INSTITUTE OF DEVELOPING ECONOMIES

Discussion Papers are preliminary materials circulated
to stimulate discussions and critical comments

DISCUSSION PAPER No. 54

Integration versus Outsourcing in Stable Industry Equilibrium with Communication Networks

Yusuke OKAMOTO*

March 2006

Abstract
For the selection of a firm's structure between vertical integration and arm's-length outsourcing, the importance of the thickness of the market had been emphasized in the previous literature. Here we take account of communication networks such as telephone, telex, fax, and the Internet. By doing so, we could illustrate the relationship between communication networks and the make-or-buy decision. With communication network technology differing in each type of firm, both vertically integrated firms and arm's-length outsourcing firms coexist, which was never indicated in the previous literature. However, when common network technology is introduced, such coexistence generically does not occur.

Keywords: buyer-supplier relationship, communication networks, international outsourcing, vertical integration
JEL classification: D23, D43, F23

---

* Institute of Developing Economies, 3-2-2, Wakaba, Mihama-ku, Chiba-shi, 261-8545, Japan. Tel.: +81-43-299-9694; fax: +81-43-299-9763; e-mail: yusuke_okamoto@ide.go.jp

The Institute of Developing Economies (IDE) is a semigovernmental, nonpartisan, nonprofit research institute, founded in 1958. The Institute merged with the Japan External Trade Organization (JETRO) on July 1, 1998. The Institute conducts basic and comprehensive studies on economic and related affairs in all developing countries and regions, including Asia, Middle East, Africa, Latin America, Oceania, and Eastern Europe.

INSTITUTE OF DEVELOPING ECONOMIES (IDE), JETRO
3-2-2, WAKABA, MIHAMA-KU, CHIBA-SHI
CHIBA 261-8545, JAPAN

Integration versus Outsourcing in Stable Industry Equilibrium with Communication Networks

Yusuke OKAMOTO [*][†]

March, 2006

---

[*] Institute of Developing Economies, 3-2-2, Wakaba, Mihama-ku, Chiba-shi, 261-8545, Japan.

[†] Tel.: +81-43-299-9694; fax: +81-43-299-9763; e-mail: yusuke_okamoto@ide.go.jp

Abstract

For the selection of a firm's structure between vertical integration and arm's-length outsourcing, the importance of the thickness of the market had been emphasized in the previous literature. Here we take account of communication networks such as telephone, telex, fax, and the Internet. By doing so, we could illustrate the relationship between communication networks and the make-or-buy decision. With communication network technology differing in each type of firm, both vertically integrated firms and arm's-length outsourcing firms coexist, which was never indicated in the previous literature. However, when common network technology is introduced, such coexistence generically does not occur.

Keywords: buyer-supplier relationship, communication networks, international outsourcing, vertical integration

JEL Classification Numbers: D23, D43, F23

1 Introduction

Since Coase (1937) raised the boundary-of-the-firm problem, the "make-or-buy" decision has been a central issue for industrial organization. So far, a large number of theoretical and empirical studies has been conducted.[1] However, as Grossman and Helpman (2002, p. 86) point out, economists who had studied the make-or-buy decision focused on the bilateral relationship between a single producer and a potential supplier and they treated the industry environment as given.

Grossman and Helpman (2002) have first offered a framework for examining an industrial structure in which integration and outsourcing are treated as equilibrium phenomena. Using a monopolistic competition model *a la* Dixit-Stiglitz, they construct a model which illustrates the selection of the firm structure between vertical integration and outsourcing[2]. They emphasize the trade-off between the costs of running a larger and less specialized organization and the costs that arise from search frictions and imperfect contracting. Their results are as follows: If the search technology has constant returns to scale[3] "(G)enerically, no industry has both vertically integrated and specialized producers" (Proposition 1 in Grossman and Helpman (2002, p. 98)). If the search technology has increasing returns to scale, there exists an equilibrium where both vertically integrated firms and pairs of upstream

---

[1] For theoretical studies, see Grossman and Hart (1986), Hart and Moore (1990) and Hart (1995). For empirical studies, see Campa and Goldberg (1997), Feenstra (1998) and Feenstra and Hanson (2005).

[2] Following this paper, many articles concerning international outsourcing have been published, for example, those by Grossman and Helpman (2003, 2005), Antras(2003), Antras and Helpman (2004).

[3] This "constant returns to scale" implies that, if the number of both upstream (specialized) suppliers and downstream (specialized) producers is doubled, the possibility of matching for both firms is doubled.

and downstream firms coexist. However, such equilibrium is never stable.[4]

Besides the search technology, in the present paper we emphasize that some more important factors such as transport and communications networks affect the selection of the firm structure between vertical integration and outsourcing. Cairncross (1997, p. 20) points out that costs for communication networks sharply decreased in the late twentieth century while the falling trend of transport costs became moderate in the middle of the twentieth century. As such a sharp decline of costs for communication networks has been observed recently, we focus on the technology for communication networks study.

