial firm S serves the investors located at $(0, x_d)$ and financial firm N serves those at $(x_d, 1)$.

As illustrated by Long and Wong (2009), we derive the reaction functions of both the financial firm and distributor by solving the following problem:

$$\text{Max } \pi_i = (\alpha_i - C_i^F)x_c \quad \text{subject to} \quad P - \alpha_i - \frac{C}{2}x_c \geq 0.$$

The reaction functions of the respective firms are:

$$\alpha_s = R_s(\alpha_N) = \frac{C}{4} + \frac{1}{2}[C_s^F + \alpha_N],$$

and

$$\alpha_N = R_N(\alpha_s) = \frac{C}{4} + \frac{1}{2}[C_N^F + \alpha_s].$$

Notice that $R_s(\alpha_N)$ intersects $\alpha_N - (C/2)$ when $\alpha_N = C_s^F + (3/2)C$. In other words, if $\alpha_s^* > C_s^F + (3/2)C$, financial firm S captures the entire market. A similar derivation shows that if $\alpha_s^* > C_N^F + (3/2)C$, financial firm N captures the entire financial market. According to the limited pricing proposition as shown in Long and Wong (2009), if condition (9a) holds and $P > \alpha_N > C_s^F + (3/2)C$, then financial firm S captures the entire market by charging a service price lower than the monopoly price.

With the above limited pricing proposition, we derive the equilibrium condition for the second stage of this game. Assume that both financial firms at this second stage compete in Bertrand fashion by choosing service prices simultaneously. We obtain similar results to those in Long and Wong (2009). Assuming the condition (9a) holds:

- 1) If $C_N^F \geq \alpha_N = C_s^F + (3/2)C$, financial firm S captures the entire market. According to the limit pricing theorem, if $C_N^F < P$, financial firm S charges the

service price, $\alpha_s = C_N^F - (C/2)$. On the other hand, if $C_N^F < P$, the financial firm charges the monopolistic service price, $\alpha_s = P - (C/2)$.

- 2) Similarly, if $C_s^F \geq \alpha_s = C_N^F + (3/2)C$, financial firm N captures the entire market. According to the limit pricing theorem, if $C_s^F < P$, financial firm N charges the service price, $\alpha_N = C_s^F - (C/2)$. On the other hand, if $C_s^F < P$, financial firm N charges the monopolistic service price, $\alpha_N = P - (C/2)$.
- 3) Finally, if $|C_N^F - C_s^F| < (3/2)C$, none of the two financial firms captures the entire market. It follows from the reaction functions that we have:

$$\alpha_s = \frac{C}{2} + \frac{1}{3}(2C_s^F + C_N^F),$$

$$\alpha_N = \frac{C}{2} + \frac{1}{3}(2C_N^F + C_s^F).$$

5 Duopoly in the Distribution Market

In this section, we consider cases in which a financial firm, either S or N, captures the entire financial market. In other words, the partial financial market is not considered here. Furthermore, here we only consider the whole market solution for the distribution market.

Similar to the previous section, we characterize the investor who is indifferent between distributor S or distributor N. The investor, located at point y_d , will be indifferent if and only if:

$$\theta_s + \frac{b}{2}y_d^2 + \alpha_i + \frac{C}{2}x_i^2 = \theta_N + \frac{b}{2}(1 - y_d)^2 + \alpha_i + \frac{C}{2}x_i^2. \quad (24)$$

To investor y_d , the cost of hiring distributor S is identical to the cost of hiring distributor N. Note that on both sides of equation (24), the financial service price, α_i , and the cost of obtaining information, $(C/2)x_i^2$, are cancelled out. This is due to the assumption that, at the second stage, there is only one financial firm (either S or N) capturing the entire financial market. Solving for y_d yields:⁷

⁷This result is similar to that of Long and Wong (2009).

$$y_d = \frac{1}{b}(\theta_N - \theta_S) + \frac{1}{2}.$$

Here there are three interesting possibilities, given that only one financial firm dominates in the financial market:

- 1) If $C_N^D \geq \theta_N = C_S^D + (3/2)b$, distributor S captures the entire distribution market. According to the limit pricing theorem, if $C_N^D < \bar{P}$, distributor S charges the service price, $\theta_S = C_N^D - (b/2)$. On the other hand, if $C_N^D < \bar{P}$, distributor S charges the monopolistic service price, $\theta_S = \bar{P} - (b/2)$.
- 2) Similarly, if $C_S^D \geq \theta_S = C_N^D + (3/2)b$, distributor N captures the entire distribution market. According to the limit pricing theorem, if $C_S^D < \bar{P}$, distributor N charges the service price, $\theta_N = C_S^D - (b/2)$. On the other hand, if $C_S^D < \bar{P}$, distributor N charges the monopolistic service price, $\theta_N = \bar{P} - (b/2)$.
- 3) Finally, if $|C_N^D - C_S^D| < (3/2)b$, none of the distributors is able to capture the entire distribution market. It follows from the reaction functions that we have:

$$\theta_S = \frac{b}{2} + \frac{1}{3}(2C_S^D + C_N^D),$$

$$\theta_N = \frac{b}{2} + \frac{1}{3}(2C_N^D + C_S^D),$$

where $P = P^* - \alpha_i - (C/2)x_i$.

