On the Role of Communications Networks in Regional Economic Development

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July 14, 2003

*An earlier version of this paper was presented at the 2003 International Conference on International Trade and Factor Mobility at Kansai University, Japan. I would like to thank David Anderson, Jota Ishikawa, Henryk Kierzkowski, Masao Oda, and Hisayuki Okamoto for constructive comments.

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Abstract

This study develops a multi-region model that captures the role of communications networks in enhancing interregional trade in intermediate business services. A link between the adoption of communications networks and improved regional performance is explored. The paper also examines the relationship between interregional trade in business services and international trade in goods.

Keywords: Communications networks; interregional trade in business services; international trade in goods; economic development

JEL Classifications: D43, F12, R12

Running Head: Communications Networks and Economic Development

1 Introduction

Over the last decade, the Internet, mobile telecommunications networks, and myriad other types of communications networks have come to play a crucial role in economic activities. In particular, it is increasingly recognized that the growing connectivity of individuals and organizations is achieved through improved communications networks and a consequent increase in the flow of business services (e.g., business software development, accounting, data processing) across regions or cities.[1] Because of this, the achievement of better economic performance via the use of advanced communications technologies has become a major interest. Success stories include the strong showing of the U.S. economy during the 1990's, with the help of the largest and most sophisticated communications infrastructure in the world. In some countries, however, the infrastructure is still immature and quite inefficient.[2] Such countries have become increasingly aware that the competitiveness of firms

[1] Business services provide critical linkages in an economy: they allow other industries to operate more efficiently. Input-output analysis reveals that the dependence of the manufacturing sector on business services increases with per capita income. See Park and Chan (1989).

[2] Examples of this are a backbone network (an overarching network to which multiple regional networks connect) and mid-level networks of the Internet: MacKie-Mason and Varian (1997) report that the connections between European national networks are often slow or of low quality.

and regions is more and more strongly dependent on the adoption of new information and communications infrastructure.

In the existing literature on economic theory, however, little attention has been given to the role of communications networks and interregional services trade in the process of regional development.[3] This study develops a model that captures that role. I focus here on the nature of the *interregional tradability* of business services. In the literature, intermediate business services are usually regarded as *non-tradable* goods.[4] This assumption comes from the characteristics of service transactions, which usually require that there be a double coincidence in both time and spatial proximity for the buyer and seller. An adoption of communications networks, however, might eliminate the necessity for the buyer and seller to be at the same location, even though the coincidence in time may still be necessary.[5] Evidence of this includes,

[3] Empirical studies have found an important relationship between interregional trade in services and economic development. Gilles (1989), for example, notes that 'import substitution' in services is as important a regional-development goal as export promotion. See also Harrington et al. (1991) for a survey of empirical studies.

[4] For the relevance of this assumption, see Matsuyama (1995) and Rodriguez-Clare (1996).

[5] Coyle (1997, Ch. 9) suggests that the use of telematics (i.e., information and communications technologies) is breaking the traditional geographic linkage between local demand and local supply of business services. Jones and Kierzkowski (2003) also suggest that the impact of the reduced communication costs is the most profound in lowering the service

for example, the fact that sophisticated software engineers from one region can deliver their services to another region via the Internet. Even though not every service can be traded interregionally, the advancement of information and communications technologies seems to suggest that the assumption of nontradable business services should be accompanied by a focus on interregional service trade through communications networks.[6]

Harris (1998) was one of the first to investigate the influence of communications networks on the interregional tradability of business services. He emphasized the *fixed cost nature of communication costs* and explored an important relationship between trade in business services and communications networks: that advanced networks will facilitate the enhancement of interregional trade in intermediate business services.[7] He termed this aspect the *virtual mobility of business services.* However, he focused on the

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costs required to coordinate spatially separated production fragments.

[6] Throughout this paper I assume that business services are internationally nontradable, which may be rationalized by language, cultural, and legal system differences among countries. I concentrate on the implications of *interregional* service tradability. For a discussion about *international* service tradability, see Section 5.