Let us examine two opinions concerning the relationship between the make-or-buy decision and technology of communication networks, presented by Caves (1996) and Jones and Kierzkowski (2001). Caves (1996, p. 61) mentions that "(T)he historical case studies (also) show that the evolution of the decentralized multiplant and multinational firm depended on nineteenth-century innovations in communications (telegraph and telephone services) that allowed the firm to achieve economies of integration." On the contrary, Jones and Kierzkowski (2001) point out and anticipate that, as services of communication networks (e.g., the Internet) become more widespread, the necessity for containing various production processes under the umbrella of a huge conglomerate is reduced. Briefly, combining Caves' and Jones and Kierzkowski's stories, we can conceive that the development of technology related to communication networks may first integrate production processes and then disintegrate them. Moreover, in the past there were only, for ex-

---

[4] Grossman and Helpman (2002, p. 98) mention that since in the case of search technology, decreasing returns to scale are not supported in the empirical literature, they do not discuss this issue in their paper.

ample, only communication by "carrier pigeon" existed and there were no large conglomerates. In the future, an "ubiquitous" network society with an advanced communication network technology more sophisticated than the current Internet system is likely to prevail and we are very much interested in what will happen to the vertical structure of industry. (The history of development of communication networks in Japan is presented in Figure 1 as an example.)

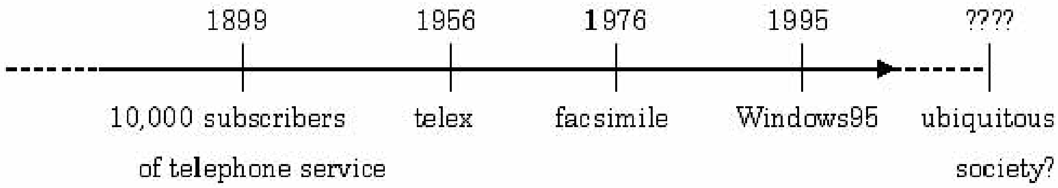

Figure 1: History of development of communication networks in Japan

The purpose of the present paper is to show that, by introducing the theoretical treatment of communication networks developed by Harris (1995), a stable equilibrium can be obtained where both vertically integrated firms and pairs of upstream and downstream firms coexist without increasing returns to matching, which was never indicated in Grossman and Helpman (2002). Since the breakthrough achieved by Harris (1995), communication networks in a monopolistically competitive industry have been studied by Harris (2001), Kikuchi (2002) and Kikuchi and Ichikawa (2002). Harris (1995) points out that one of the major limitations on coordination of production networks is communication technology. Therefore, the make-or-buy decision within conglomerates and vertically integrated multinational enterprises (MNEs) should be affected by communication technology. He emphasizes three characteristics of communication technology; a fixed cost nature (Once the technology is developed, marginal costs of transmission of information are very low), natural monopoly (Fixed costs are so large that the provider of communication services tends to be a natural monopolist), and network externalities (The more users, the less or more costs inccured by the provider). In order to analyze the effects of communication networks on the make-or-buy decision, we apply a Harris-Kikuchi-Ichikawa type cost function of communication networks.

The main results are as follows: If both vertically integrated firms such as MNEs and pairs of upstream and downstream firms utilize different types of technology for communication networks each (e.g., vertically integrated firms use telex which the outsourcing pairs cannot use because they cannot afford to subscribe to telex), stable equilibrium where both vertically integrated and specialized producers coexist can be attained depending on the relative extend of network costs inccurred between vertically integrated firms and pairs of upstream and downstream firms. (The results appear to be much more evident if vertically integrated firms incur constant network costs and pairs of upstream and downstream firms use variable network costs. We introduce this formulation in our model in Section 3.) If both vertically integrated firms and pairs of upstream and downstream firms utilize a common technology for communication networks such as the Internet, stable coexistence does not generically occur. This result is similar to Proposition 1 in Grossman and Helpman (2002).

It is important to compare these two results. In the case of different network technologies, the difference between these technologies per se results in stable coexistence. If the number of firms is small enough, variable network costs tend to decrease due to the increasing-returns-to-scale characteristic, and the firms that incur constant network costs cannot enter the market. If the scale effect ends, the "congestion" effect begins to occur and, if the variable network costs exceed the constant network costs, the firms incurring the constant network costs start to enter the market. In the case of the common network technology, the network technology itself does not result in stable existence. The important issue is the difference between the two types of firms (i.e., the difference in the effect from the search technology, the costs incurred for using network technologies, the bargaining power between upstream suppliers and downstream producers, etc.) because both types of firms can use the same network technology and there is no difference in network technology. That is, as communication networks become a common form of technology such as the Internet, network technology is not important for the make-or-buy decision, even though the probability of coexistence is very rare as in the case of Proposition 1 in Grossman and Helpman (2002). In summary, in the past all the firms (or, simple manufacturers) use underdeveloped common technology such as carrier pigeon and they could not form large conglomerates. In the nineteenth century, along with the progress of communication network technology hitherto available to MNEs due to its costs, (presumably) a vertically integrated structure started to predominate. Presently, since the costs of the network technology available to outsourcing pairs have decreased, two types of firm structures are coexisting. In the far distant future, we may witness the development of an ubiquitous network society with highly advanced and commonly used communication network technology, and the two types of firm structures may not coexist.

The remainder of the paper is organized as follows: In Section 2, we describe the basic design of the model. In Section 3, we analyze the industry equilibrium with different types of network technologies. In Section 4, we analyze the equilibrium with common network technology. In Section 5, we discuss the characteristics of the factors responsible for stable coexistence in both cases. We make some concluding remarks in the final section.

