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(This paper is currently under review for publication, comments on this paper are welcome)

In this paper, we construct a simple model to show why similar countries can trade with each other for the same good when product quality can be selected by firms. Specifically, we devise a model that shows when trade expands a market, firms will build higher quality into their goods that benefits the whole region. We find that trade does not increase the variety of goods and makes goods more costly due to their higher quality. Therefore, we conclude quality improvement is the main mechanism that helps countries gain from trade in quality differentiated goods. (JEL F12, L13)

I. Introduction

Recent studies have shown that international trade is concentrated among industrialized nations whose factor endowments are similar, and that this trade is mostly for the same goods (Gabrisch and Segnana (2003) and Bergoeing and Timothy (2003)). Generally accepted explanations for this have stressed economies of scale and more variety in goods as principle causes (for example, see Krugman (1979) and Lancaster (1980)). The predictive power of these models thus relies on horizontal differentiation of products and an assumption that trading products are identical in quality. However, the observation that a large part of trade among developed countries is vertical intra-industry trade (VIIT) - that is, trade of the same good at different quality levels – cannot be explained by these models.[1] To address such a situation, Falvey and Kierzkowski (1987), Falvey (1981), and Flam and Helpman (1987) showed how the trade of quality differentiated goods can take place between countries with different per capita income. They assumed that quality is an output of an increasing function of capital intensity so capital abundant countries will have comparative advantage in trading higher quality goods while labor abundant countries will have comparative advantage in trading lower quality ones. Davis (1995) and Bhagwati and Davis (1994) showed that VIIT can occur in traditional trade models in the presence of technology differences within an industry. These models claim that VIIT operates according to an H-O model based on comparative advantages arising from factors intrinsic to each country. For this reason, this kind of trade has been suggested to be called *inter-industry trade* instead of VIIT.

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[1] Gabrisch and Segnana (2003).

In this paper we model a case of VIIT involving similar countries trading for the same good. We show that, due to market expansion, when countries are in trade, firms will tend to produce goods of *a higher quality level,* increasing both consumers' and producers' surpluses. As a result, the whole region is better off. When we allow product quality to be chosen in this way, quality improvement becomes so dominant that internal increasing returns to scale and varieties of goods are no longer the reasons for trade of quality differentiated goods.

II. The Model

We assume a region consisting of only two similar countries: Home and Foreign. In each country, there are many industries. However, we *hereinafter* focus on the trade of goods in a single industry wherein goods are identical, but can be differentiated by quality. We assume that the industry is independent from other ones.

The goods are purchased by a number of consumers: S, in Home and T, in Foreign (T, S >0). It is reasonable to assume that S and T are proxies for Home and Foreign sizes, respectively. In each country, consumers are uniformly distributed between 0 and b according to their willingness to pay for quality, denoted by θ_j.[2] A consumer's willingness to pay for quality is dependent on her income (as conceptualized by Gabszewicz and Thisse, 1979), or it is the reciprocal of the utility of income. The more income a consumer has, the more she is willing to pay for goods at any quality level. Thus, *b* can be considered a proxy of per capita income in a country.[3] Because Home and Foreign are identical in terms of this income, we assume both countries have the same distribution range of

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[2] This assumption is widely used in vertical production differentiation studies, such as those of Wauthy (1996), Beloqui and Usategui (2005), and Sutton (1986).

[3] Consumer's willingness to pay for quality is dependent on personal income. Additionally, we assume that consumers are uniformly distributed from 0 to b with regard to their willingness. Because per-capita income is the average income of all consumers, it is directly proportional to the average of consumers' willingness, b/2 or just b.

consumers' willingness to pay for quality (from 0 to b). As in Wauthy (1996), the utility function of the consumer j, identified by θ_j, is given by

(1)
$$U_j = \begin{cases} \theta_j q - p & \text{if buying a good} \\ 0 & \text{if not buying} \end{cases}$$

Where quality level of consumed good is q, the price she has to pay for the good is p. A consumer's utility is zero if she does not purchase the good. Since there are many goods available, she will elect to purchase the one that generates the highest, and non-negative utility.