6 How Government Resources Affect Market Dominance

Up to this point, our analysis is similar to that of Long and Wong (2009), with the exception of having two markets in a sequential game. In this section, we examine how a city's resource constraint determines how much of a particular market the city can capture. For simplicity, we only consider two cases: (S, S) and (S, N). In each case, the first element denotes the firm that dominates the financial market. For instance, if the first element is S, the financial market is dominated by financial firm S. Similarly, the second element denotes the firm that dominates the distribution market.

6.1 The Financial Market

6.1.1 Analysis of Case (S, S)

In this case, both the financial and distribution markets are captured by the firms from city S. This is identical to the previous case in which the firms located in city N are so incompetent that the firms in city S are monopolistic service providers in their respective markets. Therefore, the equilibrium amounts of infrastructure built by government S for the distribution and financial markets are, respectively:

$$I_S^D = R_S \left(\frac{\psi_S^F}{\psi_S^F + \psi_S^D} \right), \quad (25)$$

$$I_S^F = R_S \left(\frac{\psi_S^D}{\psi_S^F + \psi_S^D} \right). \quad (26)$$

Accordingly, the firms' respective costs of providing services are:

$$C_S^D = \bar{C}_S^D - \frac{\psi_S^D}{2} \left(\frac{R_S \psi_S^F}{\psi_S^F + \psi_S^D} \right)^2, \quad (27)$$

$$C_S^F = \bar{C}_S^F - \frac{\psi_S^F}{2} \left(\frac{R_S \psi_S^D}{\psi_S^F + \psi_S^D} \right)^2. \quad (28)$$

Now, recall that financial firm S captures the entire financial market if and only if:

$$C_N^F \geq C_S^F + \frac{3}{2} C. \quad (29)$$

Let us assume that city N decides on the amounts of infrastructure and costs of providing services in a similar way. That is:

$$C_N^j = \bar{C}_N^j - \frac{\psi_N^j (I_N^j)^2}{2}.$$

Here, j can be either F or D, depending on the market associated with the cost.

In order to guarantee the market dominance of financial firm S, it must be the case that even if city N devotes all its resources to building a financial infrastructure,

financial firm S remains competitive enough that condition (29) continues to hold. If city N dedicates all its resources to construct a financial infrastructure (i.e., $R_N = I_N^F$), then C_N^F becomes:

$$C_N^F = \overline{C}_N^F - \frac{\psi_N^F (R_N)^2}{2}. \quad (30)$$

Substituting equations (28) and (30) into condition (29), we have:

$$\overline{C}_N^F - \frac{\psi_N^F (R_N)^2}{2} \geq \overline{C}_S^F - \frac{\psi_S^F}{2} \left(\frac{R_S \psi_S^D}{\psi_S^F + \psi_S^D} \right)^2 + \frac{3}{2} C.$$

Then, rearranging the terms yields:

$$R_S^2 \geq \left(\frac{2}{\psi_S^F} \right) \left(\frac{\psi_S^F + \psi_S^D}{\psi_S^D} \right)^2 (\overline{C}_S^F - \overline{C}_N^F + \frac{3}{2} C) + \frac{\psi_N^F}{\psi_S^F} \left(\frac{\psi_S^F + \psi_S^D}{\psi_S^D} \right)^2 R_N^2. \quad (31)$$

Condition (31) constitutes the sufficient condition under which the firms from city S capture both markets. This may occur when (i) city S has more resources than city N, (ii) the financial infrastructure of city S is more effective than that of city N, or (iii) city S has an advantage in terms of its initial service cost (C_S^F) over that of city N (C_N^F), and is able to overcome cases where city N may have more resources than city S.

