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Abstract

Both deeper market integration and advances in digital technology have driven particularly large decreases in the costs of inter-market software provision. In this note, we first explain the mechanism of how trade costs influence the software provision decision of software firms. Then, we investigated the transformation of production/trade patterns given gradually decreasing trade costs for software products.

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It is shown that, given that two incompatible hardware exist, deeper market integration may *reduce* the variety of hardware technologies. It is also shown that, if the variety of hardware technologies is reduced by deeper integration, some consumers are made worse off. In other words, deeper market integration, which forms the basis for a greater variety of software products may work as a catalyst for Pareto inferior outcomes.

Key Words: software provision; indirect network effects; hardware/software systems; market integration; Pareto inferior outcome

JEL Classification: D43, F12, R12

1 Introduction

Two of the most important trends in the global economy in recent decades have been (1) the dramatic increase in the role of information-intensive products (e.g., various types of computer software products and IT-related services) in economic activities, and (2) the decline in inter-market transaction costs such as transport and communications costs. Both deepening market integration and advances in digital technology have driven particularly large decreases in the costs of inter-market software provision. With lower costs has occurred a growing connectivity of individuals and organizations achieved through improved communications networks (e.g., the Internet and the satellite communications networks) and a consequent increase in the flow of information-intensive software provision across markets.[1]

Since these changes due to deeper market integration often provides an opportunity to acquire varieties of products not available from domestic producers, welfare gains via increased product diversification are emphasized in the trade/regional economy literature.[2] As yet, however, little attention has been paid to the impact of market integration on software provision in the

[1]According to this point, Illing and Peitz (2006) present stylized facts on software indutries.

[2]See, for example, Fujita et al. (1999) and Behrens et al. (2007).

presence of *indirect network effects.*

Indirect network effects exist when the utility of consumers is increasing in the variety of complementary "software" products available for a "hardware" device. Examples of such devices include personal computers, video casette recorders, and consumer electronics products. It is important to note that not only electronic products but also IT-related services exhibit strong indirect network effects. Internet auction site such as eBay provides a good example: the more users sells through eBay ("hardware" in our terminology), the greater the variety of items ("software" in our terminology) that can be found, and the greater the value of buying through eBay. These examples suggest that the concept of indirect network effects has a wide applicability in the modern economy.

Despite the fact that many industries have indirect network effects that are supported by deeper market integration, the literature on indirect network effects is almost exclusively focused on a single market.[3] Because the

[3] The seminal contributions on the role of a "hardware/software" system are Chou and Shy (1990) and Church and Gandal (1992). See Economides (1996), Gandal (2002), Farrell and Klemperer (2007) for surveys of the relevant literature. In the international context, Gandal and Shy (2001) analyze governments' incentives to recognize foreign standards when there are network effects. See, also, Kikuchi (2003, 2007) for the analysis of trade liberalization in the presence of network effects.

role of indirect network effects is amplified in the globalized world, it seems important to explore the impact of market integration in the presence of products with indirect network effects.

As our primary contribution, we extend Church and Gandal (1992)'s single market model with two incompatible hardware technologies to an international (or regional) trade environment with two markets:[4] we emphasize the role of *inter-market trade costs* which includes not only shipping costs but also difficulty of communication, information barriers, etc., and show how deeper market integration (i.e., a reduction in trade costs) affects the software provision decision of software firms.[5] It is shown that, given that two incompatible hardware exist, deeper market integration may *reduce* the variety of hardware technologies. It is also shown that, if the variety of hardware technologies is reduced by deeper integration, some consumers are made worse off. In other words, deeper market integration, which forms the basis for a greater variety of software products (i.e., intensified indirect network

[4]Based on the Hotelling's spatial approach, Schmitt (1993, 1995) investigate the firms' product choise in a two-market environment. Also, in order to analyze the possibility of coalition formation among suppliers of retail services, Henkel et al. (2000) adapt the work of Church and Gandal (1992) to a spatial economy setting.

