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We examine the effects of intra-industry trade in the presence of imperfect competition and heterogeneous technologies. Contrary to the common belief that intra-industry trade always improves the world welfare due to reduction of market power, we show that even in the absence of transportation costs, it may generate a net global welfare loss. With technology heterogeneity across countries, the direction of production displacement in equilibrium when opening up trade, is critical to welfare changes domestically as well as globally. When a South country has a relatively less concentrated industry and small demand, the output of the North country may contract after opening up trade. The inefficiency in production can outweigh the gain due to competition and lower price in trade, resulting in a net loss in the global welfare. In some circumstances, voluntary technology transfer, managed trade through VERs or tariff can improve both trading partners" welfare.

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(First Draft)

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We examine the effects of intra-industry trade in the presence of imperfect competition and heterogeneous technologies. Contrary to the common belief that intra-industry trade always improves the world welfare due to reduction of market power, we show that even in the absence of transportation costs, it may generate a net global welfare loss. With technology heterogeneity across countries, the direction of production displacement in equilibrium when opening up trade, is critical to welfare changes domestically as well as globally. When a South country has a relatively less concentrated industry and small demand, the output of the North country may contract after opening up trade. The inefficiency in production can outweigh the gain due to competition and lower price in trade, resulting in a net loss in the global welfare. In some circumstances, voluntary technology transfer, managed trade through VERs or tariff can improve both trading partners' welfare.

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1 Introduction

The literature on intra-industry trade, as exemplified by the works of Brander (1981), Brander and Krugman (1982), Brander and Spencer (1984), Eaton and Grossman (1986), and Markusen (1980), has shed light on a number of important issues. We know, for example, rivalry of oligopolistic firms serves as independent cause of international trade. Intra-industry trade without transportation costs generally improves global welfare. When countries differ in size, trade will always increase total world welfare as well as the welfare of the smaller country, but the large country may experience a welfare loss (Markusen (1980)). With transportation costs, the welfare effects of intra-industry trade are ambiguous. On one hand, resources are wasted in cross-handling of goods; one the other hand, increased competition reduces monopoly distortions. Nonetheless, the existing literature generally assumes that trading partners have the same technologies, and focus on the competition effect on pricing and total output. An interesting question is whether the findings are still valid when countries have heterogeneous technologies. This paper is an effort to extend the existing literature on welfare effects of intra-industry trade by emphasizing the effects of technology heterogeity and equilibrium output distribution.

The first contribution of the paper is to show the limitation of a generally accepted principle in intra-industry trade literature: free intra-industry trade in the absence of transportation costs always increases total world welfare due to the reduction of domestic monopoly power. Trade indeed always reduces prices, increase the world output, and in turn world consumer's surplus. When both countries have the same constant-return-to-scale technology, the costs of producing the world autarky outputs remains the same in trade. Thus, the net world welfare change under trade, which is simply the world welfare gain due to the increase in total world output, is always positive. However, we will show that when two countries' technologies are heterogeneous, it is plausible that free intra-industry trade can reduce the world welfare. The key to our argument is the equilibrium output distribution in trade and the associated production inefficiency. *In particular, in a two country trade model, when the country with inferior technology (hereafer the South country) does not have much disadvantage and has a relatively large number of firms, the*

output of the country with superior technology (hereafter the North country) may contract after opening up trade. As a result, the costs of producing the world autarky outputs increase. We show that the loss in production efficiency due to the adverse displacement of output of the more efficient country by the less efficient country can dominate the gain of trade due to the reduction of market power. Intra-industry trade does not necessarily increase world welfare when countries are asymmetric in technology. In fact, under some circumstances, managed trade through VERs or tariff may improve the welfare of all trading partners.