By symmetry, the financial and distribution firms in city N capture their respective markets entirely if and only if:

$$R_N^2 \geq \left(\frac{2}{\psi_N^F} \right) \left(\frac{\psi_N^F + \psi_N^D}{\psi_N^D} \right)^2 (\overline{C}_N^F - \overline{C}_S^F + \frac{3}{2} C) + \frac{\psi_S^F}{\psi_N^F} \left(\frac{\psi_N^F + \psi_N^D}{\psi_N^D} \right)^2 R_S^2. \quad (32)$$

The above findings permit us to establish the following proposition:

Proposition 1: *If the relationship between the amount of resources (R_S^2) available to city S and the amount of resources (R_N^2) available to city N satisfies condition (31), then the financial and distribution firms located in city S capture their respective markets entirely. Consequently, the firms located in city N do not capture either market. By contrast, if the relationship between R_S^2 and R_N^2 satisfies condition (32), then the financial and distribution firms located in city N capture their*

respective markets entirely, and the firms located in city S do not capture either market.

6.1.2 Analysis of Case (S, N)

Next, we consider the case in which financial firm S captures the financial market and distributor N captures the distribution market. Given that the distribution market is dominated by distributor N , there is no incentive for government S to invest resources in the local distribution infrastructure to help its distributor lower its operating costs. Instead, government S decides to allocate all available resources to construct the financial infrastructure (i.e., $R_s = I_s^F$). We can justify this situation using backward induction. Suppose that government S has to determine the amount of resources to be allocated to construct the distribution infrastructure. By backward induction, government S starts the game backwards, and examines the third stage first. Given the parameters, government S knows that its distribution firm cannot compete in the distribution market. Therefore, its optimal strategy is to expend all available resources on the financial infrastructure. However, in the third stage, it is unclear whether government N will expend all its resources on its distribution infrastructure. Therefore, for financial firm S to dominate the financial market, it must be the case that, even if government N expends all its resources on enhancing its financial infrastructure, financial firm S remains competitive enough to capture the entire financial market.

By substituting equation (30) into condition (29) and replacing I_s^F with R_s , we have:

$$\overline{C}_N^F - \frac{\psi_N^F (R_N)^2}{2} \geq \overline{C}_S^F - \frac{\psi_S^F}{2} R_s^2 + \frac{3}{2} C.$$

After rearranging the terms, we have:

$$R_s^2 \geq \left(\frac{2}{\psi_S^F} \right) \left(\overline{C}_S^F - \overline{C}_N^F + \frac{3}{2} C \right) + \frac{\psi_N^F}{\psi_S^F} R_N^2. \quad (33)$$

By symmetry, financial firm N captures the entire financial market and distributor S captures the entire distribution market if:

$$R_N^2 \geq \left(\frac{2}{\psi_N^F}\right) (\overline{C}_N^F - \overline{C}_S^F + \frac{3}{2}C) + \frac{\psi_S^F}{\psi_N^F} R_S^2. \tag{34}$$

We summarize the above conditions and combine them into Proposition 1a:

Proposition 1a: *If condition (33) holds, financial firm S captures the entire financial market. Furthermore, in the case in which the firms located in city S capture both markets, condition (31) must hold. By contrast, if condition (34) holds, financial firm N captures the entire financial market. Furthermore, condition (32) must hold for the firms located in city N to capture both markets. Finally, if both conditions (33) and (34) fail to hold, then neither firm is able to dominate the financial market.*

Figure 1 presents a graphical illustration of the aforementioned findings. Line AB represents condition (33). For any distribution of resources (R_S^2, R_N^2) (that lies to the right of line AB, financial firm S captures the entire financial market. Line CD represents condition (31). For any distribution of resources (R_S^2, R_N^2) to the right of line CD, the firms in city S capture both markets.

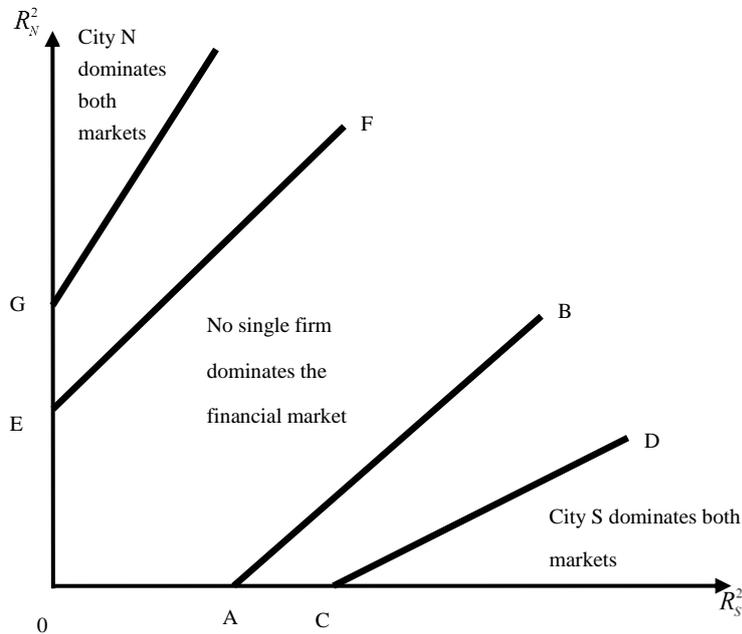


Figure 1: The Distribution of Government Resources Affects the Market Dominance

The next case is where financial firm N dominates the financial market. Condition (32) and condition (34) are represented by line GH and line EF, respectively. For any allocation of resources (R_S^2, R_N^2) that lies to the left of line EF, financial firm N captures the entire financial market. In addition, if such a resource distribution also lies to the left of line GH, both markets are dominated by the firms in city N.