[5]Recent empirical studies suggest that trade costs are still large, even aside from trade-policy barriers and even between apparently highly integrated economies. See Anderson and van Wincoop (2004) for surveys of the relevant literature.

effects), may work as a catalyst for Pareto inferior outcomes.

The rest of this note is organized as follows. Section 2 describes the basic model. Section 3 analyze trading equilibrium and Section 4 considers the impact of deeper market integration (i.e., a reduction in trade costs). Section 5 contains concluding remarks.

2 The Model

In this section, we describe the basic setup of the model: both technology and consumers' preferences are specified. Then, is the next section, the trading equilibrium with positive transport costs is explained in detail.

Suppose that there are two countries (or regions), Home and Foreign, and that they are identical in regard to tastes, size, and technology.[6] In each country there are three types of goods: hardware, a large variety of software products, and the outside good. We assume that there are two hardware technologies in both countries: *Hardware 0* and *Hardware 1*. We also assume that the hardware technologies are *incompatible*: software written for one hardware will not work with the other's. Without the provision of compatible software, no consumers will purchase a hardware.

A market in each country is defined as a line of unit length representing

[6] In this way, we rule out Ricardian comparative advantage.

both consumers' set of preferences and the firms' attribute space for hardware products. The characterization of the two hardware technologies is exogenous: each is located at the end point of the unit line: let Hardware 0's technology be at the left end point and Hardware 1's technology at the right end point. We denote the marginal cost of each hardware production by c. We further assume that the hardware technologies are non-proprietary and that they will be offered at marginal cost.

Following Church and Gandal (1992), consumer preferences over the combination of hardware and software are modelled as a Dixit-Stiglitz (1977) CES utility function. We assume that the distribution of the tastes of Home (Foreign) consumers is uniform along a line of unit length $s \in [0, 1]$. In each country, the consumers' density is uniform and equal to 1.

The preferences of a Home consumer of type s for system $h \quad (h = 0, 1)$ are:

$$U(s,h) = \left[\sum_{i}^{n^h} (x_i^h)^\theta + \sum_{i*}^{n_*^h} (x_{i*}^h)^\theta \right]^{(1/\theta)} + \phi - k|s-h|, \quad (1/2) < \theta < 1, \quad (1)$$

where n^h (n_*^h) is the number of Home (resp. Foreign) software products written for Hardware h, x_i^h (resp. x_{i*}^h) is the level of consumption of software product i (resp. $i*$) written for Hardware h, $\sigma \equiv 1/(1-\theta) > 2$ is the elasticity of substitution between every pair of software products, and we assume that $\phi > k$. k is a measure of the degree of product differentiation between the hardware technologies: the greater k, the greater the degree of differentiation.

Inter-market trade in software products is inhibited by frictional trade barriers, which are modeled as iceberg costs à la Samuelson: for one unit of the software product to reach the other country (or region), $t \in (1, \infty)$ units must be shipped.[7] Thus, the price of an imported software product to Home consumers will be tp_*^h, where p_*^h is the producer's price for software products written in Foreign. Inter-market trade cost includes all impediments to trade, such as shipping costs per se, but also different product standards, difficulty of communication, information barriers and cultural differences.

The representative consumer who purchases Hardware h will maximize (1) subject to the following budget constraint:

$$\sum_{i}^{n^h} p_i^h x_i^h + \sum_{i*}^{n_*^h} t p_{i*}^h x_{i*}^h = e - c, \tag{2}$$

where p_i^h (resp. p_{i*}^h) is the price of Home (resp. Foreign) software variety i (resp. $i*$) for Hardware h, e is the total expenditure allocated to hardware and software, and c is the price (i.e., cost) of a unit of Hardware h.