In each country, we assume an infinite number of free-entry/exit firms which are willing to produce one type of the good. In particular, each firm can offer a good and faces a total cost function as follows:

(2)
$$TC_i = V_i c + f(q_i) \quad i = 1, 2, ..., n; \; n \to +\infty$$

The function $f(q)$ is the same for all firms and is seen as the quality-dependent fixed cost with $f(0) = 0$. It is reasonable to further assume $f'(q) > 0$ or the marginal quality cost is increasing. In addition, $f(q)$ is strictly convex in q for all feasible quality levels or $f''(q) > 0$. To simplify our model, $f(q) = \frac{1}{2}q^2$ is used as a specific form of the quality function.[4] All firms are indexed and named according to the quality rank of their good: the firm with a quality rank i is called '*firm i*' (Thus, $f(q_i)$ is the quality cost incurred by firm i).

The output of firm i is denoted by V_i and c is unit cost in production. Without loss of generality, we assume $c = 0$, as in other models.[5] We note that the total cost function in (2) has a property of *economies of scale*, for a given level of

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[4] Mussa and Rosen (1978), Liao (2008), and Motta (1993) used this quadratic form of quality cost function.

[5] Wauthy(1996), Alvisi (2000), Beloqui and Usategui (2005), and Sutton (1986).

quality. This is because the average cost goes down when the output V_i increases for a fixed level of quality.

We assume there are no trade barriers between Home and Foreign, and that transportation cost is zero. In addition, complete and perfect information is also assumed.

2.1 Similar countries

In this section, we consider a country that is similar to Home and Foreign in all aspects, but its consumer size can be different. When a consumer size is 1, we call this country the *Unitary Country*.

Lemma 1: *In any similar country, there are an infinite number of firms at equilibrium.*

Proof: Shaked and Sutton (1983) points out that the assumption of zero marginal costs combined with the lower bound on the marginal willingness being zero implies that an arbitrarily large number of firms co-exists at equilibrium with positive market shares.

Lemma 2: *If (q_i^*, p_i^*) is the optimal pair of quality and price decided upon by firm i in the Unitary Country, $(\Psi q_i^*, \Psi p_i^*)$ is the optimal pair of quality and price selected by firm i in a similar country with a size of Ψ.*

Proof of lemma 2 will be provided upon request.

Lemma 3: *In any similar country, the industry concentration ratio of any number of firms (CR(n)) is the same and independent of its size.*

Proof: a consumer who is indifferent between a good of *firm i* and that of *firm i+1* is defined by $q_i \theta_i - p_i = q_{i+1} \theta_i - p_{i+1} \Leftrightarrow \theta_i = (p_i - p_{i+1})/(q_i - q_{i+1})$, $\forall i \geq 1$. We let $\theta_0 = b, \theta_\infty = 0$. A firm with quality ranked i will sell its good to consumers between θ_i and θ_{i-1}. From Lemma 2, we can easily prove that θ_i is the same at equilibrium in any similar country (for $\forall i$). It is because the optimal qualities and

prices are both increased by a factor of country size. Because consumers are uniformly distributed from $\theta_\infty = 0$ to $\theta_0 = b$ and θ_i is independent of the country size, the market share of *firm i* is the same in all similar countries (see figure 1). We note that a higher quality firm will have a higher market share. Thus, CR(n) is simply obtained by the sum of the market shares of the *top n quality* firms in a country. As a result, CR(n) is the same in any similar country and independent of the country size.

Because the number of firms in each country is infinite and firms are asymetric, it is not possible to define the variety of goods based on the number of firms with positive market share as in Krugman (1979). However, the concept of CR(n) can be used as an indicator for the variety of goods (as they are inversely related).

An analytic solution to obtain specific values for optimal prices and qualities from (4) or (6) is very difficult. Fortunately, we can examine the differences in optimal qualities and prices at equilibrium in any similar country to those in the Unitary Country without solving the above problems. We have added the Unitary Country into our paper for this purpose.