Finally, for any distribution of resources (R_S^2, R_N^2) that lies between line AB and line EF, no single firm is able to capture the entire financial market. In other words, this is the area where the financial market is shared between the two cities.

It is instructive to investigate how the effectiveness of the financial infrastructure in a city affects the market dominance of the financial sector. Here, we focus on the case for city S. If the financial infrastructure in a given city becomes more effective, *ceteris paribus*, the value of ψ_S^F increases. This case may emerge when, for instance, city S has a new policy-maker who is more capable than his predecessor. Intuitively, an increase in the effectiveness of the financial infrastructure will enhance the ability of financial firm S to capture the financial market. In terms of condition (33), a larger ψ_S^F makes the right-hand side of the inequality smaller. In other words, it becomes easier for city S to dominate the financial market. Figure 2 provides a graphical interpretation of this finding. An increase in ψ_S^F shifts the line AB to A'B'. Thus, the area between AB and A'B' indicates the gains from this improvement.

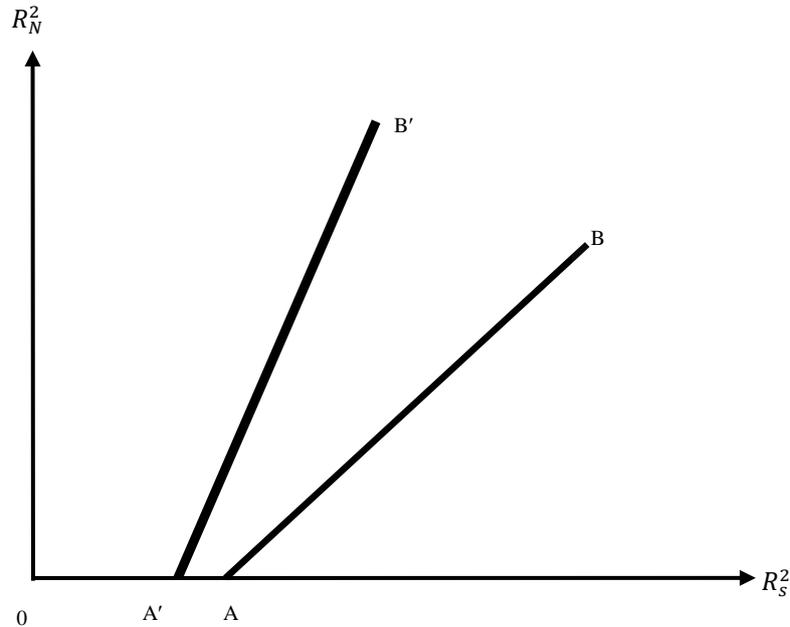


Figure 2: An Improvement in Financial Infrastructure Enhances the Market Dominance of the Financial Sector

However, it is unclear whether an increase in ψ_s^F will also help city S capture the distribution market. On the one hand, equation (25) indicates that an increase in ψ_s^F increases I_s^D . Consequently, distributor S becomes more competitive. On the other hand, the increase in ψ_s^F reduces the amount that government S invests in the financial infrastructure. This makes condition (31) more difficult to satisfy. In other words, it reduces the ability of city S to capture both the financial and distribution markets. The net result depends on the relationship between ψ_s^F and ψ_s^D :

- (i) If $\psi_s^D > \psi_s^F$, an increase in ψ_s^F improves the likelihood that city S will capture both markets;
- (ii) If $\psi_s^D < \psi_s^F$, an increase in ψ_s^F reduces the likelihood that city S will capture both markets;
- (iii) If $\psi_s^D = \psi_s^F$, an increase in ψ_s^F has no effect on capturing the distribution market.

We summarize these findings in the following proposition:

Proposition 2: *An increase in ψ_i^F improves the likelihood of city i capturing the entire financial market. However, it is ambiguous whether this improvement will also help city i capture the distribution market.*

Corollary 2: An increase in $\psi_j^F, i \neq j$, reduces the likelihood of city i capturing the entire financial market.

We can prove Corollary 2 by analyzing the improvement in ψ_S^F from the perspective of city N.

