E C O N O M I C S   B U L L E T I N

Network externalities as a source of comparative advantage

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Abstract

This note examines how the network externalities of communications activities and trading opportunities interact to determine the structure of comparative advantage between countries. These interactions are obtained by constructing a two−country, two−sector model of trade involving a communications network sector. The role of network interconnectivity, which allows users of a network to communicate with users of another network, is also explored. A comparative advantage in the good that requires network services is held by the countries with interconnected networks.

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1 Introduction

The rapidly growing connectivity of individuals and organizations achieved through improved communications networks (e.g., the Internet, mobile telephone networks, and satellite communications systems) has allowed a consequent increase in the flow of business transactions. These networks are often characterized by the existence of strong *network externalities*: the more people who use it, the more useful it is to any individual user. In accordance with this, it has become increasingly recognized that sophiscated and well-connected country-specific networks are the 'competitive weapons' upon which the structure of comparative advantage will critically depend.

The seminal contribution on the role of network externalities is Katz and Shapiro (1985), which analyzes oligopolistic competition between providers of network services.[1] However, as their model is based on a closed market for a consumption good, the role of network externalities as a determinant of comparative advantage is downplayed in the analysis. Since such effects are often observed in the world economy, it seems important to explore the role of network externalities in the trading-economies setting.

As its primary contribution, this note examines how the network externalities of communications activities and trading opportunities interact to determine the structure of comparative advantage between countries. I also emphasize an important concept related to network externalities – *interconnectivity* –which allows users of a network to communicate with users of other networks.[2] For these purposes I construct a two-country, two-good model of trade with country-specific communications networks. It will be shown that a comparative advantage in the good that requires network services is held by the country with interconnected networks.

2 The Model

Consider a world economy consisting of two countries, Home and Foreign. There are two goods: a primary commodity which is produced by labor

[1] See Katz and Shapiro (1994), Roson (2002) for surveys of the relevant literature. In network externalities context, there is a new literature on 'two-sided markets.' See, for example, Rochet and Tirole (2003).

[2] Cremer et al. (2000) explores the role of interconnectivity between Internet Service Providers (ISPs) in the closed economy setting. Kikuchi (2003) explores the role of interconnectivity using a monopolisticaly competitive trade model. However, he pays scant attention to the role of network externalities as a determinant of comparative advantage, which is the main focus of this note.

without the use of communications services and high-tech products which are produced with communications services. I refer to the former as the *non-network good* and to the latter as the *network good*. Communications services are assumed to be provided by country-specific *network service providers*. There are n identical providers in each country: they compete in a Cournot fashion. Providers will be indexed by label i ($i = 1, ..., n$). Let x_i denote the size of the i-th provider (i.e., the number of subscribers), y_i the size of the network with which the i-th provider is associated, and let z be the total number of network users. For example, when n providers are fully interconnected, $z = y_i = x_1 + ... + x_n$ holds.

Let the network good be the numeraire and p indicate the relative price of the non-network good. The non-network good is produced under constant returns technology; units are chosen such that its unit input coefficient is unity.

Each country is populated by a continuum of workers with population L. Each worker is endowed with one unit of labor and some level of specific skill for the production of the network good, which is measured by index r. The values of r are uniformly distributed over the interval $[0,\ L]$. Each worker's productivity is also affected by the level of network externalities, v, which is identical for all workers and dependent on the size of the network, y. The v term captures gains through increased information flow between individuals. It is simply assumed that a type-r worker can produce $r + v$ units of the network good. Following Katz and Shapiro (1985), the network externality function $v(y)$ is assumed to be concave and increasing.

Workers have the choice of either supplying labor for the production of the non-network good or becoming a supplier of the network good, and workers will become the latter only if they connect to a communications network. To connect to the i-th provider's network, each worker must pay a connection fee, f_i, in exchange for unlimited access up to the maximum throughput of their particular connection. A type-r worker chooses to connect to the network for which

$$r + v(y_i) - (f_i + p) \tag{1}$$

is largest. If $r + v - f_i \geq p$ holds for a particular worker, that worker pays the connection fee and starts to produce the network good. However, if $r + v - f_i < p$ holds, that worker chooses not to connect to the network and produces the non-network good instead. As p rises, more workers choose not to connect to the network. Thus, one can interpret $(f_i + p)$ as a connection fee including the outside option.