Now, suppose we had obtained specific values of optimal qualities and prices (q_i^*, p_i^*) in the Unitary Country, for $i = 1, 2 \ldots n;\ n \to \infty$. We calculate average cost of goods, total consumers' surplus, and total producers' surplus as presented in Table 1. Please refer to Appendix (A1) for calculations.

TABLE 1- AVERAGE COST, TOTAL CONSUMERS' SURPLUS, AND TOTAL PRODUCERS' SURPLUS IN THE UNITARY COUNTRY

Terms	Formula	Note

AC_i^U : average cost of firm i	$AC_i^U = \dfrac{\dfrac{b}{2}(q_i^*)^2}{(\theta_{i-1} - \theta_i)}$	$\theta_0 = b$
CS^U : total consumers' surplus	$CS^U = \displaystyle\sum_{i=1}^{\infty} \{CS_i^U\}$ where $CS_i^U = \dfrac{1}{b}\displaystyle\int_{\theta_i}^{\theta_{i-1}} (q_i^*\theta_j - p_i^*)d\theta_j$	$\theta_i = \dfrac{p_i^* - p_{i+1}^*}{q_i^* - q_{i+1}^*}$ $\theta_\infty = 0$
PS^U : sum of all producers' surplus	$PS^U = \displaystyle\sum_{i=1}^{\infty} \{PS_i^U\}$ Where $PS_i^U = \dfrac{[\theta_{i-1} - \theta_i]}{b} p_i^* - \dfrac{1}{2}(q_i^*)^2$	

Note: - Superscript U denotes the Unitary Country.

It is worth noting that both CS^U and PS^U converge.[6]

2.2 Autarkic and trading situations

Proposition 1: *Trade between Home and Foreign does not increase the variety of goods.*

Proof: Lemma 3 carries an implication that an increase in the market size does not change the industry concentration ratio of any number of firms (CR(n)) at equilibrium. Without trade, Home's market size is S and Foreign's market size is T. The trade between Home and Foreign expands the market size to S+T, but exactly the same *CR(n)* as that in Home or Foreign will be found at equilibrium (for any number of firms). In addition, the market share of *firm i* is the same in Home, Foreign, and the region. Because we can use CR(n) as an "inverse proxy"

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[6] We have $CS_i^U > 0$ and $PS_i^U > 0$. For $M = \dfrac{1}{b}\displaystyle\int_0^b (q_1^*\theta_j)d\theta_j$ and $N = p_1^*$, it is easy to show that $CS^U = \displaystyle\sum_{i=1}^{\infty} \{CS_i^U\} < M$ and $PS^U = \displaystyle\sum_{i=1}^{\infty} \{PS_i^U\} < N$ or CS^U and PS^U are converged.