Further, we show that the world welfare change in trade is a quasi U-shaped function of the South country's marginal cost. On one hand, when the South country is relatively inefficient (the foreign country's marginal cost is greater than a critical value), trade is harmful globally. On the other hand, trade with a less efficient country does not necessarily cause more global harm. In fact, the most harmful is the trade with a country with inefficient but not too inefficient technology. Such a country is not efficient enough to raise the average production efficiency of the world but competitive enough to take a significant amount of production away from the more efficient country. When a country is very inefficient, the welfare-reducing displacement effect in trade is small, since such a country is not competitive enough to cause a substantial reduction in the output of the more efficient country. An implication of this finding is that world welfare might suffer if the inefficient country improves its inferior technology.

Nonetheless, technology improvements in the South country can sometimes increase the global welfare. One practice of realizing technology improvement is teconology transfer. Two types of technology transfers are discussed in the literature (Mansfield (1975)): vertical, where technology is transferred from fundamental research to applied research, and horizontal, which includes all technology transfers between organizations at the same production stream. The latter has been studied in international trade context, particularly in North-South trades. For example, Krugman (1979)) discusses horizontal technology transfer using general equilibrium model, and concludes that the innovating North which exports new products and imports traditional products would carry out innovation continuously to maintain its relative position and real income. Jensen and Thursby (1987)

find that in the presence of technology transfer, the optimal rate of innovation under either North's profit maximizing firms which conduct R&D or North's social planner who is domestically benevolent, is less than globally optimal rate. The intuition of this result is straightforward since technology transfer decreases the welfare of the North and reduces the incentive to innovate. Intellectual property rights then plays a safeguard role against horizontal technology transfer in North South trade (Connolly and Valderrama (2005)).

However, our model offers a striking result, i.e., transfer may be also beneficial to the North country since incremental consumer's surplus can outweigh the profit reduction by North's firms. Therefore, under some conditions, the North has an incentive to transfer part of the technology to the South, even at zero cost to the South.

We also show that the direction of trade balance, or more precisely, the sign of the change in domestic output level after opening up free trade determines whether a country gains from trade. As long as the output of a country does not contract in trade, it gains from trade. It implies that at least one country will gain from free trade. When countries are symmetric, both countries gain from trade. *In this paper, in order to better illustrate the efficiency loss, it is assumed that both the market and number of firms in the South country are larger.* Contrary to the findings in Markusen (1980) which is based on a duopoly model, we show that the smaller country can lose relative to autarky if the large country is sufficiently competitive. In such case, the output of the smaller country contracts in trade, since the smaller country can not penetrate the bigger country's market but the large country is able to take away a significant share of the market in the smaller country. For the smaller country, the loss due to rent-shifting outweighs the gain in consumer surplus due to a lower price.

Even though our analysis is mainly based on linear demand, our results can be easily generalized to a more general demand structure. The curvature of demand function is important to the welfare effect of output composition. When demand is concave, the welfare effect of output composition is weaker relative to the linear demand case. When demand is convex, the opposite prevails. Regardless the curvature of the demand function, the output displacement effect always exists.

Our analysis is closely related to Bergstrom and Varian (1985a and 1985b), Long and

Soubeyran (1992), Salant and Shaffer (1999), and Yuan and Khan (2000). These papers also consider cases where competing firms produce at heterogeneous constant marginal costs. Bergstrom and Varian (1985a and 1985b) and Salant and Shaffer (1999) mainly focus on the implication of mean-preserving variation of marginal cost distribution, in which the vector of constant marginal costs is changed exogenously without altering the sum of its components. In such a setting, the industry output, price, revenue and gross consumer surplus will not change provided all firms continue to produce (Bergstrom and Varian (1985b)). Hence, the change in both industry profit and social welfare depends only on the change in aggregate production costs, which decrease with the variance of marginal costs (Bergstrom and Varian (1985a)). This implies that the aggregate production costs are maximized when firms are symmetric in marginal costs. Contrary to intuition, therefore, when every firm has the same marginal cost, industry profit and social welfare are smaller than when firms have different marginal costs with the same sum. Asymmetry has both social and private advantages. Based on these conclusions, Salant and Shaffer (1999) argue that government should pursue a policy of "unequal treatment of identical agents" to promote asymmetry in marginal costs in subsequent competition. Our paper contributes to the literature in the following ways. Yuan and Khan (2000) extend the analysis to the non-mean-preserving variation of marginal costs, to the case of governmental subsidy, and to the case of entry, generating many interesting findings. Second, by decomposing the overall welfare effect into three terms, namely, the price effect, the displacement effect and the direct effect, they substantially enhance the understanding of the impact of increasing competition when firms are asymmetric in marginal costs. This paper extends of the analysis to the intra-industry trade.