Given the homogeneity of networks, providers i and j will both have a positive number of subscribers only if

$$(f_i + p) - v(y_i) = (f_j + p) - v(y_j), \tag{2}$$

where $(f_i + p) - v(y_i)$ is the connection cost for the i-th network, i.e., the cost adjusted for network size.[3] Let Φ denote the common value of this cost. For a given value of Φ, only those workers for whom $r > \Phi$ become producers of the network good. Given the uniform distribution of r, there are $L - \Phi$ workers who choose to connect to the networks. Thus, if the total number of network users is z, $z = L - \Phi$ holds. Then, by substituting $\Phi = (f_i + p) - v(y_i)$ into this, we obtain the condition for the connection fee

$$f_i = L - p + v(y_i) - z. \tag{3}$$

To simplify the analysis, I assume that the production cost for each provider is equal to zero. Thus the i-th provider's profits are

$$\pi_i = x_i f_i = x_i[L - p + v(y_i) - z]. \tag{4}$$

Note that the valuation for the network, $v(y_i)$, is equivalent to a reduction in marginal cost, which affects the pricing decision.

Depending on the interconnectivity between providers, two cases can emerge as the production equilibrium. The following subsections discuss each case.

2.1 The Case of Interconnected Networks

Let us assume that n providers are fully interconnected. A user who connects to one network can communicate with users of other networks. Interconnectivity expands the size of each network to the total membership of all providers. This raises the productivity gains enjoyed by a worker who subscribes to only one provider's network because network externalities depends on the total size of the network (i.e., $z = x_1 + ... + x_n$). Thus, maximizing (4) with respect to x_i, we obtain

$$x_i = [L - p + v(z)]/(n + 1), \quad i = 1, ..., n. \tag{5}$$

By summing Equation (5) over all i, we obtain the total network size as a function of the price of the network good $(1/p)$.

$$z^I(1/p) = [n/(n + 1)][L - p + v(z^I(1/p))], \tag{6}$$

[3] (2) implies that all the existing networks in equilibrium provide necessarily the same 'surplus,' which is defined as (1).

where superscript I denotes the equilibrium value when the networks are fully *interconnected*. Under our assumptions about v, Equation (6) has a unique solution. The equilibrium is depicted in Figure 1(a). The horizontal axis shows the total size of the network, z, while the vertical axis shows the values of $L - p + v$ and $[(n+1)z]/n$. Equilibrium is obtained at an intersection of two curves: Line ON represents $[(n+1)z]/n$ while the other curve represents $L - p + v$. As p becomes smaller, the curve will shift upward, which results in a larger total size of the network.

Now consider the equilibrium supply level of the network good. By Equations (1) and (3), a type-r worker can produce $r + z + f + p - L$ units of output. Furthermore, only those workers for whom r is greater than $L - z$ join the network, while the others choose to produce non-network goods. Integrating all workers who do connect to the networks, we can obtain the total output of the network good:

$$S(z) = \int_{L-z}^{L} (\rho + z + f + p - L) d\rho = (z^2/2) + (f + p)z. \tag{7}$$

We can interpret this as the supply function of the network good. This function is represented by OS in Figure 1(b). As the total number of network users becomes larger, the average productivity of each network good supplier rises (this is shown as lines OA and OA' in Figure 1(b)). The economy thus has a supply function that exhibits increasing returns to the size of the networks.

There are two sources of these gains: (1) as more workers join the networks and the total number of subscribers increases, each infra-marginal worker can attain higher productivity through intensified network effects, and (2) through these network effects, each service provider chooses to set a lower connection fee, which further attracts more workers. More noteworthy is that, in terms of income inequality between sectors, as the size of the networks becomes larger, income inequality between sectors increases.[4]

2.2 The Case of Unconnected Networks

Next, let us consider the case in which n providers are unconnected to each other. Subscribers on one network cannot communicate with those on the other network. In this case, $y_i = x_i$ holds. If there exists a symmetric equilibrium, $x = z/n$ holds. Thus, instead of (6), we obtain,

$$z^U(1/p) = [n/(n+1)][L - p + v(z^U(1/p)/n)], \tag{8}$$

[4] Note that the productivity of the non-network good sector remains unchanged.

with superscript U denoting the equilibrium value for the *unconnected* networks. This case is shown by the dotted curve in Figure 1(a). Since network externalities are smaller than in the case of interconnection, the equilibrium total size of the network, z^U, also becomes smaller than z^I. With these figures we obtain the supply curves of the network good (Figure 2): the supply curve of the country with interconnected networks is located to the right of the country with unconnectd networks.[5]

3 The Impact of Trade Integration

Suppose that the only difference between two countries is the interconnectivity of the country-specific communications networks. Without loss of generality, Home is assumed to have interconnected networks while Foreign has unconnected networks.[6] Also, let each country have the same demand function for the network good, $D(1/p)$, which is shown as a downward sloping curve in Figure 2.[7] In this case, from Figure 2, Home has the lower autarky price of the network good (i.e., $(1/p^I) < (1/p^U)$).