for the variety of goods, trade does not increase variety of goods. Please refer to figure 1.
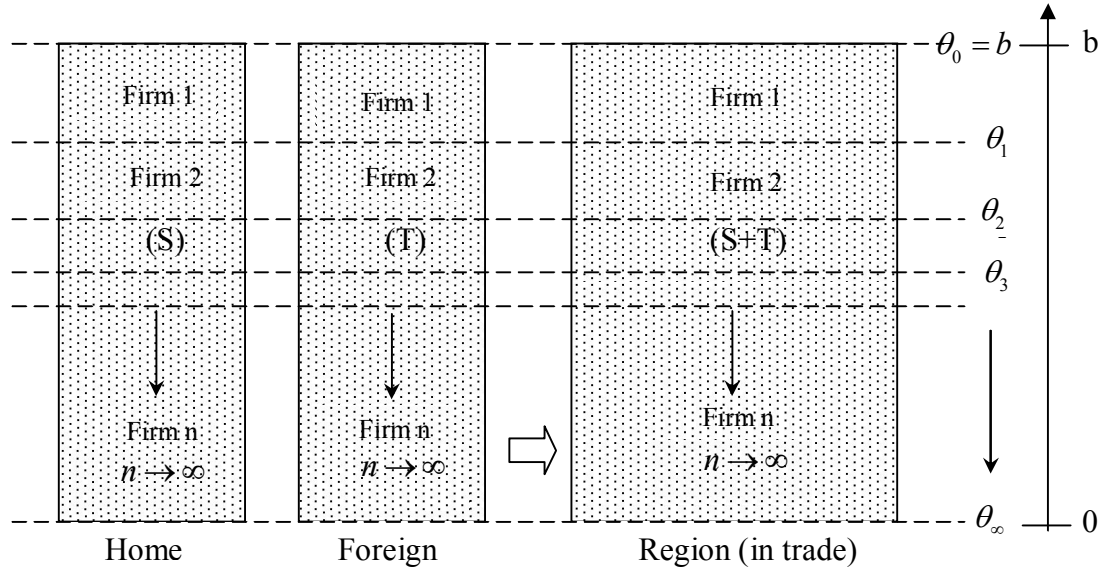
Note: $\theta_0 = b$, $\theta_i = \dfrac{p_i^* - p_{i+1}^*}{q_i^* - q_{i+1}^*} = \dfrac{Sp_i^* - Sp_{i+1}^*}{Sq_i^* - Sq_{i+1}^*} = \dfrac{Tp_i^* - Tp_{i+1}^*}{Tq_i^* - Tq_{i+1}^*} = \dfrac{(S+T)p_i^* - (S+T)p_{i+1}^*}{(S+T)q_i^* - (S+T)q_{i+1}^*}$

Figure 1: *Trade does not change the variety of goods.*

Proposition 2: *When countries are in trade, a firm ranked i will produce its good at a higher level of quality compared with that of the firm with the same rank in an autarkic country (Home or Foreign). In addition, goods become more costly to produce when Home and Foreign trade with each other as a consequence of quality improvement.*

Proof: From Lemma 3, it is straightforward to derive optimal quality of firm *i*: Sq_i^* in Home, Tq_i^* in Foreign, and $(S+T)q_i^*$ in the region (Home and Foreign with trade). Thus, the quality increases when countries are in trade.

Referring to Table 2, it is easy to show that $(T+S)AC_i^U > (S)AC_i^U$ and $(T+S)AC_i^U > (T)AC_i^U$. Proposition 2 is proven.

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Proposition 3: *Trade makes the region better off and the regional gain from trade is proportional to the product of the country sizes. However, the welfare of a trading country might be harmed when its firms lose from international competition and when the relative size of its trading partner is not big enough.*

Proof: From data in Table 2, it is straightforward to prove that $(S+T)^2(PS^U + CS^U) > (S^2 + T^2)(PS^U + CS^U)$ or trade enhances the welfare of the region as a whole. In addition, the regional gain from trade is $2TS(CS^U + PS^U)$ or it is proportional to the product of country sizes.

We note that when Home and Foreign trade with each other, firms from both countries will compete with each other. As a result, many firms which have positive market shares prior to trade must exit the market. In the Krugman (1979) model, the expansion of a market allows more firms to coexist at equilibrium. However, our present model concerns vertically differentiated products, and the number of firms coexisting is unchanged even when the market expands. In order to envision what ensues from our model when considering an infinite number of firms, let us consider *n firms* when *n* is finite but extremely large. There will be *n firms* in Home and *n firms* in Foreign which coexist at equilibrium prior to trade, and *n firms* will survive at equilibrium only when Home and Foreign trade each other. Thus if we consider our large *n* as an approximation of an infinite number of firms at equilibrium, we can make a similar conclusion. At equilibrium, we cannot tell where surviving firms come from, Home or Foreign.[7]

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[7] For this reason, the Grubel–Lloyd index might not fully account for the extent of VIIT between countries.