[7] Harris (1995) also emphasized the distinction between transport costs and communication costs: the former is a variable cost which is positive, while the marginal cost of communications is assumed to be zero – the costs of a communications network are all fixed.

effects of the introduction of networks on labor markets, such as the emergence of the skill premium. In contrast, this study focuses on the role of country-specific communications networks through which business services are traded interregionally, and examines the impact of these networks on regional development. I model a country as a collection of regions which produce intermediate business services, and consider the impact of a network on regional performance. It will be shown that the impact of networks depends on a number of factors including the number of regions that are covered by communications infrastructure, and the cost of providing the network.

The next section presents a basic multi-region model of monopolistic competition. Section 3 deals with the effect of a network on interregional service trade. The relationship between *interregional* service trade and *international* goods trade is considered in Section 4. Some extensions are considered in Section 5, followed by concluding remarks in Section 6.

2 The model

Suppose that a country consists of m geographically distinct regions (or cities). In the following two sections, this country is assumed to be a closed one. Each region produces three types of goods. Two of the goods, Good X and Good Y, are potentially tradable, and one–business services such as software development, accounting, and consulting – are not traded across regions. Each region is endowed with L units of labor, and labor is assumed to be physically immobile across regions. Throughout this section, the equations are for a representative region.

Good Y is produced competitively under constant returns using only labor. Labor units are chosen such that their unit input coefficient is unity. The Good X sector is also competitive with constant returns but uses only business services as inputs. The production and unit cost functions for Good X are respectively:[8]

$$X = \left(\sum_{i=1}^{N} {x_i}^{\theta}\right)^{1/\theta}, \quad 0 < \theta < 1, \tag{1}$$

$$C = \left(\sum_{i=1}^{N} {p_i}^{\theta/(\theta-1)}\right)^{(\theta-1)/\theta}, \tag{2}$$

where N is the number of *available* intermediate business services, x_i and p_i are the quantity and price of service i respectively, and $1/(1-\theta)$ is the elasticity of substitution between every pair of services.

Intermediate business services are supplied by monopolistically competitive *service firms*. The central assumption is that both the production and the distribution of business services require communications activities. This emphasizes the fact that highly differentiated services require communica-

[8] See Ethier (1982) and Markusen (1989).

tions capable of transferring complex information.

In the initial situation service firms are assumed to be purely region-specific; a region is defined as a geographic area sufficiently small that service activities can occur via face-to-face meetings and without the communications network.[9] I shall call this situation a *communications autarky.* In this situation service firms both sell their outputs and purchase their inputs in the same regional market. Given the symmetry, the initial equilibrium will be one in which the number of services is equal across all regions.

To produce x units of service, $\alpha + \beta x$ units of labor are required. Given a Dixit-Stiglitz specification with constant elasticity $1/(1-\theta)$, and a wage rate w, each service firm sets its price as $p/w = \beta/\theta$. Hence, the unit cost of Good X, given by (2), is simplified to

$$C(N) = N^{(\theta-1)/\theta}(\beta w/\theta). \tag{3}$$

This equation has the property that as input differentiation increases, unit cost decreases ($C' < 0$). With free entry and exit, the level of output that generates zero profits is given by $x^A = \alpha\theta/\beta(1-\theta)$, where A refers to the communications autarky value.

[9] Following Harris (1998), I assume that face-to-face meetings are perfect substitutes for communications via the network (virtual meetings), which is a dramatic simplification. Gasper and Glaeser (1998) explored the complementary relationship between these two activities.

Let n be the number of business services *produced* within a region. In the communications autarky case, the price of Good X, P, must be equal to its cost:[10]

$$P = C(n) = n^{(\theta-1)/\theta}(\beta/\theta). \tag{4}$$

Assuming that a constant fraction μ of income is spent on Good X, the communications autarky number of service firms in each region becomes $N^A \equiv n^A = \mu(1-\theta)L/\alpha$ and we get

$$P^A = [\mu(1-\theta)L/\alpha]^{(\theta-1)/\theta}(\beta/\theta). \tag{5}$$

Given that both goods are produced, income in terms of Good Y remains constant. Thus, N (or P) can be used as the index of welfare: an increase in the number of available services increases the welfare level of the region.