The solution to this problem consists of the following demand functions:

$$x_i^h = (e - c)(P^h)^{\sigma-1}/(p_i^h)^{\sigma}, \tag{3}$$

$$x_{i*}^h = (e - c)(P^h)^{\sigma-1}/(tp_{i*}^h)^{\sigma}, \tag{4}$$

[7]See Ottaviano and Thisse (2004, p.2581).

where

$$P^h = \left[\sum_j^{n^h} \left(p_j^h\right)^{1-\sigma} + \sum_{j*}^{n_*^h} \left(tp_{j*}^h\right)^{1-\sigma} \right]^{1/(1-\sigma)}. \tag{5}$$

If the prices of software product are identical among countries (i.e., $p_i^h = p_{i*}^h = p^h$), the CES price index (5) simplifies to

$$P^h = p^h (n^h + \tau n_*^h)^{1/(1-\sigma)}, \tag{6}$$

where $\tau \equiv t^{1-\sigma} \in (0,1)$ is the measure of the *freeness of trade*, which increases as t falls and is equal to one when trade is costless ($t = 1$). Note that τ can be interpreted as an 'weight' on imported software products: the price index is decreasing in τ.

The indirect utility of a type-s consumer who purchases a system h is

$$V(s,h) = \frac{[(n^h + \tau n_*^h)^{1/(\sigma-1)}(e-c)]}{p^h} + \phi - k|s-h|. \tag{7}$$

The indirect utility function is concave in $(n^h + \tau n_*^h)$: the marginal benefit of additional software variety is decreasing.

Now, let us turn to the cost structure of software provision. The technology for the production of software is characterized by increasing returns to scale, since software creation typically involves fixed costs. We denote the constant marginal cost of software production for every product by b, and the software development cost by f.

We assume that software firms are monopolistic competitors. With the total number of products available to consumers being very large, each producer chooses its constant markup prices as:[8]

$$p = p_* = b\sigma/(\sigma - 1). \tag{8}$$

3 Trading Equilibrium

In this section, we specify a simple game in which the strategy of each software firm in a decision to provide software for either hardware, 0 or 1. The timing of the game is as follows:[9] In the first stage software firms enter the industry. There is free entry into the software industry and software firms have rational expectations. Although there may be more than one equilibrium software configuration, we show that the free-entry number of software firms, $N = n^0 + n^1$ (resp. $N_* = n_*^0 + n_*^1$), is unique,[10] where n^h (resp. n_*^h) is the number of firms providing software for Hardware h in Home (resp. Foreign). Since two countries are identical in regard to tastes, size, and technology, it is easily shown that $N = N^*$ holds. Also, in order to emphasize the role of trade costs, we restrict our attention to the case of *symmetric equilibrium* where $n^h = n_*^h$ holds. In other words, we concentrate on the case

[8] Hereafter, we drop the superscript h.

[9] This is taken from Church and Gandal's (1992) single market model.

[10] See Subsection 3.3.

where each country's equilibrium configuration is *identical*. From the consumers' viewpoint, this implies that the *effective* number of software varieties for Hardware h is $(1+\tau)n^h$ [see equation (7)].

In the second stage, software firms simultaneously choose which platform to provide software for. In the final stage, each consumer purchases either a Hardware 0 or a Hardware 1 system and some of the compatible software. We solve this problem backward.

3.1 Final Stage

Since we assume the marginal costs (prices) of hardware and software are equal for both systems, consumers determine which hardware to purchase considering only their tastes and the amount of software available for each system. From (5), a consumer located at s purchases Hardware 0 if the following inequality holds:

$$\frac{[(1+\tau)n^0]^{1/(\sigma-1)}(e-c)}{p}+\phi-ks > \frac{[(1+\tau)(N-n_0)]^{1/(\sigma-1)}(e-c)}{p}+\phi-k(1-s), \tag{9}$$

where use has been made of the equation $n^0 + n^1 = N$. Therefore, the location of the marginal consumer who purchase Hardware 0 is given by a function of n^0, that is,