Now, we consider a case of Home as an example. Let $\omega \in [0,1]$ be the share of the regional producers' surplus gained by Home's firms. We note that the weaker the firms of Home are, the less this share is. The welfare of Home when it trades with Foreign, W_H^T, is:

$$W_H^T = S(S+T)CS^U + \omega(S+T)^2 PS^U = (S^2)CS^U + (ST)CS^U + \omega(S+T)^2 PS^U$$

The welfare of Home without trade, W_H^{NT}, is:

$$W_N^{NT} = (S^2)CS^U + (S)^2 PS^U$$

Thus, the welfare of Home will be harmed by trade if $W_H^T < W_H^{NT}$ or

(7) $(S^2)CS^U + (ST)CS^U + \omega(S+T)^2 PS^U < (S^2)CS^U + (S^2)PS^U$

$$\Leftrightarrow (\frac{T}{S})CS^U + \omega(1+\frac{T}{S})^2 PS^U < PS^U$$

We let $\frac{T}{S}$ be λ (the relative country size of Foreign). We can rewrite (7) as follows:

(8) $\lambda CS^U + \omega(1+\lambda)^2 PS^U < PS^U$

It is easy to show that inequality (8) is more likely to be satisfied when λ and ω are small. Proposition 3 is proven.

The impact of trade on quality, average cost, consumers' surplus and producers' surplus in Home, Foreign, and the region are summarized in the following table. Please refer to Appendix (A2) for details.

TABLE 2- THE IMPACT OF TRADE TO HOME, FOREIGN, AND THE REGION

Impact	Without trade		In Trade
	Home	Foreign	Region

Quality (q_i)	Sq_i^*	Tq_i^*	$(S+T)q_i^*$
Average cost (AC_i)	$(S)AC_i^U$	$(T)AC_i^U$	$(S+T)AC_i^U$
Total Consumers' Surplus (CS)	$(S^2)CS^U$	$(T^2)CS^U$	*Home:* $S(S+T)CS^U$ *Foreign:* $T(S+T)CS^U$
	Home and Foreign: $(S^2+T^2)CS^U$		*The Region:* $(S+T)^2CS^U$
Total Producers' Surplus (PS)	$(S^2)PS^U$	$(T^2)PS^U$	*Location of a firm in Home or Foreign can not be determined.*
	Home and Foreign: $(S^2+T^2)PS^U$		*The Region:* $(S+T)^2PS^U$
Regional Welfare	$(S^2+T^2)(CS^U+PS^U)$		$(S+T)^2(CS^U+PS^U)$
Regional Gains from Trade	$2TS(CS^U+PS^U)$		

Note: - S is the consumer size in Home and T is the consumer size in Foreign

III. Discussion

We have considered a model in which firms can adjust their good quality as well as price. Thus, our findings might be applicable in *the long run*. There are some implications as follows:

First, we have pointed out that the increase in good quality as a result of trade is the main mechanism that makes the region better off. This finding confirms that the reason for VIIT derives from a firm's level (differentiation of products) and it should be classified as *a kind of intra-industry trade*.

Second, contrary to the findings of Krugman (1979), we found that the variety of goods is not the cause for VIIT and that the possibility for the effect of internal increasing returns to scale is destroyed by the raise in quality. Thus, the

causes of trade proposed by Krugman (1979) may be ineffective in explaining international trade based on good quality differentiation in the long run.

Third, VIIT does not always benefit the country engaging in trade. The welfare from trade added to a country is a consequence of two reasons: the success of its firms in the international market and the scale of quality improvement possible (as a result of its trading partner size). Thus, a larger country often attracts trading partners more strongly because of the opportunity of quality improvement, while a country whose firms are already strong exerts a weaker (or even an opposite) effect.

IV. Conclusion

By using a basic model, we have identified that quality improvement of goods as a result of trade is the main mechanism to achieve gains from VIIT. We have argued that it is reasonable to consider VIIT as a kind of intra-industry trade. In addition, we have shown that internal increasing returns to scale, as well as good varieties do not play a role in explaining VIIT in the long run. Thus, we find the causes of VIIT are quite different from those suggested by Krugman (1979).