2 The Model

We build a Dixit-Stiglitz type monopolistic competition model. Our setting heavily depends on Grossman and Helpman (2002). The economy has J industries. The representative consumer maximizes a utility function of the form,

$$u = \sum_{j=1}^{J} \mu_j \log \left[\int_0^{h_j} y_j(i)^{\alpha_j} di \right]^{1/\alpha_j},$$

where $y_j(i)$ is the consumption of variety i in industry j and h_j is the number of differentiated varieties. We assume that $\sum_j \mu_j = 1$, so that the parameter μ_j gives the share of spending. We select labor, which is an only primary factor of production, as the numeraire. The parameter $\alpha_j \in (0,1)$ measures the degree of product differentiation. $\sigma_j = 1/(1-\alpha_j) > 1$ is the elasticity of substitution as well as the price elasticity of demand. These preferences yield demand functions,

$$y_j^D(i) = A_j p_j(i)^{-\sigma_j},$$

where $p_j(i)$ is the price of good i in industry j, and

$$A_j = \frac{\mu_j L}{\int_0^{h_j} p_j(l)^{1-\sigma_j} dl},$$

and L is aggregate spending, as labor is selected as the numeraire. All the firms treat A_j (the industry demand level of j) as a constant. A_j can be rewritten as $PI_j^{\sigma_j-1}\mu_j L$, where PI_j is the price index of y_j .

Final goods ($y(i)$) may be produced by vertically integrated firms or by downstream producers that purchase their inputs at arm's-length from upstream suppliers. An upstream supplier can produce an input ($x(i)$) with one unit of labor per unit of output. We assume that $y(i) = x(i)$, i.e., one unit of production of $y(i)$ needs one unit of production of $x(i)$. A vertically integrated firm in industry j requires $\lambda_j \geq 1$ units of labor to produce a unit of the input. Let us denote n_j as the number of pairs of upstream and downstream firms in industry j and v_j as the number of vertically integrated firms in industry j. Analogously, the total number of producers of final goods in industry j is $h_j = n_j + v_j$. For simplicity, we analyze symmetric equilibrium and we omit the index j from the industry-specific variables hereafter.

Firms in pairs play a game with the following five stages: (1) entry; (2) search with a probability $\eta \equiv n(1, r)$ [5] for downstream producers and with a probability $\eta(r)/r \equiv n(s, m)/m$ for upstream suppliers, where $min[s, m] \geq n(s, m)$ pairings are formed and s denotes the number of downstream producers, m the number of upstream suppliers, and $r = m/s$ (As $n(s, m)$ is

---

[5] $n(\bullet)$ itself expresses the number of outsourcing pairs. However, due to the homogeneous-of-degree-one characteristic, $n(\bullet)$ can be expressed as the matching probability of outsourcing pairs by taking account of $r \equiv m/s$, where $n(\bullet)$ forms an abstract number.

homogeneous of degree one, $n(s,m)/s = n(s/s, m/s) = n(1,r)$, which shows the probability that downstream producers can find upstream partners. The same kind of discussion can be applied to a probability of upstream suppliers finding partners.); (3) production of intermediate inputs; (4) bargaining for capturing the joint surplus $(p(i)x(i))$ with a fraction ω for an upstream supplier and with a fraction $(1-\omega)$ for a downstream producer where $\omega \in (0,1)$; and (5) production and sale of final goods where both an upstream supplier and a downstream producer maximize the joint surplus. As for the vertically integrated firms, they play a game with the following two stages: (1) entry; (2) production and sale of final goods.

An upstream supplier maximizes a potential reward $\omega p(i)x(i)$. By maximizing it, we obtain the resulting sales of a pair, $y_o(i) = x_o(i) = A{p_o}^{-\sigma}$, and the price, $p_o(i) = 1/\alpha\omega$. Analogously, we obtain the resulting sales of a vertically integrated firm, $y_v(i) = Ap_v^{-\sigma}$, and the price, $p_v(i) = \lambda/\alpha$.

Let $N(H)$ denote the U-shaped cost function for economy-wide communication networks $(N(H) > 0, \lim_{H\to 0} N'(H) = -\infty, \lim_{H\to\infty} N'(H) = \infty, N'' > 0)$, where $H \equiv J(n+v)$ denotes the total number of users of communication network services. We assume that all the firms use network services if available and that, when vertically integrated firms use network services, their costs are denoted by $gN(H)$, where $g > 0$ is a parameter which shows the difference in the availability of network technology to vertically integrated firms. (If $g \in (0,1)$, the network costs for vertically integrated firms are lower than those for outsourcing pairs. If $g > 1$, the opposite is observed. If $g = 1$, the costs are similar for each.)

3 Use of Different Types of Technologies for Communication Networks

In this section we assume that each type of firms uses a different type of technology for communication networks. For example, vertically integrated firms (e.g., MNEs) use telex or a specialized extension telephone system, whereas pairs of upstream and downstream firms use a regular telephone service system, as they cannot afford expensive systems. For simplicity, we assume that $p_v < p_o$ and that vertically integrated firms use the technology with constant returns to scale (k, a parameter) and pairs of upstream and downstream firms use $N(H)$.[6] Obviously, $H \equiv Jn$ in this section.