Now suppose that two countries (Home and Foreign) open their goods markets and have a trade relationship. The opening of trade provides an opportunity for entry into Home's network goods sector because, with expanded network size, the average productivity of Home workers is much higher than that of Foreign workers. On the other hand, marginal workers in Foreign's network goods sector stop producing the network good due to the reduced relative price of the network good. Thus the scale of Home (interconnected) networks will expand, while Foreign (unconnected) ones will contract. The differences in the network sizes will be reinforced by this entry-exit process. That is, there will be a *cumulative process* in which trading opportunities bring an opportunity for larger networks, and the increased sizes of the networks promote (through increased network externalities) exports. This process will continue until the price differential between countries disappears ($(1/p^T)$ in Figure 2).

Proposition 1: *A comparative advantage in the network good is held by a country with interconnected networks. With freer trade, both countries*

[5] Note also that, since productivity rises as the price of the network good rises, the supply curves have concave shapes.

[6] Throughout this paper I assume the interconnectivity of country-specific networks in each country to be exogenous.

[7] Note that we assume away any income effect.

reallocate resources toward a good for which it has a comparative advantage.

Since the size differential between country-specific networks is magnified through international trade, we can also obtain the following proposition.

Proposition 2: *Opening international trade increases inequality in the country that exports the network good and reduces inequality in the country that exports the non-network good.*

It should be emphasized that differences in connectivity among country-specific commuications networks determine the comparative advantages of countries: although each country is endowed with equal amount of labor, the country with connected networks can attain higher productivity through increased information flow. More noteworthy is that there is a circular process between network expansion and trade creation which further affects income inequalities within each country. Although these results are derived under the assumption that communications networks are purely country-specific, it appears that something similar to this will occur in more general settings.

References

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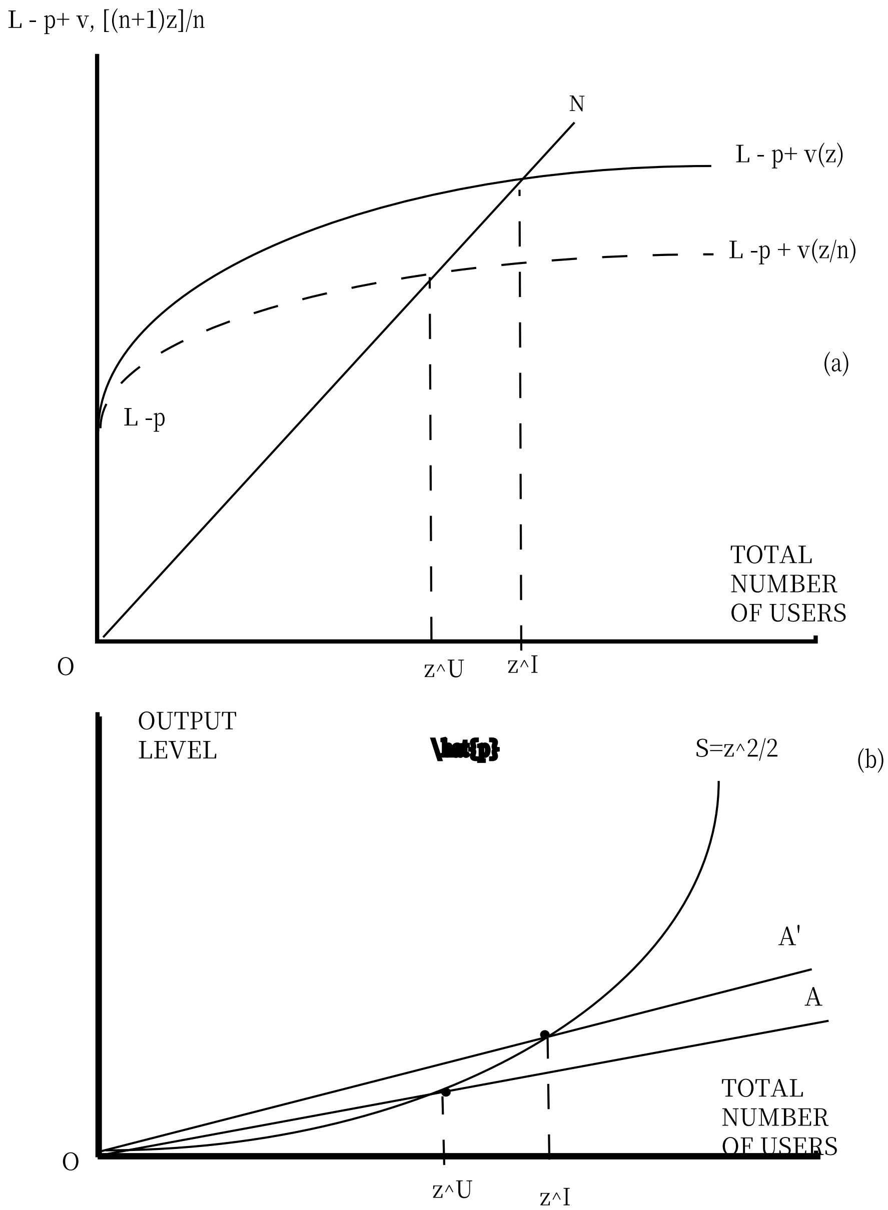
L - p+ v, [(n+1)z]/n
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L - p+ v(z)
L -p + v(z/n)
(a)
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NUMBER
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LEVEL
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S=z^2/2
(b)
A'
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FIGURE 1