3 Introducing the communications network

Now assume the introduction of a communications network infrastructure that covers all regional markets. The introduction of the network allows any firms in the Good X sector to purchase intermediate business services from any other regional market. Thus the country-specific communications network effectively integrates the business services sector interregionally. Note

[10] Note that $w = 1$ holds because Good Y is produced regionally.

that this technological change is not costless: each service firm must pay γ (hereafter, *the network cost*) in order to be on the network. This brings the fixed costs per service firm up from α to $\alpha + \gamma$.

The country-specific communications network can be thought of as being provided by a public monopoly that employs average-cost pricing. One of the main assumptions is that there are only fixed costs in the provision of the network, which is linear in the number of regions.[11] For tractability, I assume a simple cost function for the monopolistic provider: $K(m) = mF$, where F represents the fixed costs of network provision for each region. Because of average-cost pricing, the network costs per service firm are simply[12]

$$\gamma(n) \equiv K(m)/mn = F/n. \tag{6}$$

This implies that the network cost per service firm falls as the number of firms in the business services sector increases, allowing more users to share the common cost of providing the network, F. The level of output that generates zero profits becomes

$$x^C = [(\alpha + \gamma)\theta]/[\beta(1 - \theta)],$$

where C represents the situation after connection. As the number of firms increases, the level of output per service firm decreases. This cost-sharing

[11] This assumption emphasizes the public-good nature of the communications network.

[12] Note that I concentrate on the symmetric equilibrium.

effect is a natural consequence of the existence of a large fixed cost for the provision of the communications network.

After the introduction of the network there is now interregional business services trade where previously there was none.[13] The volume of business services imports in a single region is given by $n^C x^C (m-1)/m$, where n^C is the number of business services *produced* within each region. Thus, in aggregate, the number of available intermediate business services in each region changes from $N^A = n^A$ to $N^C = mn^C$ upon adopting the network.

In the new equilibrium the price of Good X becomes [14]

$$P^C = (m[\mu(1-\theta)L - F]/\alpha)^{(\theta-1)/\theta}(\beta/\theta). \tag{7}$$

Let L_B be the amount of labor devoted to the production of business services in each region. Comparing (6) and (7), $P^C < P^A$ (or $N^C > N^A$) holds if [15]

$$L_B^C = \mu L > mF/[(1-\theta)(m-1)]. \tag{8}$$

This relationship is summarized graphically in Figure 1. On the horizontal axis is the level of labor input for the business services sector in each

[13] Note that there is only intraindustry trade in business services.

[14] By using the labor market equilibrium condition, $n^C = [\mu(1-\theta)L - F]/\alpha$ can be obtained.

[15] Note that the first equation is derived from the labor market equilibrium condition: fraction μ of the total labor supply is devoted to the production of business services.

region, L_B. On the vertical axis is the number of available business services, N. The two solid lines reflect the technologies of production: line AA' is for the communications autarky, and steeper line CC' is for the interregional service trade through the communications networks.[16]

Condition (8) indicates that if (a) the level of the construction cost (shown by the horizontal segment AC) is sufficiently small and/or (b) the number of regions (shown by the slope of line CC') is sufficiently large, each region's welfare will be raised by interregional service trade.[17] For example, when the level of labor input is ${L_B}^1$, the number of available business services will be increased (and the price of Good X will be decreased) relative to the autarky situation. The productivity benefits of communications are the gains from trade that accrue from increased specialization in the provision of business services. On the other hand, if condition (8) does not hold, each region will

[16] Note that the lines correspond to the following conditions.

$$AA': \quad N^A \equiv n^A = (1-\theta)L_B/\alpha,$$
$$CC': \quad N^C \equiv mn^C = m([(1-\theta)L_B] - F)/\alpha.$$

Segment AC corresponds to the amount of labor required for the construction of the network, $F/(1-\theta)$.

[17] Note that these results are closely related to the ones obtained by Murphy et al. (1989), who examined the interdependence between investment in infrastructure and industrialization.

lose from a decrease in the total number of service firms since more resources are devoted to network provision costs.