Taking account of $n = s\eta(r)$, we obtain the industry demand level,

$$\begin{aligned} A &= \frac{\mu L}{v p_v^{1-\sigma} + n p_o^{1-\sigma}} \\ &= P I^{\sigma-1} \mu L. \end{aligned}$$

In equilibrium, taking account of $p_o = 1/\alpha\omega$ and $p_v = \lambda/\alpha$, each firm's profit function must satisfy zero profit,

$$\begin{aligned} \pi_s &= \eta(r)(1-\omega) p_o y_o - N(H) \\ &= \eta(r)(1-\omega) A (\alpha\omega)^{\alpha/(1-\alpha)} - N(H) = 0, \end{aligned}$$

$$\pi_m = (\eta(r)/r) x_o (\omega p_o - 1) - N(H)$$

---

[6] The results are qualitatively the same even if we assume that both types of firms can use the U-shaped network technology (i.e., $M(Jn)$ and $N(Jv)$).

$$= (1-\alpha)(\eta(r)/r)\omega A(\alpha\omega)^{\alpha/(1-\alpha)} - N(H) = 0,$$

$$\begin{aligned}
\pi_v &= y_v(p_v - \lambda) - k \\
&= (1-\alpha)A(\alpha/\lambda)^{\alpha/(1-\alpha)} - k = 0.
\end{aligned}$$

Using $\pi_s = 0$ and $\pi_m = 0$, we obtain $r_o = \omega(1-\alpha)/(1-\omega)$. Furthermore, rearranging $\pi_s = 0$ and $\pi_m = 0$ in taking account of r_o, we have the following industry demand level for outsourcing pairs is as follows:

$$A_o = {p_o}^{\sigma}(\sigma - 1)\frac{r_o}{\eta(r_o)}N(H),$$

and the industry demand level for vertically integrated firms is as follows:

$$A_v = {p_v}^{\sigma}(\sigma - 1)\frac{k}{\lambda}.$$

A_o is required for the viability of outsourcing pairs and A_v is required for the viability of vertically integrated firms.

Taking account of A, A_o and A_v, the dynamics of the entry/exit processes of upstream firms and vertically integrated firms is described below:

$$\begin{aligned}
\dot{n} &= A - A_o = \frac{\mu L}{v p_v^{1-\sigma} + n p_o^{1-\sigma}} - {p_o}^{\sigma}(\sigma - 1)\frac{r_o}{\eta(r_o)}N(H), \quad (1) \\
\dot{v} &= A - A_v = \frac{\mu L}{v p_v^{1-\sigma} + n p_o^{1-\sigma}} - {p_v}^{\sigma}(\sigma - 1)\frac{k}{\lambda}. \quad (2)
\end{aligned}$$

At the intersections of $\dot{n} = 0$ and $\dot{v} = 0$, we obtain the combinations of numbers of outsourcing pairs and vertically integrated firms that are consistent with zero expected profits for each firm, when upstream suppliers and downstream producers enter the market in the ratio r_o.

In order to obtain stability conditions for the above nonlinear system, let us linearize it around an equilibrium point (if it exists). Then we have,

$$\begin{bmatrix} \dot{n} \\ \dot{v} \end{bmatrix} = \begin{bmatrix} -\frac{\mu L p_o^{1-\sigma}}{PI^{-2(\sigma-1)}} - \frac{{p_o}^{\sigma} r_o(\sigma-1)JN'}{\eta(r_o)} & -\frac{\mu L p_v^{1-\sigma}}{PI^{-2(\sigma-1)}} \\ -\frac{\mu L p_o^{1-\sigma}}{PI^{-2(\sigma-1)}} & -\frac{\mu L p_v^{1-\sigma}}{PI^{-2(\sigma-1)}} \end{bmatrix} \begin{bmatrix} n - n^* \\ v - v^* \end{bmatrix}. \tag{3}$$

For simplicity, we define the above as follows:

$$\begin{bmatrix} \dot{n} \\ \dot{v} \end{bmatrix} = \begin{bmatrix} B_{11}^d & B_{12}^d \\ B_{21}^d & B_{22}^d \end{bmatrix} \begin{bmatrix} n - n^* \\ v - v^* \end{bmatrix},$$

where

$$B_{11}^d = -\frac{\mu L p_o^{1-\sigma}}{PI^{-2(\sigma-1)}} - \frac{{p_o}^{\sigma} r_o(\sigma-1)JN'}{\eta(r_o)},$$

$$B_{12}^d = -\frac{\mu L p_v^{1-\sigma}}{PI^{-2(\sigma-1)}},$$

$$B_{21}^d = -\frac{\mu L p_o^{1-\sigma}}{PI^{-2(\sigma-1)}},$$

$$B_{22}^d = -\frac{\mu L p_v^{1-\sigma}}{PI^{-2(\sigma-1)}}.$$

(n^*, v^*) denotes the equilibrium point and superscript d denotes "different types". The determinant (DET) and the trace (tr) of the system are,

$$\begin{aligned} DET &= B^d_{11}B^d_{22} - B^d_{12}B^d_{21} \\ &= \frac{r_o}{\eta(r_o)}(\sigma-1)p_o^{\sigma}p_v^{1-\sigma}PI^{2(\sigma-1)}JN', \end{aligned}$$

$$\begin{aligned} tr &= B^d_{11} + B^d_{22} \\ &= -\left[p_o^{1-\sigma}PI^{2(\sigma-1)}\mu L + \frac{r_o}{\eta(r_o)}p_o^{\sigma}(\sigma-1)JN' + p_v^{1-\sigma}PI^{2(\sigma-1)}\mu L\right]. \end{aligned}$$

$DET > (<) 0$ if $N' > (<) 0$. The sign of tr is negative if $N' > 0$ and is ambiguous if otherwise. There is no unique solution to the linear system (3) if $N' = 0$ and we eliminate this case. Taking account of the signs of DET and tr, we obtain the following proposition:

Proposition 1. *If each type of firms uses different types of technologies for communication networks (one is constant and the other is the U-shaped) and if U-shaped network technology has decreasing returns to scale ($N' > 0$), there is a stable equilibrium where vertically integrated firms and pairs of upstream and downstream firms coexist.*

This is a new result not obtained in Grossman and Helpman (2002). Technology for communication networks results in stable coexistence of both types of firms if they use different types of network technologies. Moreover, the coexistence is stable, which is never indicated in Grossman and Helpman (2002).