Next, we examine how the relative effectiveness of the financial infrastructure influences the dominance of the financial market. Suppose that ψ_N^F/ψ_S^F decreases. This decrease may be caused by an increase in ψ_S^F , a decrease in ψ_N^F , or both. If it happens because of an increase in ψ_S^F or simultaneous changes in ψ_S^F and ψ_N^F , from condition (33), Figure 2 shows how this change increases the competitiveness of financial firm S. On the other hand, if the decrease occurs because of a decrease in ψ_N^F , then the graphical representation is slightly different. In this case the slope becomes steeper, but the intercept remains unchanged. Figure 3 illustrates this change. Recall that condition (33) is used to graph line AB. With this increase in the slope, the line switches to AB'. As in the previous case, the area between line AB and line AB' represents the gain from the improvement in the effectiveness of the financial infrastructure.

However, it is ambiguous whether this improvement will also assist distribution firm S in capturing the distribution market. Proposition 2 applies if this improvement is caused by an increase in ψ_S^F or by simultaneous changes in ψ_S^F and ψ_N^F . However, if this improvement is caused by a reduction in ψ_N^F , condition (31) tells us that this reduction helps the firms in city S to capture both markets. We summarize this result in the following proposition:

Proposition 3: *An improvement (A reduction) in the relative effectiveness of the financial infrastructure helps (prevents) city i capture the financial market. Whether the magnitude of this increase (decrease) will enhance the market dominance depends on the source of the improvement. Nevertheless, it is ambiguous how changes in relative effectiveness affect the market dominance of the distribution*

sector.

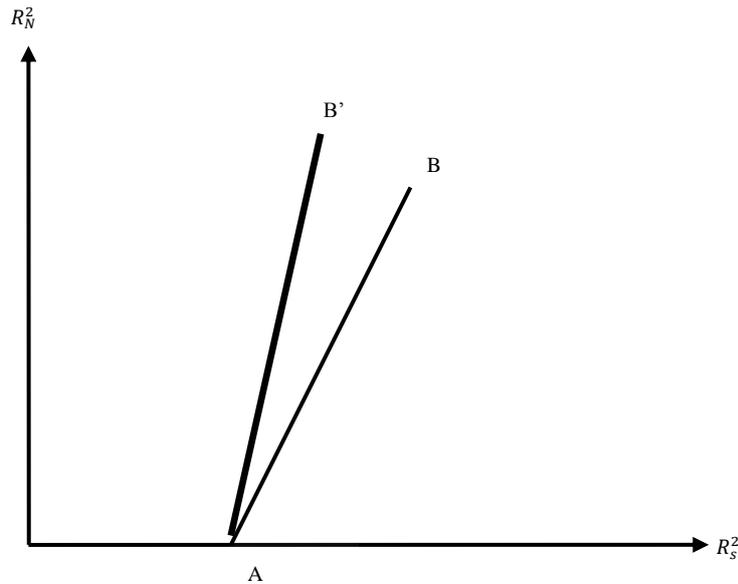


Figure 3: A Decline in the Rival City's Financial Infrastructure Enhances the Market Dominance of the Financial Sector

Next, we examine how changes in the initial cost affect the financial market. It is reasonable to assume that the initial cost is positively related to the history of the city. Established cities have lower initial costs than newer cities. Therefore, one can argue that by examining the initial cost differential, we can evaluate how the history of the city affects the financial market.

We continue to use city S as an example, and suppose that the initial cost differential, $\overline{C}_S^F - \overline{C}_N^F$, decreases. It follows from equation (33) that this decrease causes a parallel shift in line AB to the left, as shown in Figure 4. This change in the initial cost differential helps financial firm S to serve more investors in the financial market. The gain in market share is measured by the area between line AB and line A'B'. Moreover, an investigation of equation (31) reveals that this decrease in the initial cost differential also helps distributor S capture the distribution market. Since the term on the right-hand side of equation (31) becomes smaller, it is more likely that the inequality condition is satisfied. We summarize this finding in the following

proposition.

Proposition 4: *A decrease (An increase) in the initial cost differential of providing services helps city i to capture (prevents city i from capturing) both the financial and distribution markets.*

