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ON NETWORK EFFECTS IN MODELS OF MARKET INTEGRATION

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Two models of market integration in which there are network effects are investigated. The first model looks at the relationship between the degree of competition in the network sector and the welfare consequences of opening trade in a model of oligopoly with network effects. The second model focuses on the impact of market integration on producers' profits. In this model, a link between market expansion and intensified competition is established.
Keywords: Network effects; Market integration.

1. Introduction

The proliferation of market integration through both economic integration and free trade agreements (e.g., NAFTA) has spawned a vast literature on the implications of market integration. As yet, however, little attention has been paid to the implications of market integration in the presence of products with network effects.

A product that creates network effects generates some of its value through compatibility with other products of the same type. The network value of the good takes the form of an externality which is a function of the volume of the product in use. The markets of goods characterized by network effects are especially appropriate subjects for the study of international product standards because product standards and the resulting compatibility influence consumers' valuation of a product.

Despite the fact that many industries characterized by network effects are crucially related to market integration, the literature on industrial organization is almost exclusively focused on closed economies.[1)] Since the role of network effects is amplified in the globalized economy, it seems important to explore the impact of market integration on goods with network effects.

The purpose of this study is to explore this relationship a little further. To make this point we develop two different models. In the first, we use the Katz and Shapiro (1985) model of oligopoly with network effects. Although Katz and Shapiro emphasized *consumption* network effects, we emphasize network effects in the production sector.[2)] There are two goods: a primary good and high-tech products. We will show that, given that each country has a different number of service providers of network services, the comparative advantage in the

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1) See Katz and Shapiro (1994), Economides (1996a), and Shy (2001) for surveys of the relevant closed-economy literature. For the open-economy context, see Gandal and Shy (2001), Barrett and Yang (2001), and Kikuchi (2003, 2005, 2006).
2) The first model based on Kikuchi (2005, 2006), Kikuchi and Kobayashi (2006a).

high-tech good is held by the country with the competitive network sector.

In the second model, we examine how market integration affects the profits of firms in the presence of network effects, which also helps to explain the international coordination of standards. For these purposes, based on Economides (1996b), we construct another simple two-country oligopoly model of market integration with network effects.

The structure of this paper is as follows. The two models are developed and analyzed in Sections 2 and 3 of the paper. Section 4 presents some conclusions.

2. Development and Analysis of Model I

2.1 Model I

Consider a world economy consisting of two countries, Home and Foreign. There are two goods: a primary commodity which is produced only by labor and a high-tech product which is produced with both labor and communications services. Communications services are assumed to be provided by country-specific *network service providers*. There are n (n^*) identical providers in Home (Foreign): they are playing a Cournot competition. 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 high-tech product be the numeraire and p indicate the relative price of the primary good. The primary 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 human capital for the production of the high-tech product, 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, vy^e_i, where v ($v \leq 1$) is a valuation parameter and y^e_i is the worker's expectation of the (i-th) network size.The v term captures gains through increased information flow between individuals: if more workers join to the communications network, each worker can collect information more efficiently. It is simply assumed that a type-r worker can produce $r + vy^e_i$ units of the high-tech product.

Workers have the choice of either supplying labor for the production of the primary good or becoming a supplier of the high-tech product, 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

$$r + vy^e_i - (f_i + p) \tag{1}$$

is largest. This can be interpreted as follows. If $r+vy^e_i - f_i \geq p$ holds for a particular worker, that worker pays the connection fee and starts to produce the high-tech product. However, if $r+vy^e_i - f_i < p$ holds, that worker chooses not to connect to the network and produces the primary 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.

In equilibrium, providers i and j will both have a positive number of subscribers only if

$$(f_i + p) - vy^e_i = (f_j + p) - vy^e_j, \tag{2}$$

where $(f_i + p) - vy^e_i$ is the connection cost adjusted for network size.We can obtain the condition for the connection fee

$$f_i = L - p + vy^e_i - z. \tag{3}$$

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

$$\pi_i = x_i f_i = x_i (L - p + vy^e_i - z). \tag{4}$$

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

$$S(z) = \int_{L-z}^{L} (\rho + z + f + p - L)\, d\rho = (z^2/2) + (f + p)z. \tag{5}$$

We can interpret this as the supply function of the high-tech product: the country thus has a supply function that exhibits increasing returns to the size of the networks.

Depending on the interconnectivity between providers, several cases can emerge as the production equilibrium. For simplicity, let us assume that n providers are fully interconnected (i.e., $y_i = x_1 + \ldots + x_n = z$). Interconnectivity expands the size of each network to the total membership of all providers.

Thus, maximizing $x_i (L - p + vz^e - z)$ with respect to x_i, we obtain

$$x_i = L - p + vz^e - z.$$

Imposing the requirement that in equilibrium workers' expectations are fulfilled (*Fulfilled Expectation Equilibrium*), $z^e = z = nx$ holds. Then we obtain the equilibrium sales level for each provider

$$x = (L - p)/(n + 1 - nv). \tag{6}$$

By summing Equation (6) over all providers, we obtain the total network size as a function of the relative price of the high-tech product ($1/p$).

$$z\,(1/p) = [n\,(L - p)]/(n + 1 - nv). \tag{7}$$

Note the impact of increased competition between providers. As the total number of network users becomes larger, the average productivity of each worker in the high-tech product sector rises.