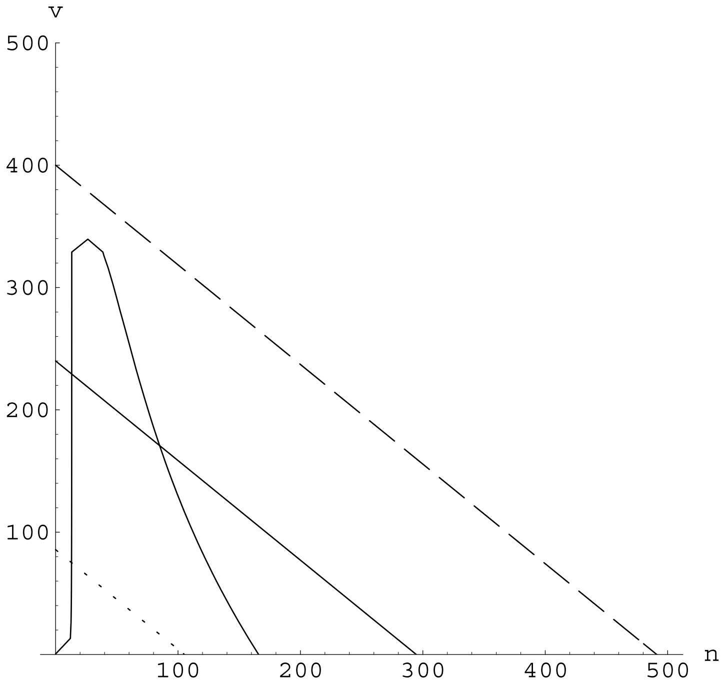

Figure 2: Use of different technologies

Various types of results can be obtained with combinations of the signs of DET and tr. Taking account of (1), (2) and (3), we can draw Figure 2 on the $n - v$ plane[7]. The solid straight line shows that $\dot{v} = 0$ and it shifts upward if the k value is relatively lower than the $N(n)$ value, which is represented by a dashed line in Figure 2. It shifts downward if otherwise, as indicated by the dotted line in Figure 2. The solid curved line shows $\dot{n} = 0$. Clearly, Figure 2 depicts the development process of technology for

---

[7] To draw Figure 2, we assume the followings: $\omega = 0.5$, $\alpha = 0.8$, $L = 300000$, $\mu = 1$, $\eta = 0.19$, $\lambda = 1.9$, 150 for a low k value, 250 for a midium k, 700 for a k value. We further assume that $J = 1$. Following Harris (2001) and Kikuchi and Ichikawa (2002), we specify the network cost function as $N(n) = n + F/n$, where $F = 1000$.

communication networks from the 19th century through the 20th century. (Note that the era of far advanced network technology such as the ubiquitous network has not yet occurred. We discuss this aspect in the next section.) If the k value is relatively lower than the $N(n)$ value (i.e., if the network technology which is only available to vertically integrated firms (e.g., telex) is much more efficient than that for pairs of upstream and downstream firms), $\dot{v} = 0$ is the dashed line and $(n, v) = (0, v^*)$ is the only stable pair $(v^* > 0)$. If the technology which is available to pairs of upstream and downstream firms advances (e.g., lowering of costs of international phone call), both types of firms coexist (both solid lines). If the technology becomes much more advanced (fax machines), $\dot{v} = 0$ is the dotted line and $(n, v) = (n^*, 0)$ or $(n, v) = (0, v^*)$ are stable pairs ($n^* > 0$, $v^* > 0$) and the industrial structure never allows stable coexistence. Moreover, in Grossman and Helpman (2002, p. 91), it is assumed that fixed costs (i.e., constant network costs in the present paper) for vertically integrated firms must exceed the sum of the costs incurred by pairs of upstream and downstream firms. In our results, however, such a condition is not necessary for the industry equilibrium. (Dynamics of the stable coexistence case is shown in Figure 3.)

In the previous literature, emphasis was placed on the importance of the "thickness of the market (availability of partners or high possibility of finding partners)" (McLaren (2000), Grossman and Helpman (2002)). Their studies show that complete specialization of the industrial structure (no coexistence of vertically integrated firms and pairs of upstream and downstream firms) or coexistence is unstable, as a result. Actually, however, both types of firms appear to coexist. In addition to the previous literature in which emphasis was placed on the importance of the thickness of the market, we emphasize

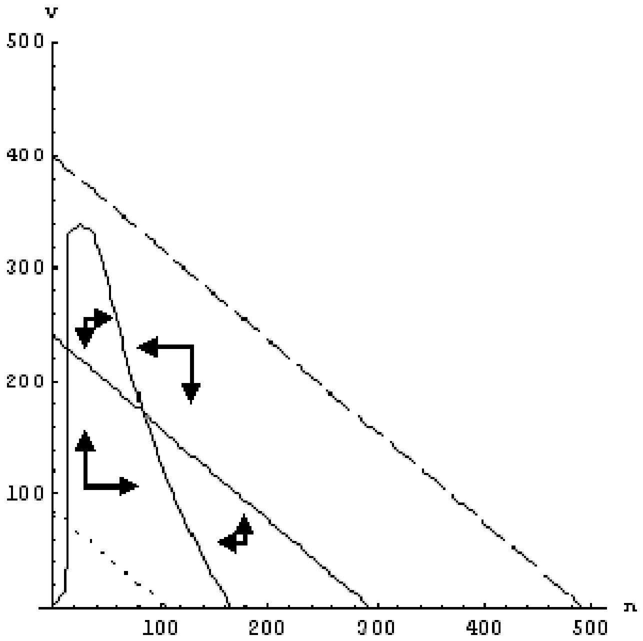

Figure 3: Dynamics of stable coexistence

the importance of communication networks for the make-or-buy decision. This aspect had been discussed over a long period of time (e.g., Caves (1996) and Jones and Kierzkowski (2001)) but, as far as the author knows, not formally modeled before.