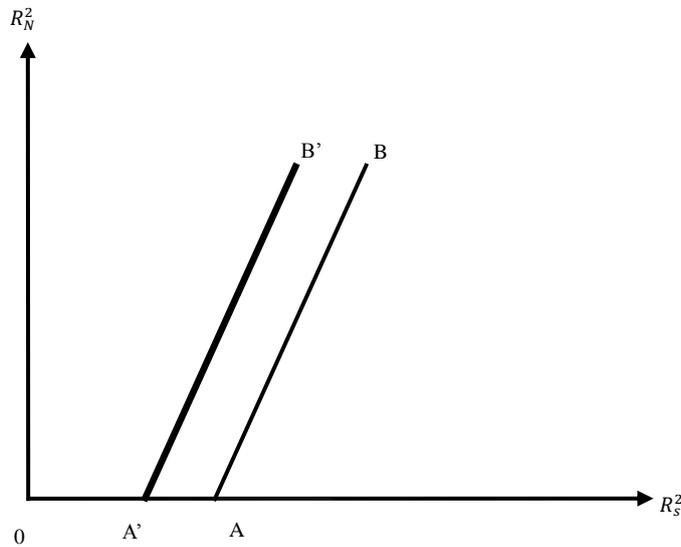


Figure 4: An Improvement in the Initial Cost Differential Enhances the Market Dominance of the Financial Sector

6.2 The Distribution Market

In this section, we examine how government resource constraints affect the distribution market. Given that we consider a three-stage sequential game, we assume that financial firm S captures the entire financial market. That is, equation (33) holds.⁸ As in Section 6.1, we consider only two cases, namely, (S, S) and (S, N).

6.2.1 Analysis of Case (S, S)

⁸Cases of partial financial markets are ignored owing to their mathematical complexity.

In this case, the firms in city S dominate both markets. This case is identical to the one in which the firms in city S have monopolistic power over their respective markets. As a result, the amount invested by government S in the distribution infrastructure is identical to that in equation (20):

$$I_s^D = R_s \left(\frac{\psi_s^F}{\psi_s^F + \psi_s^D} \right). \quad (35)$$

The equilibrium service cost for distributor S is:

$$C_s^D = \overline{C}_s^D - \frac{\psi_s^D}{2} \left(\frac{R_s \psi_s^F}{\psi_s^F + \psi_s^D} \right)^2. \quad (36)$$

Now, recall that in analyzing the duopoly in the distribution market, the firms in city S capture both markets if and only if:

$$C_N^D \geq C_s^D + \frac{3}{2}b. \quad (37)$$

For city S to dominate both markets, it must be the case that, even if city N devotes all available resources to building its distribution infrastructure, distributor S remains sufficiently competitive to capture the entire market. Substituting $R_N = I_N^D$ into C_N^D yields:

$$C_N^D = \overline{C}_N^D - \frac{\psi_N^D (R_N)^2}{2}. \quad (38)$$

Next, by substituting equations (36) and (38) into equation (37), we have:

$$\overline{C}_N^D - \frac{\psi_N^D (R_N)^2}{2} \geq \overline{C}_s^D - \frac{\psi_s^D}{2} \left(\frac{R_s \psi_s^F}{\psi_s^F + \psi_s^D} \right)^2 + \frac{3}{2}b.$$

Then, rearranging the terms yields:

$$R_s^2 \geq \left(\frac{2}{\psi_s^D} \right) \left(\frac{\psi_s^F + \psi_s^D}{\psi_s^F} \right)^2 \left(\overline{C}_s^D - \overline{C}_N^D + \frac{3}{2}b \right) + \frac{\psi_N^D}{\psi_s^D} \left(\frac{\psi_s^F + \psi_s^D}{\psi_s^F} \right)^2 R_N^2. \quad (39)$$

If the firms in city S wish to dominate both markets, condition (39) must hold. In

addition, recall from the previous section that condition (31) must also hold for city S to capture both markets. Therefore, given that city S captures the financial market, both condition (31) and condition (39) must hold for city S to capture the distribution market as well.

Similarly, suppose city N captures the entire financial market. Then, the following condition must hold:

$$R_N^2 \geq \left(\frac{2}{\psi_N^D} \left(\frac{\psi_N^F + \psi_N^D}{\psi_N^F} \right)^2 (\overline{C}_N^D - \overline{C}_S^D + \frac{3}{2}b) + \frac{\psi_S^D}{\psi_N^D} \left(\frac{\psi_N^F + \psi_N^D}{\psi_N^F} \right)^2 R_S^2 \right). \quad (40)$$

Once again, we know from the previous section that condition (32) must hold for city N to capture both markets. We can summarize these findings in the following proposition:

Proposition 5a: *Suppose condition (33) holds and city S captures the entire financial market. Then, city S will also capture the distribution market if conditions (31) and (39) are satisfied. Similarly, assuming that condition (34) holds and city N captures the entire financial market, city N will also capture the distribution market if conditions (32) and (40) are satisfied.*