Proposition 1: *If condition* (8) *holds, every region will gain from interregional service trade through the communications network.*

4 Interregional trade in business services and international trade in goods

In this section, the relationship between *interregional trade in business services* and *international trade in goods* is examined. Suppose that a country opens its final goods markets and has a trade relationship, while business services are nontradables across countries.[18] Also suppose that the country is a small open economy, and let the world relative price of Good X and the corresponding number of business services be $\bar{P}$ and $\bar{N}$, respectively:

$$\bar{P} = C(\bar{N}) \equiv \bar{N}^{(\theta-1)/\theta}(\beta/\theta). \tag{9}$$

[18] This assumption implies that the communications networks are purely country-specific, which may be rationalized by language, cultural and legal system differences. For example, international trade in engineering consultancy will be hindered by governments that set technical standards that differ too much from the standards of others. Kikuchi (2003) explores the impact of the interconnection of country-specific networks.

Assume that there is a simple entry-exit process whereby service firms enter the business service sector if profits there are negative and slowly exit when they incur losses. Given this process, if $P^i < \bar{P}$ $(N^i > \bar{N})$ for $i = A, C$, this country specializes in Good X, whereas if $P^i > \bar{P}$ $(N^i < \bar{N})$, it specializes in Good Y. In the latter case, no business services are produced in this country and the welfare level becomes lower compared to the former case. Thus, in the present model, there are multiple equilibria with underdevelopment traps: the country may get trapped in an historical pattern of inadequate specialization.

Here I would like to emphasize the role of communications networks in compensating for historical handicaps. Consider the following case:[19]

$$N^A < \bar{N} < N^C. \tag{10}$$

Condition (10) implies that, without a network, the production costs of Good X are higher than the world relative price of Good X $[C(N^A) > \bar{P} = C(\bar{N})]$. This will cause service firms to exit the business services sector, and the production costs of Good X will increase due to the decreased number of business services available. This process continues until the economy completely specializes in Good Y, as represented in Figure 2 by downward arrows starting from point a on line AA'. In the case of specialization in Good Y,

[19] Note that (8) is the necessary condition for this.

the wage rate in terms of Good X becomes:

$$\left(\frac{w}{P}\right)^Y = \frac{1}{\bar{P}} = \bar{N}^{(1-\theta)/\theta}\left(\frac{\theta}{\beta}\right), \tag{11}$$

where superscript Y represents the case of specialization in Good Y.[20]

Here I would like to emphasize that the country might have a large number of business services (i.e., the total number of business firms mn^A might be greater than $\bar{N}$). Due to the lack of connectivity, however, this country cannot take advantage of its business services availability.

In summary, without the communications network, the opening of international trade in goods prevents a country from allocating resources to the production of Good X and business services. Alternatively, by adopting a network before the opening of international trade in goods, a country can overcome this problem. With a network, the international price is so favorable $[C(N^C) < \bar{P} = C(\bar{N})]$ that the only equilibrium involves complete specialization in Good X. Let us consider the dynamic process in detail. Given that $\bar{N} < N^C$ holds, the opening of trade provides an opportunity for entry into each region's business services sector. Thus the total size of the country's network (mn) will expand, which makes the unit cost of Good X much lower through the increased interregional service trade (i.e., the increased degree of specialization), and the export of Good X increases. This

[20] This equation can be obtained from equation (9).

process continues until the economy completely specializes in both Good X and business services, as represented in Figure 2 by upward arrows starting from point c on line CC'. Let N^X be the number of available services when this country completely specializes in Good X. There will be a cumulative process in which the export of Good X provides an opportunity for the enhancement of trade in business services, and enhanced *interregional* trade in services promotes *international* trade in goods. There are gains both from the increased specialization in services and from the increased trade in goods. Furthermore, there are additional gains from efficient utilization of the network: as the number of service firm increases, the monopolistic provider can spread the fixed costs of network provision over service firms.

In the case of specialization in Good X, the wage rate becomes:

$$\left(\frac{w}{P}\right)^X = \frac{w}{\overline{P}} = \left(N^X\right)^{(1-\theta)/\theta}\left(\frac{\theta}{\beta}\right), \tag{12}$$

where superscript X represents the case of specialization in Good X. Given that $N^X > \bar{N}$ holds, this equilibrium clearly dominates one of specialization in Good Y [see (11) and (12)]. This case illustrates the potential role of communications networks in correcting for historical handicaps.