4 Use of Common Technology for Communication Networks

In this section, we introduce the common technology for communication networks which is available to both vertically integrated firms and pairs of upstream and downstream firms (i.e., $H \equiv J(n+v)$). We can easily conceive that the technology which we assume is represented by the Internet, or the ubiquitous network technology in the far distant future. Following the last section, the dynamics of the entry/exit processes of vertically integrated firms and pairs of upstream and downstream firms is described as indicated below:

$$\begin{aligned}\dot{n} &= A - A_o = \frac{\mu L}{v p_v^{1-\sigma} + n p_o^{1-\sigma}} - p_o^{\sigma} \frac{r_o}{\eta(r_o)} (\sigma - 1) N(H), \qquad (4)\\ \dot{v} &= A - A_v = \frac{\mu L}{v p_v^{1-\sigma} + n p_o^{1-\sigma}} - p_v^{\sigma} \frac{g}{\lambda} (\sigma - 1) N(H). \qquad (5)\end{aligned}$$

Let us linearize the above nonlinear system around an equilibrium point (if it exists). Then we obtain,

$$\begin{bmatrix} \dot{n} \\ \dot{v} \end{bmatrix} = \begin{bmatrix} -\frac{\mu L p_o^{1-\sigma}}{PI^{-2(\sigma-1)}} - \frac{p_o^{\sigma} r_o (\sigma-1) J N'}{\eta(r_o)} & -\frac{\mu L p_v^{1-\sigma}}{PI^{-2(\sigma-1)}} - \frac{p_o^{\sigma} r_o (\sigma-1) J N'}{\eta(r_o)} \\ -\frac{\mu L p_o^{1-\sigma}}{PI^{-2(\sigma-1)}} - \frac{p_v^{\sigma} (\sigma-1) J g N'}{\lambda} & -\frac{\mu L p_v^{1-\sigma}}{PI^{-2(\sigma-1)}} - \frac{p_v^{\sigma} (\sigma-1) J g N'}{\lambda} \end{bmatrix} \begin{bmatrix} n - n^* \\ v - v^* \end{bmatrix}. \qquad (6)$$

For simplicity, we define the above as follows:

$$\begin{bmatrix} \dot{n} \\ \dot{v} \end{bmatrix} = \begin{bmatrix} B_{11}^c & B_{12}^c \\ B_{21}^c & B_{22}^c \end{bmatrix} \begin{bmatrix} n - n^* \\ v - v^* \end{bmatrix},$$

where

$$B_{11}^c = -\frac{\mu L p_o^{1-\sigma}}{PI^{-2(\sigma-1)}} - \frac{p_o^{\sigma} r_o (\sigma - 1) J N'}{\eta(r_o)},$$

$$B_{12}^c = -\frac{\mu L p_v^{1-\sigma}}{PI^{-2(\sigma-1)}} - \frac{p_o^{\sigma} r_o (\sigma - 1) J N'}{\eta(r_o)},$$

$$B^c_{21} = -\frac{\mu L p_o^{1-\sigma}}{PI^{-2(\sigma-1)}} - \frac{p_v^\sigma(\sigma-1)JgN'}{\lambda},$$

$$B^c_{22} = -\frac{\mu L p_v^{1-\sigma}}{PI^{-2(\sigma-1)}} - \frac{p_v^\sigma(\sigma-1)JgN'}{\lambda},$$

and superscript c stands for "common."

The determinant (DET) and the trace (tr) of the system are,

$$\begin{aligned} DET &= B^c_{11}B^c_{22} - B^c_{12}B^c_{21} \\ &= JN'\frac{\mu L p_o {p_v}^{\sigma-1}}{PL^{-2(\sigma-1)}}\frac{r_o(\sigma-1)}{\eta(r_o)}\overbrace{[{p_v}^{1-\sigma} - {p_o}^{1-\sigma}]}^{(+)}\left[\left(\frac{p_o}{p_v}\right)^{\sigma-1} - \frac{\eta(r_o)}{r_o}\omega g\right], \end{aligned}$$

$$\begin{aligned} tr &= B^c_{11} + B^c_{22} \\ &= -\left[\frac{\mu L {p_o}^{1-\sigma}}{PI^{-2(\sigma-1)}} + p_o^\sigma\frac{r_o}{\eta(r_o)}(\sigma-1)JN' + \frac{\mu L {p_v}^{1-\sigma}}{PI^{-2(\sigma-1)}} + p_v^\sigma\frac{(\sigma-1)}{\lambda}JgN'\right]. \end{aligned}$$

In the case of the common technology, signs of DET and tr are not easily determined. We must pay attention to the signs of N', the signs of the first square brackets of DET, and the signs of the second square brackets of DET. As we assumed that $p_v < p_o$, the sign of the first square brackets is positive.