6.2.2 Analysis of Case (S, N)

This is the case in which city S dominates the financial market, but city N dominates the distribution market. By backward induction, we know that the optimal strategy for city S is to not invest in the infrastructure of the distribution market (i.e., $I_S^D = 0$ and $C_S^D = \overline{C}_S^D$). However, what about city N? By just observing the game in the third stage, it is unclear what government N should do. Thus, government N will move back to the second stage. Once government N observes the second stage, it realizes that it cannot compete in the financial market. As a result, government N will allocate all available resources to improving the distribution infrastructure (i.e., $I_N^D = R_N^2$). Given this condition, we have:

$$C_N^D = \overline{C}_N^D - \frac{\psi_N^D (R_N^2)^2}{2}. \quad (41)$$

It follows from the analysis in the section on the duopoly in distribution that case (S, N) emerges if and only if:

$$C_s^D \geq C_N^D + \frac{3}{2}b. \quad (42)$$

Replacing C_s^D with $\overline{C_s^D}$ and substituting equation (41) into equation (42), we have:

$$\overline{C_s^D} \geq \overline{C_N^D} - \frac{\psi_N^D (R_N)^2}{2} + \frac{3}{2}b.$$

Then, rearranging the terms yields:

$$R_N^2 \geq \frac{2}{\psi_N^D} (\overline{C_N^D} - \overline{C_s^D}) + \frac{3}{\psi_N^D} b. \quad (43)$$

Thus, the above equation constitutes the sufficient condition under which case (S, N) arises. In addition, given that financial firm S dominates the financial market, condition (33) must also be satisfied. There are three possibilities:

Case I: If $(2/\psi_N^D)(\overline{C_N^D} - \overline{C_s^D}) + (3/\psi_N^D)b > 0$, the terms on the right-hand side of equation (43) become non-negative. Figure 5 illustrates this case. Line AB represents condition (33), and line CD represents the line that satisfies both conditions (32) and (40). Line EF represents condition (43). We know that case (S, N) must satisfy both condition (33) and condition (43). The area that satisfies both conditions is between BE and DF and bounded below by EF. In addition, the area bounded above by EF and lying between BE and DF represents the case in which financial firm S dominates the financial market, but firm N captures the entire distribution market.

Case II: $(2/\psi_N^D)(\overline{C_N^D} - \overline{C_s^D}) + (3/\psi_N^D)b \leq 0$. In this case, the right-hand side of equation (43) is non-positive. Figure 6 illustrates this case. The obvious difference between this case and the previous case is the non-existence of a partial distribution market. In this case, the distribution market is dominated by either distributor S or distributor N.

The above findings are described in the following proposition.

Proposition 5b: *Suppose city S dominates the financial market and condition (33)*

holds. If both the sufficient conditions in (31) and (39) hold, city *S* captures both markets. If either condition (33) or condition (39), or both, fail to hold, then there are two cases:

- (i) If $(2/\psi_N^D)(\overline{C}_N^D - \overline{C}_S^D) \leq (3/\psi_N^D)b$, a partial distribution market does not exist. In other words, the distribution market is dominated by distributor *N*.
- (ii) If $(2/\psi_N^D)(\overline{C}_N^D - \overline{C}_S^D) > (3/\psi_N^D)b$, then a partial distribution market exists.