$$s(n^0) = T(\tau)\frac{[(n^0)^{1/(\sigma-1)} - (N-n^0)^{1/(\sigma-1)}](e-c)(\sigma-1)}{2kb\sigma} + \frac{1}{2}, \tag{10}$$

$$T(\tau) \equiv (1+\tau)^{1/(\sigma-1)}. \tag{11}$$

And the first derivative of $s(n^0)$ is positive:

$$s'(n^0) \equiv \frac{ds(n^0)}{dn^0} = \frac{T(\tau)[(n^0)^{(2-\sigma)/(\sigma-1)} + (N-n^0)^{(2-\sigma)/(\sigma-1)}](e-c)}{2kb\sigma} > 0. \tag{12}$$

This means that the share of Hardware 0 is increasing in the amount of software for it. It can also be shown that

$$s(0) \geq 0 \text{ and } s(N) \leq 1 \iff [(1+\tau)N]^{1/(\sigma-1)} \leq kb\sigma/[(e-c)(\sigma-1)] \tag{13}$$

and

$$s'(N/2) \geq 1/N \iff [(1+\tau)N]^{1/(\sigma-1)} \geq 2^{1/(\sigma-1)}kb\sigma/2(e-c). \tag{14}$$

Based on the above, the function $s(n^0)$ can be depicted as curves in Figure 1,[11] where curves A, B, and C correspond to the graph of $s(n^0)$ under each of the following three cases: in case A, $t \geq \bar{t} \equiv [N/(K^\sigma - N)]^{1/(\sigma-1)}$, where $N = [(e-c)/f\sigma]$ and $K \equiv kb\sigma/[(e-c)(\sigma-1)]$; in case B, $\bar{t} > t > \underline{t} \equiv$

[11]The second derivative of $s(n^0)$ is negative (positive) if n^0 is smaller (greater) than $N/2$, since

$$\frac{d^2 s(n^0)}{d(n^0)^2} = -\frac{T(\tau)[(n^0)^{(3-2\sigma)/(\sigma-1)} - (N-n^0)^{(3-2\sigma)/(\sigma-1)}](\sigma-2)(e-c)}{2kb\sigma(\sigma-1)},$$

where $\sigma > 2$ from the assumption $\theta > 1/2$.

$(N/(K'^{\sigma} - N))^{1/(\sigma-1)}$; and in case C, $t \leq \underline{t}$.[12] The three curves are drawn for high, intermediate, and low levels of inter-market trade costs, respectively.

Note that in cases B and C, $s(n^0)$ can reach 0 or 1, even if there are still two types of software. Since the market is of unit length, that is, $0 \leq s \leq 1$, there exists a critical number of software firms for each type of hardware such that if the number of software firms for one technology exceeds the critical number, then all consumers purchase the dominant hardware. On the other hand, in case A, there are two types of consumers unless one hardware is standardized; no software for the other hardware exists.[13]

3.2 Second Stage

In the second stage, software firms simultaneously select the network for which to supply software are. Given the marginal consumer, s, in each country, and the number of competing software firms ($(1+\tau)n^0$ or $(1+\tau)n^1$), the profit of a software firm writing software for Hardware 0 is

$$\pi^0(s,\ n^0) = (1+\tau)s(p-b)x^0 - f = \frac{s(e-c)}{n^0\sigma} - f, \tag{15}$$

[12] The importance of discrimination between case B and C will appear in the following.