Let us check the characteristics of the second square brackets. (One may consider that it is somehow strange to start with the second brackets. However, the reader for this approach will be clarified.) One should recall that there are two types of firm structures and there are three types of profit functions for each. For equilibrium, the profit functions must satisfy zero profit, i.e., $\pi_s = 0$, $\pi_m = 0$ and $\pi_v = 0$. Rearranging $\pi_m = 0$ and $\pi_v = 0$[8], we obtain:

$$\left(\frac{p_o}{p_v}\right)^{\sigma-1} = \frac{\eta(r_o)}{r_o}\omega g.$$

Clearly, $DET = 0$ if zero profit conditions for both types of firms are satisfied. In summary, we have the following conditions for stability:

$$\left(\frac{p_o}{p_v}\right)^{\sigma-1} < \frac{\eta(r_o)}{r_o}\omega g \qquad if \quad \pi_m \geq 0 \quad and \quad \pi_v < 0, \tag{7}$$

$$\left(\frac{p_o}{p_v}\right)^{\sigma-1} > \frac{\eta(r_o)}{r_o}\omega g \qquad if \quad \pi_m < 0 \quad and \quad \pi_v \geq 0, \tag{8}$$

$$\left(\frac{p_o}{p_v}\right)^{\sigma-1} = \frac{\eta(r_o)}{r_o}\omega g \qquad if \quad \pi_m = 0 \quad and \quad \pi_v = 0. \tag{9}$$

We have three types of stable equilibria with the above three conditions. With condition (7), only the pairs of upstream and downstream firms exist. One should recall that $(\eta(r_o)/r_o)$ is the probability of matching for downstream firms, ω is the bargaining power of downstream firms, and g is a parameter for weighting network costs to vertically integrated firms. To hold (7), the $(\eta(r_o)/r_o)$ or g values must be relatively high, implying the existence of a positive effect on the revenue of outsourcing pairs. Therefore, only outsourcing pairs can exist and vertically integrated firms exit from the market. The opposite occurs if (8) holds. With (9), both types of firms can coexist.

---

[8] We need only these two profit functions for the analysis here.

However, equilibrium is indeterminate because $DET = 0$.

Now we present an other proposition:

Proposition 2. *Stable equilibrium is obtained (i) where only pairs of upstream and downstream firms exist if pairs of upstream and downstream firms are more competitive than vertically integrated firms, (ii) where only vertically integrated firms exist if vertically integrated firms are more competitive than pairs of upstream and downstream firms, (iii) where both types of firms coexist if, and only if, both types of firms satisfy zero profit conditions, even though this equilibrium is not unique.*

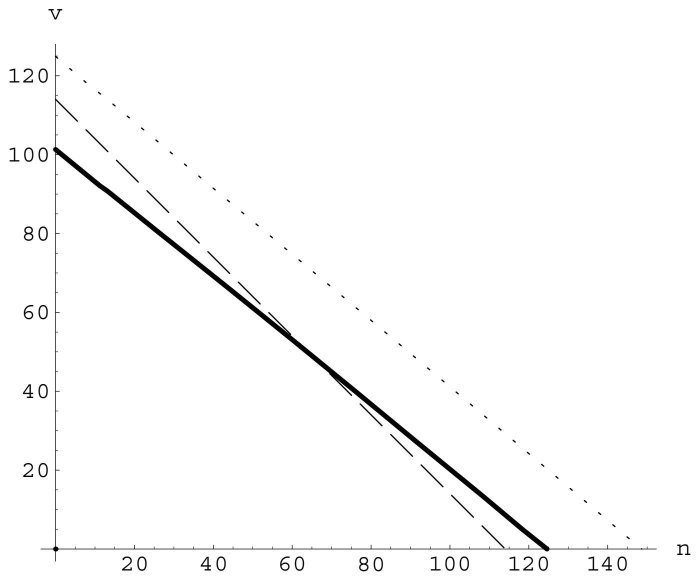

Figure 4: Use of the common technology where condition (8) holds

Figure 4 and Figure 5 show the results obtained in this section where only the vertical integrated firms exist, namely, here we assume that condition (8)

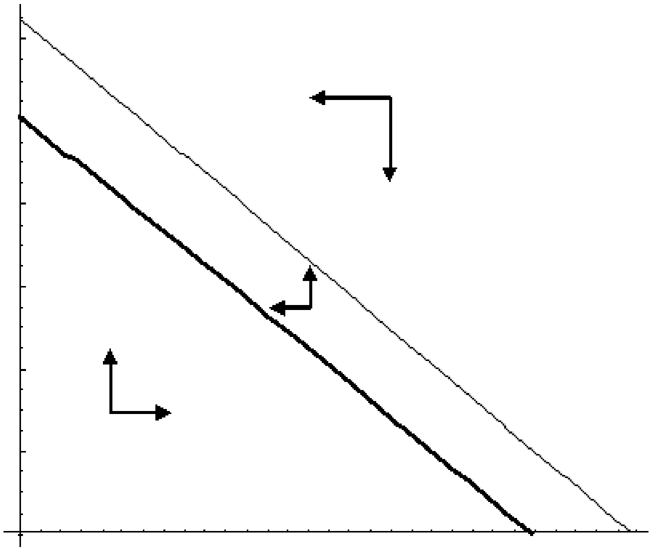

Figure 5: Dynamics where the condition (8) holds

holds $((p_o/p_v)^{\sigma-1} > (\eta(r_o)/r_o))\omega g)$[9]. The bold line denotes $\dot{n}=0$, the dotted line denotes $\dot{v}=0$, and the dashed line denotes $N'(n+v)=0$. As vertically integrated firms are more competitive than outsourcing pairs, as shown in Figure 4, stable equilibrium is obtained on the intercepts of the dotted line on the v axis. If both the dotted line and the bold line overlap, two types of firm structures coexist but such equilibrium is indeterminate, as in the case of Proposition 1 in Grossman and Helpman (2002).