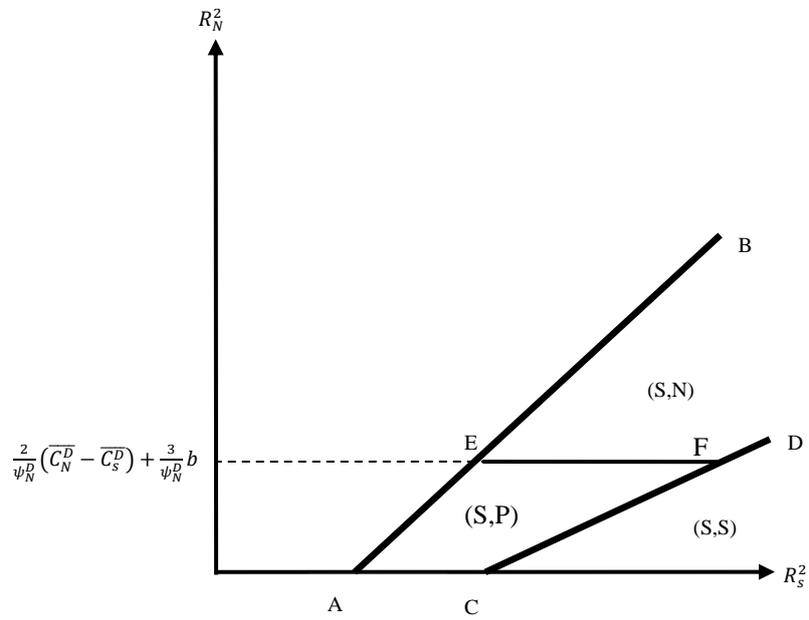


Figure 5: The Case in Which Cities May Share the Distribution Market

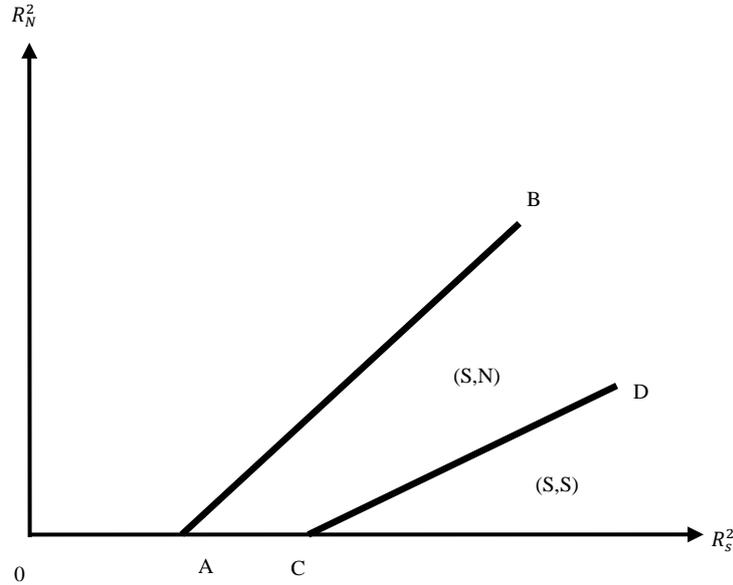


Figure 6: The Case in Which Either City N or City S Dominates the Entire Distribution Market

By symmetry, we summarize the situations in which city N dominates the entire financial market.

Proposition 5c: *Suppose city N dominates the financial market and condition (34) holds. If both condition (32) and condition (40) hold, city N captures both markets. If either condition (32) or condition (40), or both, fail to hold, then there are two cases:*

- (i) *If $(2/\psi_S^D)(\overline{C}_S^D - \overline{C}_N^D) \leq (3/\psi_S^D)b$, then a partial distribution market does not exist. In other words, the distribution market is dominated by distributor S;*
- (ii) *If $(2/\psi_S^D)(\overline{C}_S^D - \overline{C}_N^D) > (3/\psi_S^D)b$, then a partial distribution market exists.*

7 Concluding Remarks

In this study, we extend the model of Long and Wong (2009) to allow for a multidimensional analysis, where two cities compete to become the distribution center and the financial center. We show that if the resources of one city are more

abundant than those of the other city, *ceteris paribus*, this city tends to dominate both markets. This conclusion is reached under the assumption that city governments efficiently use their limited resources to undertake cost-reducing investments in infrastructure. Given that the resources a city has available may reflect the size and the prosperity of the city, our analysis implies that larger and wealthier cities are more likely to become both the distribution and financial centers. We observe this phenomenon in the real world. For instance, Singapore, rather than Manila, is the main financial market in South East Asia.

We further show that an improvement in infrastructure enhances the competitiveness of either the financial or the distribution sector. This result is not limited to cases that include physical infrastructure, such as buildings. It also applies to, for example, legal and/or economic systems in a city. A better legal system helps improve the competitiveness of local firms in international markets by providing assurances and trust, as observed frequently in the real world. One of the common features of major financial cities such as New York, Hong Kong, Tokyo, and London is their sophisticated legal systems. Our simple model provides a possible explanation as to why these cities are capable of being major players in the financial industry, both regionally and globally.

Lastly, we should mention some caveats and, hence, potentially interesting extensions to the proposed model. First, we assume in our simple analysis that two competing cities share a similar geographical background. However, this is not realistic, because geographical location affects the types of cities and the competitiveness of firms located within the cities. For example, almost all major cities in the world today are located along a coastline. One could argue that the initial costs in the model reflect some degree of geographical advantage, but these advantages are not sufficient to explain how location affects market outcomes. Thus, a more complete framework that includes spatial competition should be considered in future research. Another possible extension is to incorporate production technology into the analysis. In this case, the quality of labor and the return on capital may be important in determining whether cities can be major players in their respective markets. Economies of scale in production may also play a crucial role in the equilibrium outcome of market competition. Furthermore, while we only consider two cities and two sectors in our study, real-world situations are more

complex than this. Therefore, it would be interesting to see how the solutions would change if we were to extend this model beyond two cities and two sectors. We postulate that while the mathematical form will be more complicated, the basic principles will remain the same. Finally, this study can be extended by examining how the infrastructures of one sector provide positive externalities to other sectors. For example, building more schools in a sector will boost the quality of workers in other sectors. In this sense, rather than competing for resources, sectors may complement one another, which will affect the optimal allocation of resources.

Acknowledgements

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