2.2 The Impact of Market Integration

Suppose that the only difference between the two countries is the number of network service providers. Without loss of generality, Home is assumed to have more providers than Foreign (i.e., $n > n^*$). In this case, Home has the lower autarky price of the high-tech product (i.e., $(1/p) < (1/p^*)$). Then , we can obtain the following proposition.[3)]

Proposition 1: *A comparative advantage in the high-tech product is held by the country with competitive service providers. If the two countries commence free trade from autarky, the country with more competitive providers incompletely specializes in the high-tech product and the country with less competitive providers incompletely specializes in the primary good.*

3. Development and Analysis of Model II

3.1 Model II

We saw in the preceding section that the degree of network effects determine the structure of comparative advantage. The preceding model emphasizes network effects on the *production* side. In this section, in contrast, we focus on a different aspect of network effects: network effects on the *consumption* side.[4)]

Suppose that there are two countries in the world: Home and Foreign. There is a Home monopolist and n - 1 Foreign firms.

First, let us describe the Home autarky (monopoly) equilibrium. Suppose that the expected volume of sales in the market is S. Let the network effect function $f(S)$ measure the increase in the aggregate willingness to pay because of the network effects. It is assumed that both $f(0) = 0$ and $f'(S) \geq 0$. Given expected sales of volume S, let the aggregate willingness to pay for quantity Q increase from $P(Q;0)$ to $P(Q;S) = P(Q;0) + f(S)$.

3) See Kikuchi and Kobayashi (2006a) for discussion.
4) The model is based on Kikuchi and Kobayashi (2006b).

Assume that Home's inverse demand function before the market integration is as follows:

$$P = a- (Q/m) + f(S), \quad (8)$$

$$0 < m < 1,$$

where Q is the equilibrium quantity supplied and m (1-m) measures the relative size of the Home (Foreign) market.

In the monopoly case, the profit of $\Pi = qP(q;S)$ is maximized by choosing q. In this case, the autarky market size of Home, S^A, becomes

$$S^A = m\,[a + f\,(S^A)]/2, \quad (9)$$

where superscript A indicates the autarky equilibrium. Note that $q^A = Q^A = S^A$ holds at the monopoly equilibrium. Thus the equilibirum profit for the Home monopolist becomes

$$\Pi^A = m[a+f\,(S^A)]^2/4. \quad (10)$$

Now consider the trading equilibrium: market integration allows competition into the market and results in an n-firm symmetric Cournot oligopoly. The industry demand function for the integrated market is

$$P(Q;S) = a-f(S) - Q. \quad (11)$$

Firm i chooses q_i to maximize $\Pi_i = q_iP(Q;S)$, where $Q = q_i+\sum_{j\neq i}q_j$. The first-order condition for firm i is

$$a + f(S) - 2q_i - \sum_{j\neq i} q_j = 0. \quad (12)$$

The implied symmetric market equilibrium is

$$q_i = (a + f(S))/(n + 1), \text{ Q} = n(a + f(S))/(n + 1), \quad (13)$$

$$P = (a + f(S))/(n + 1), \Pi_i = (a + f(S))^2/(n + 1)^2. \quad (14)$$

With fullfilled expectations, the following condition must hold:

$$S^T = n[(a + f(S^*)]/(n +1), \quad (15)$$

where superscript T indicates a trading equilibrium value. The equilibrium profits of a firm at an n-firm fullfilled expectations equilibrium are

$$\Pi^T = (a + f(S^T))^2/(n+1)^2 = (S^T/n)^2. \tag{16}$$

3.2 The Impact of Market Integration

This analysis considers the extreme case of moving from prohibitive trade barriers to completely free trade. In other words, we discuss the decision to invite entry by the Home monopolist if, after entry, the resulting competition will create an n-firm symmetric Cournot oligopoly. The Home monopolist's profit will change from Π^A to Π^T. From (10) and (16), this change depends on both the relative Home market size (m) and the number of Foreign rivals (n-1).

In what follows, to simplify the analysis, let the network effect function be linear: $f(S) = bS$, b < 1. In this case, $\Pi^A = ma^2/(2 - b)^2$ and $\Pi^T = a^2/[n(1- b) +1]^2$ hold.

As we have shown in the previous section, the equilibrium profits of a firm under market integration are a decreasing function of the number of Foreign firms. As the network effect (b) becomes larger, the reduction in profit caused by increased competition will be mitigated.

Proposition 2: *The network effect will mitigate the negative effect of competition on the profit of the Home monopolist.*

4. Concluding Remarks

We have constructed two different models of oligopoly with network effects and have investigated the welfare consequences of market integration. Of course, both models depend on several restrictive assumptions, and the analysis in this study is obviously suggestive rather than conclusive. Nonetheless, the features derived here should not be overlooked. Hopefully the analysis presented here provides at least some grounds for the widespread concern over the gains/losses from market integration.

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