5 Concluding Remarks

In the present paper we examined the relationship between stable industry equilibrium and technology for communication networks. We obtained two

---

[9] To draw Figure 4, we assume that $\omega = 0.5$, $\alpha = 0.8$, $L = 300000$, $\mu = 1$, $\eta = 0.19$, $\lambda = 1.9$, $g = 2.45$. We further assume that $J = 1$ and we specify the network cost function as $N(n+v) = (n+v) + F/(n+v)$ where $F = 13000$.

important results for the make-or-buy decision: One is that two types of firms can coexist stably with communication networks, even though search technology is associated with constant returns to scale, which is important for the results of Grossman and Helpman (2002). The other is that stable coexistence cannot occur where common network technology is available. In the previous literature such as Grossman and Helpman (2002) and McLaren (2000), the researchers had emphasized the importance of the thickness of the market, which enables upstream and downstream firms to easily find partners. However, our results revealed the importance of technology for communication networks for the make-or-buy decision, if firms use different types of communication network technologies. These results are consistent with empirical observations of the make-or-buy decision reported by Caves (1996) and with theoretical anticipations reported by Jones and Kierzkowski (2001). Furthermore, our results may enable to predict that one type of firm structure may develop in the far distant future, namely the ubiquitous network society.

For further extension, we can introduce the concept of the relationship between market openness (which leads to the "thicker" market) and the make-or-buy decision. McLaren (2000) mentions that, the more open the market is, the easier it is for outsourcing firms to find partners, because the market becomes thicker. Taking account of Kikuchi (2002) and Kikuchi and Ichikawa (2002), we can extend the present model to an open economy to observe the international outsourcing pattern.

Actually, we may conceive that outsourcing firms can find partners by making use of advanced technology for communication networks. For example, if many upstream and downstream firms have their own web sites on the

Internet, it becomes easier for outsourcing firms to find partners and to collect information. Therefore, we can treat the technology for communication networks in the present model not only as simple input but also as a tool to increase the possibility of finding partners ($\eta(r)$), namely, communication networks may directly affect the thickness of the market.

Acknowledgements

I am very grateful to Professors Hiroshi Ohta, Kazuhiro Igawa and Towa Tachibana of Kobe University, Yoshifumi Okawa of Shiga University, Syoji Haruna of Okayama University, Tetsuro Ichikawa of Surugadai University, for their valuable comments.

I am, of course, solely responsible for any remaining errors.

References

[1] Antras, Pol (2003), Firms, Contracts, and Trade Structure, Quarterly Journal of Economics 118, 1375-1418.

[2] Antras, Pol and Elhanan Helpman (2004), Global Sourcing, Journal of Political Economy 112, 552-580.

[3] Cairncross, Frances (1997), The Death of Distance, Boston: Harvard Business School Press.

[4] Caves, Richard E. (1996) Multinational Enterprise and Economic Analysis, Cambridge: Cambridge University Press.

[5] Coase, Ronald H. (1937) The Nature of the Firm, Economica 4, 386-405

[6] Campa, Jose and Linda S. Goldberg (1997) The Evolving External Orientation of Manufacturing Industries: Evidence from Four Countries, NBER working paper No. 5919.

[7] Feenstra, Robert C. (1998) Integration of Trade and Disintegration of Production in the Global Economy, Journal of Economic Perspective 12, 31-50.

[8] Feenstra, Robert C. and Gordon H. Hanson (2005) Ownership and Control in Outsourcing to China: Estimating the Property-Rights Theory of the Firm, Quarterly Journal of Economics 2, 729-761.

[9] Grossman, Sanford J. and Oliver Hart (1986) The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration, Journal of Political Economy 94, 691-719.

[10] Grossman, Gene M. and Elhanan Helpman (2002) Integration versus Outsourcing in Industry Equilibrium, Quarterly Journal of Economics 117, 85-120.

[11] Grossman, Gene M. and Elhanan Helpman (2003), Outsourcing versus FDI in Industry Equilibrium, Journal of the European Economic Association 1, 317-327.

[12] Grossman, Gene M. and Elhanan Helpman (2005), Outsourcing in a Global Economy, Review of Economic Studies 72, 135-159.

[13] Harris, Richard G. (1995) Trade and communication costs, Canadian Journal of Economics 28, S46-S75.

[14] Harris, Richard G. (2001) A Communication-Based Model of Global Production Fragmentation, in S. W. Arndt and H. Kierzkowski eds., Fragmentation: New Production Patterns in the World Economy, New York: Oxford University Press, 52-75.

[15] Hart, Oliver and John Moore (1990) Property Rights and the Nature of the Firm, Journal of Political Economy 98, 1119-1158.

[16] Jones, Ronald W. and Henryk Kierzkowski (2001), A Framework for Fragmentation, in S. W. Arndt and H. Kierzkowski eds., Fragmentation: New Production Patterns in the World Economy, New York: Oxford University Press, 17-34.

[17] Kikuchi, Toru (2002) Country-Specific Communications Networks and International Trade in a Model of Monopolistic Competition, Japanese Economic Review 53, 167-176.

[18] Kikuchi, Toru and Tetsuro Ichikawa (2002) Congestible Communications Networks and International Trade, Canadian Journal of Economics 35, 331-340.

[19] McLaren, John (2000) Globalization and Vertical Structure, American Economic Review 90, 1239-1254.