We formulated a model that reached conclusions using assumptions that are commonly made concerning vertical product differentiation. However among our assumptions was a zero production cost, which could be considered in a more comprehensive model.

Appendix

A1. *In Table 1*

We define the consumer θ_i ($i = 1, 2, ..., n; n \to \infty$) is the consumer who is indifferent between a good of *firm i* and a good of *firm i+1*. From figure 1, the set $\Omega = \{b, \theta_1, ..., \theta_n\}$ ($n \to \infty$) is the same in Home, Foreign and the region.

i) The average cost of firm i:

We note that $c = 0$. Thus, the average cost of a good can be obtained by dividing its quality cost by good quantity demanded. The demand of good i is $\frac{1}{b}[\theta_{i-1} - \theta_i]$ where $\theta_0 = b$ and $\theta_i = \frac{p_i^* - p_{i+1}^*}{q_i^* - q_{i+1}^*}$. The quality cost incurred by firm i is $\frac{(q_i^*)^2}{2}$. Thus, $AC_i^U = \frac{\frac{b}{2}(q_i^*)^2}{(\theta_{i-1} - \theta_i)}$.

ii) Total Consumers' Surplus

From figure 1, *firm i* will sell its goods to consumers from θ_i to θ_{i-1}. These consumers will get a surplus of $CS_i^U = \frac{1}{b}\int_{\theta_i}^{\theta_{i-1}} (q_i^*\theta_j - p_i^*)d\theta_j$. Thus, the total consumers' surplus is $CS^U = \sum_{i=1}^{\infty} CS_i^U$.

iii) Total Producers' Surplus

Profit of firm i is $PS_i^U = \frac{1}{b}[\theta_{i-1} - \theta_i]p_i^* - \frac{1}{2}(q_i^*)^2$. Thus, the total producer's surplus is the sum of all profits gained by n firms: $PS^U = \sum_{i=1}^{\infty} PS_i^U$.

A2. *In Table 2*

i) The average cost of firm i:

In Home, the demand of good i is $\frac{S}{b}[\theta_{i-1} - \theta_i]$ where $\theta_0 = b$ and $\theta_i = \frac{p_i^* - p_{i+1}^*}{q_i^* - q_{i+1}^*}$.

The quality cost incurred by firm i is $\frac{(Sq_i^*)^2}{2}$. Thus, $AC_i^H = \frac{Sb(q_i^*)^2}{2(\theta_{i-1} - \theta_i)} = (S)AC_i^U$.

Similarly, the average cost in Foreign is $AC_i^F = (T)AC_i^U$ and the average cost in the region is $AC_i^R = (S+T)AC_i^U$.

ii) Total Consumer's Surplus

The set $\Omega = \{b, \theta_1, ..., \theta_n\}$; $n \to \infty$ is the same in the Unitary Country, Home, Foreign as well as in the region (Home and Foreign in trade). In autarkic Home, firm i will sell its good to consumers from θ_i to θ_{i-1}. These consumers will get a surplus of $CS_i^H = \frac{S}{b} \int_{\theta_i}^{\theta_{i-1}} (Sq_i^* \theta_j - Sp_i^*)d\theta_j = \frac{S^2}{b} \int_{\theta_i}^{\theta_{i-1}} (q_i^* \theta_j - p_i^*)d\theta_j = S^2 CS_i^U$.

Thus, the total consumers' surplus in Home is $CS^H = \sum_{i=1}^{n} S^2 CS_i^U = (S^2)CS^U$. With similar calculations, we can derive total consumers' surpluses in Foreign as well as in the region as shown in Table 2.

iii) Total Producers' Surplus

In Home, profit of *firm i* is $PS_i^H = \frac{S[\theta_{i-1} - \theta_i]}{b} Sp_i^* - \frac{1}{2}(Sq_i^*)^2 = S^2 PS_i^U$. Thus, the total producers' surplus is $PS^H = \sum_{i=1}^{n} S^2 PS_i^U = (S^2)PS^U$. With similar calculations, we can derive total producers' surpluses in Foreign as well as in the region as shown in Table 2.

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