[13] Since we assume that hardware only facilitates the consumption of software and provides no stand-alone benefits, in case A, the marginal consumer, s, changes discontinuously to 0 or 1 when n^0 is equal to 0 or N.

where $x^0 = (e-c)/[(1+\tau)n^0 p]$. Note that, due to the presence of inter-market trade costs, profits from exporting is discounted by an weight τ. The profit of a software firm for Hardware 1 is

$$\pi^1(s,\ n^1) = (1+\tau)(1-s)(p-b)x^1 - f = (1-s)\frac{(e-c)}{n^1\sigma} - f, \tag{16}$$

where $x^1 = (e-c)/[(1+\tau)n^1 p]$. From these equations, it is easily derived that

$$\pi^0(s,\ n^0) \gtreqless \pi^1(s,\ n^1) \quad \Longleftrightarrow \quad s \gtreqless \frac{n^0}{N}. \tag{17}$$

Based on the latter inequality, each firm considers whether $s(n^0)$ is greater than n^0/N or not, and then chooses the network to supply.

3.3 First Stage

At any equilibrium where two networks coexist, $\pi^0(s,\ n^0) = \pi^1(s,\ n^1)$ must be satisfied. Therefore, $s = n^0/N$ holds at the equilibrium and

$$\pi^0 = \pi^1 = \frac{(e-c)}{N\sigma} - f. \tag{18}$$

On the other hand, if all software firms provide software for one network at equilibrium, then $(s, n^0) = (1, N)$ or $(s, n^1) = (0, N)$ hold and

$$\pi^0 = \frac{(e-c)}{N\sigma} - f \quad \text{or} \quad \pi^1 = \frac{(e-c)}{N\sigma} - f. \tag{19}$$

Thus, the profit of each firm is independent of equilibrium software configurations, and the free-entry number of firms in each country, N, is uniquely given as

$$N = \frac{(e-c)}{f\sigma}. \tag{20}$$

Based on the foregoing argument, we can conclude that $\pi^0 = \pi^1 = 0$ holds for any pair (s, n^0) on the dotted line in Figure 1, $\pi^0 = 0$ at $(1, N)$, and $\pi^1 = 0$ at $(0, 0)$, while π^0 (π^1) is positive (negative) at any pair above the line and *vice versa.*

3.4 Nash Equilibrium Configurations

Based on the foregoing argument, we obtain the Nash equilibrium configurations as follows: In order for a configuration to be a Nash equilibrium, it must be impossible for a software firm to switch networks and increase its profit.

In case A, the graph of $s(n^0)$ is drawn as curve A in Figure 1. So, there are three equilibrium candidates; $(n^0 = n^1 = N/2)$, $(n^0 = N, n^1 = 0)$, and $(n^0 = 0, n^1 = N)$. Since

$$s(n^0) \begin{cases} > n^0/N & \text{if} \quad n^0 < N/2, \\ < n^0/N & \text{if} \quad n^0 > N/2, \end{cases} \tag{21}$$

we can conclude that only symmetric equilibrium $(n^0 = n^1 = n^0_* = n^1_* = N/2)$ is stable in the sense of a Nash equilibrium.

On the other hand, in case C, the graph is drawn as curve C and

$$s(n^0)\begin{cases} < n^0/N & \text{if} \quad n^0 < N/2, \\ > n^0/N & \text{if} \quad n^0 > N/2. \end{cases} \tag{22}$$

Therefore, only two equilibria, $(n^0 = n^0_* = N, n^1 = n^1_* = 0)$ and $(n^0 = n^0_* = 0, n^1 = n^1_* = N)$, are stable.[14]

Finally, in case B, the graph of $s(n)$ is drawn as curve B and it is apparent from the discussion above that all three of the equilibria, $(n^0 = n^1 = n^0_* = n^1_* = N/2)$, $(n^0 = n^0_* = N, n^1 = n^1_* = 0)$, and $(n^0 = n^0_* = 0, n^1 = n^1_* = N)$, are stable. So, we have the following lemma:

Lemma: Depending on the parameter values, the following three cases emerge:

Case A: If $t \geq \bar{t} \equiv [N/(K^\sigma - N)]^{1/(\sigma-1)}$, *where* $N = [(e-c)/f\sigma]$ *and* $K \equiv kb\sigma/[(e-c)(\sigma-1)]$, *a unique symmetric equilibrium exists,* $(n^0 = n^1 = n^0_* = n^1_* = N/2)$.