Proposition 2: *By introducing a communications network, a country may overcome historical handicaps and gain through specialization in both Good X and business services.*

5 Discussion

In this section I describe three directions in which the model could be extended. Firstly, let us consider the assumption about the international tradability of business services. For simplicity, I have assumed that the business services are nontradable across countries. Of course, this assumption is quite restrictive: more and more business services, which can be traded via communications networks, have become internationally tradables. Recent examples include India, which has emerged as a popular provider of a range of intermediate activities in services. The inclusion of internationally tradable business services, however, does not change the qualitative results from the basic analysis. We can interpret the rise of internationally tradable business services as an increase in the number of regions through which business services can be traded. Under this interpretation, international tradability strengthens the gains from trade in business services. In order to analyze the relationship between the degree of international tradability of business services and the regional economic performance, this kind of extension needs further consideration.[21]

Secondly, let us consider the assumption of symmetric regions. With size asymmetries among regions, the outcomes in a communications autarky

[21] Kikuchi (2002; 2003) explore the role of international tradability of business services.

would be different from those discussed in the previous sections. Due to the lack of service availability, some small regions might end up specializing in Good Y. Then, the introduction of a network would have a different impact on regional economic performance. Thus the model could be enriched with the inclusion of size asymmetries among regions.

Thirdly, let us consider the industrial organization of the communications industry. In order to simplify the argument, I have assumed that the network services are provided by a public monopoly which employs average-cost pricing. In reality, however, this monopoly may exhibit some monopoly power and raise the network cost for each service firm, which weakens the potential role of the communications networks in correcting historical handicaps. Therefore, it is important to realistically model the market structure of the communications industry: there is room for further investigation.

6 Concluding remarks

The Internet, mobile-phone systems, and other types of communications networks have raised the use of business services to a new level. This study models some of the important factors through which communications networks affect regional development. A country-specific communications network, through which business services are traded interregionally, is characterized by

(1) the existence of large fixed costs of provision, and (2) a public monopoly that employs average-cost pricing.

It should be emphasized that the technological conditions of the communications network infrastructure determine the degree of regional economic development. For example, given that the number of regions covered by the network is relatively high, each region will gain through interregional business services trade–each region will gain from an increased degree of specialization in the business services sector. In other words, if there is a lack of substantial network infrastructure, the scale advantage of a large country in providing services will be eliminated: a large country may simply consists of a large number of disconnected regional economies.[22] What really matters for economic development is the connectivity of regional economies rather than the size of a country.

More noteworthy is that, in an open economy setting, a country-specific communications network can lead a country towards a more desirable equilibrium. The adoption of communications networks may facilitate interregional business services trade, which further promotes international goods trade.

Although these results are derived under the assumption that communications networks are purely country-specific, it appears that something similar

[22] See Matsuyama (1992) for the related argument.

to this will occur in a more general setting. The present analysis must be regarded as tentative. Hopefully it provides a useful paradigm for considering how communications infrastructure works as a driving force for regional development.