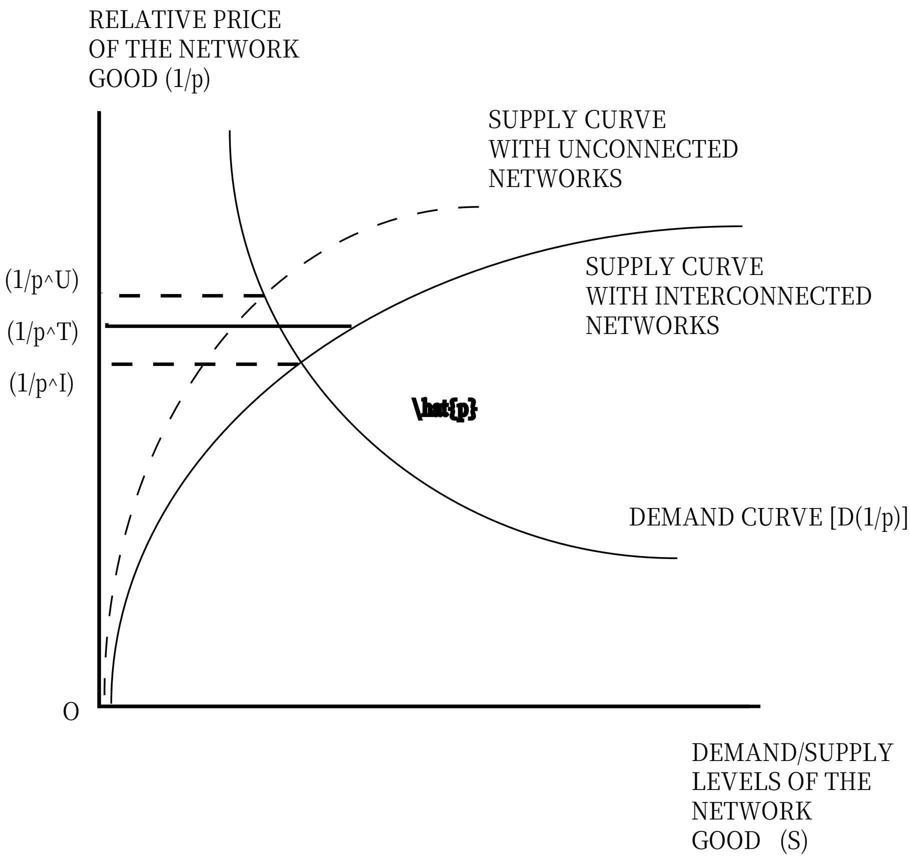
RELATIVE PRICE
OF THE NETWORK
GOOD (1/p)
SUPPLY CURVE
WITH UNCONNECTED
NETWORKS
(1/p^U)
(1/p^T)
(1/p^I)
SUPPLY CURVE
WITH INTERCONNECTED
NETWORKS
\hat{p}
DEMAND CURVE [D(1/p)]
O
DEMAND/SUPPLY
LEVELS OF THE
NETWORK
GOOD (S)

FIGURE 2