Case B: If $\bar{t} > t > \underline{t} \equiv (N/(K'^\sigma - N))^{1/(\sigma-1)}$, *where* $K' \equiv (2^{1/(\sigma-1)}kb\sigma)/[2(e-c)]$, *three equilibria,* $(n^0 = n^1 = n^0_* = n^1_* = N/2), (n^0 = n^0_* = N, n^1 = n^1_* = 0)$, *and* $(n^0 = n^0_* = 0, n^1 = n^1_* = N)$, *exist.*

Case C: If $t \leq \underline{t}$, *only two equilibria,* $(n^0 = N, n^1 = 0)$ *and* $(n^0 = n^0_* =$

[14]In the interval of n where $s(n^0)$ is greater than 1 (smaller than 0), the actual marginal consumer, s, is equal to 1 (0) and is still above (below) the line $s = n^0/N$.

$0, n^1 = n^1_* = N)$, *exist.*

There is one important thing to note about the effect of deeper market integration: the gradient of $s(n^0)$ in the neighborhood of the symmetric equilibrium is increased, and that change tends to make the symmetric equilibrium less stable. Figure 1 suggests that deeper market integration, by intensifying indirect network effects, increases the extent to which a given number of software varieties is consistent with hardware/software standardization.

4 The Impact of Market Integration

Now let us turn to the impact of deeper market integration (i.e., a gradual decrease in trade costs for software products).[15] A reduction in inter-market trade costs (i.e., a larger τ) implies one basic change: the effective number of software varieties, $(1+\tau)n^h$, becomes larger. This implies that the integrated market can support an easier access to software products.[16] Since consumers prefer to consume a wide variety of software products, deeper market integration might result in gains from product diversification. However, we have

[15]The case of a move from closed economy to full trade liberalization is discussed in Iwasa and Kikuchi (2008).

[16]Note that the total number of software varieties remained unchanged as $2N$.

to check *the changes in the variety of hardware.*

Figure 2 traces out equilibrium values of n^h as functions of the level of inter-market trade costs. At high values of t the symmetric equilibrium is unique and both systems exist. As t drops below level $\bar{t}$, hardware (and software) standardization (i.e., only one type of hardware remains) becomes sustainable. For trade costs below $\underline{t}$, the symmetric equilibrium is unstable.

Let us suppose a secular fall in inter-market trade costs. From an initial position in which two technologies coexist, hardware standardization spontaneously arises through a process of intensified indirect network effects. In what follows, to highlight the interaction between deeper market integration and software provision, let us examine the following two representative cases.

4.1 The Case of Hardware Differentiation

In what follows, t (resp. t') indicates trade costs before (resp. after) integration. Let us assume that the following condition is satisfied:

$$t > t' > \bar{t} \equiv \left([N/(K^{\sigma} - N)]\right)^{1/(\sigma-1)}, \tag{23}$$

where $N = [(e-c)/f\sigma]$ and $K \equiv kb\sigma/[(e-c)(\sigma-1)]$. Note that this condition holds when the degree of hardware differentiation (k) is relatively large (or the degree to which indirect network effects exist is relatively low). In this case, two types of hardware remain during the process of market integration. Thus, no consumer changes his or her hardware and market integration induces an effectively large number of software varieties for each type of hardware. From (7), this clearly increases every consumer's utility.

Proposition 1: *Given that condition* (23) *holds, both types of hardware remain in the equilibrium and both countries gain from deeper market integration.*

4.2 The Case of Hardware Standardization

Next, let us assume that the following condition is satisfied:[17]

$$t > \underline{t} > t', \tag{24}$$

where t (resp. t') is the trade costs before (resp. after) market integration. In this case, while both types of hardware exist before integration, only one type of hardware remains after integration. In other words, intensified indirect network effects result in a *reduced* number of hardware varieties (2 rather than 1).