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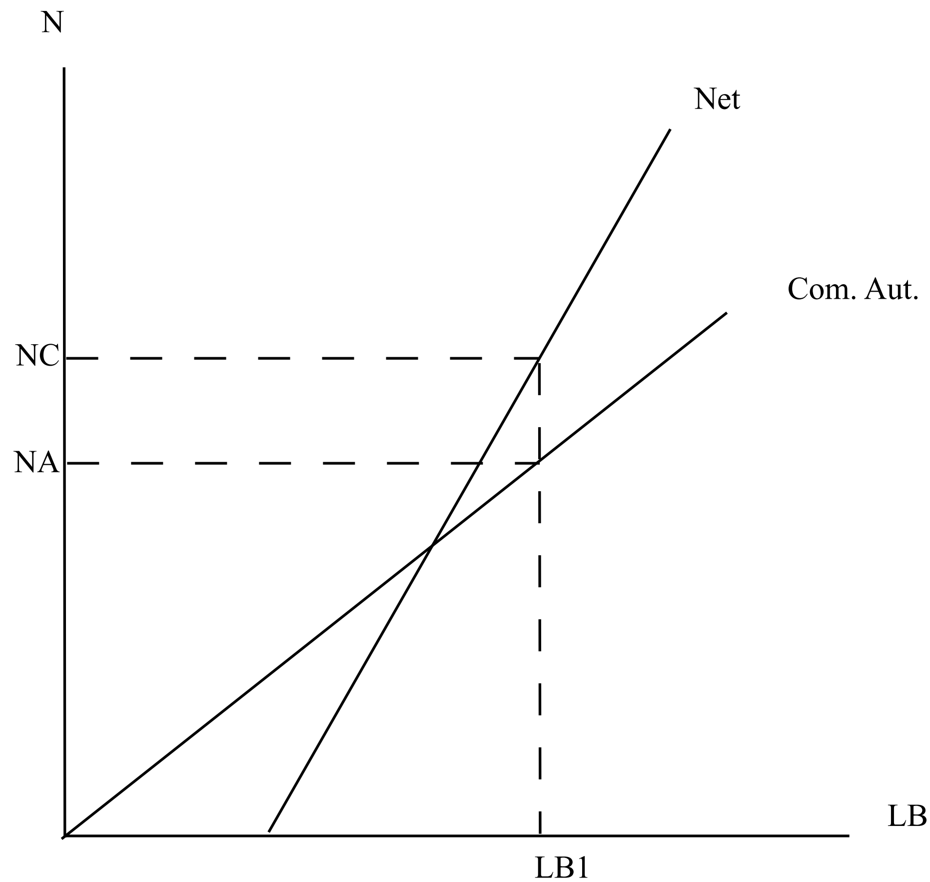

Figure 1

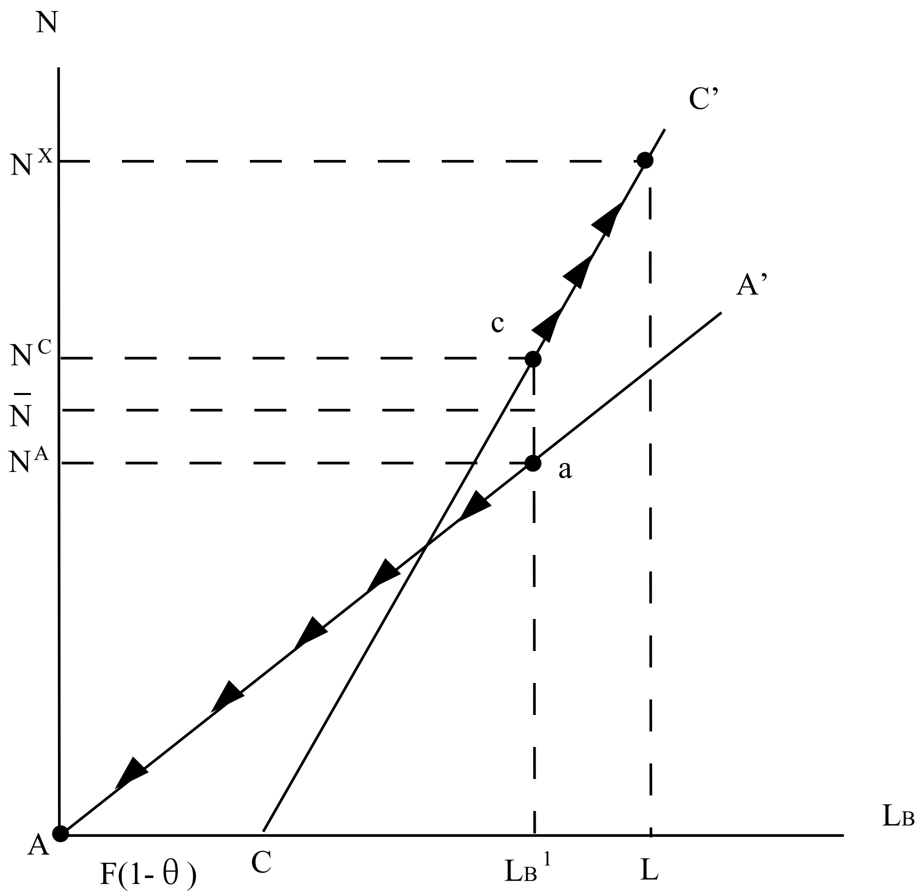

Figure 2