This can be interpreted as follows. An increased number of effective software varieties intensifies indirect network effects, which makes consumers to choose a hardware with a largest number of software written for that. Due

[17]Note that $\sigma \leq 3$ is required for this condition.

to these changes, software firms change their software provision decision: all software firms choose to write software for a single hardware. Then, the demand for other type of hardware vanishes.

For simplicity, let us suppose that only Hardware 1 remains after market integration. In this case, some consumers have to switch from Hardware 0 to Hardware 1. While there are gains from the increased diversity of software available, there are losses from switching to the other network. The change in the indirect utility of a type-s consumer who switches to the other network is:[18]

$$\Delta V(t) = [(4^{1/(\sigma-1)} - 1)(N/2)^{1/(\sigma-1)}(e - c)(\sigma - 1)]/(b\sigma) - k(1 - 2t). \quad (25)$$

Note that the first term on the RHS represents the gains from software diversification while the second term on the RHS represents costs from increased disutility. Let us define a type-$\tilde{t}$ consumer who is indifferent to switching hardware as follows:

$$\tilde{t} = (1/2) - [(4^{1/(\sigma-1)} - 1)(N/2)^{1/(\sigma-1)}(e - c)(\sigma - 1)]/2kb\sigma. \quad (26)$$

Let us define the solution of $2^{1/(\sigma-1)} - 4^{1/(\sigma-1)} + 1 = 0$ as $\tilde{\sigma}$. Then we can show that $\tilde{t} > 0$ holds when $\sigma > \tilde{\sigma}$:

$$\tilde{t} \;\geq\; (1/2) - (4^{1/(\sigma-1)} - 1)/2^{1+1/(\sigma-1)}$$

[18]Note that, in the case of hardware standardization, the number of software varieties for Hardware 1 increases from n_1 to $4n_1$ (or from $N/2$ to $2N$).

$$= \quad (2^{1/(\sigma-1)} - 4^{1/(\sigma-1)} + 1)/2^{\sigma/(\sigma-1)} \quad \begin{cases} < 0 & \text{if } 2 < \sigma < \tilde{\sigma} \\ > 0 & \text{if } \sigma > \tilde{\sigma} \end{cases}$$

Now we can state the possibility of losses from market integration.

Proposition 2: *If condition* (26) *and* $\tilde{\sigma} \leq \sigma \leq 3$ *are satisfied and Hardware* 1 *(resp.* 0*) dominates the integrated market, both countries' consumers who located at* $t \in [0, \tilde{t}]$ *(resp.* $t \in [1 - \tilde{t}, 1]$*) are made worse off by deeper market integration.*

This implies that trade liberalization leads some consumers to "switch" to an other-dominated brand, thereby increasing disutility. Note that this case is highly contrasted with the cases of universal gains from trade, which are emphasized in the literature. We would like to emphasize that deeper market integration, which forms a basis for a greater variety of software products (i.e., intensified indirect network effects), may work as a catalyst for Pareto inferior outcome.

5 Concluding Remarks

Both deeper market integration and advances in digital technology have driven particularly large decreases in the costs of inter-market software provision. In this note, we first explain the mechanism of how trade costs influence the software provision decision of software firms. Then, we investigated the transformation of production/trade patterns given gradually decreasing trade costs for software products. It is shown that, given that two incompatible hardware exist, deeper market integration may *reduce* the variety of hardware technologies. It is also shown that, if the variety of hardware technologies is reduced by deeper integration, some consumers are made worse off (Proposition 2). In other words, deeper market integration, which forms the basis for a greater variety of software products may work as a catalyst for Pareto inferior outcomes.

The present analysis must be regarded as tentative. Hopefully it provides a useful paradigm for considering how deeper market integration affect both the structure of software provision and inter-market trade patterns.

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