At the end of our model, in order to make our analysis more complete, we also carry out some research on the resource substitution under exdogenous tariff. In addition, we summarize the relationship between resource substitution and global welfare under different trade patterns including free trade and trade with optimal endogenous tariffs, and illustrate them in a Venn graph.

The paper is organized as follows: Section 2 presents the basic model and the welfare measures under cost asymmetry, Section 3 provides the welfare analysis of free intra-

industry trade of countries with heterogeneous technologies, *Section 4 analyses trade with endogenous tariff,* and Section 5 concludes the model.

2 A Cournot Model of Intra-industry Trade

Let there be two countries, denoted by subscripts $i = 1, 2$. In country 1, which without loss of generality, we shall also refer to as the South country, let there be n symmetric firms, each of which has constant marginal cost c_1. The demand in country 1 is $y_1 = a - bp_1$, where p_1 is the price charged in country 1. In country 2, which we shall also refer to as the North country, the demand is $y_2 = \gamma(a - bp_2)$, where $0 \leq \gamma$, and there are m symmetric firms, each of which has constant marginal cost c_2. γ measures the relative size of the foreign country: $\gamma = 0$ indicates that country 2 is an exporter of the good only; $\gamma = 1$ indicates that country 2 has the same size as country 1; $\gamma < 1$ indicates that the foreign country is the smaller country. Linear demand captures the essence of our model and is easy to work with, but the results are not dependent on the assumption of linearity. Firms compete under Cournot conjectures, and welfare is the simple sum of consumer surplus plus firm profits. We assume that the number of firms is exogenously fixed in order to focus on the effects of interest.

2.1 Autarky

Let us consider first as a benchmark the autarky, in which firms within one country engage in Cournot competition. The typical firm from country i will then choose its output to maximize its profits. Solving the first order conditions in the familar way, we can derive the equilibrium total output (x_i^A), price (p_i^A) and welfare (W_i^A) for the two countries. The welfare is the sum of firms' profit and consumer surplus. The superscript A represents equilibrium values in autarky.

For home country,

$$x_1^A = \frac{n}{n+1}(a - bc_1)$$

$$p_1^A = \frac{a + nbc_1}{b\,(n+1)}$$

$$W_1^A = \frac{n}{b}\left(\frac{a - bc_1}{n+1}\right)^2\left(1 + \frac{n}{2}\right) \tag{1}$$

For foreign country,

$$x_2^A = \frac{\gamma m}{m+1}\,(a - bc_2)$$

$$p_2^A = \frac{a + mbc_2}{b\,(m+1)}$$

$$W_2^A = \frac{\gamma m}{b}\left(\frac{a - bc_2}{m+1}\right)^2\left(1 + \frac{m}{2}\right) \tag{2}$$

2.2 Free Trade

We now assume that free trade is permitted between the two countries and that transportation costs are zero. We make this latter assumption in order to isolate the effects of output displacement in trade and also to contrast our results to those of Brander and Krugman (1983). The firms in each country will only operate if their costs are below the autarky price in the other country, so that $x_i^T > 0$ requires that $c_i \leq p_j^A$, for $i, j = 1, 2$. Under free trade, n firms from country 1 and m firms from country 2 engage in a standard Cournot competition in the market of each individual country. y_i^T, the demand of country i in trade, can be written as $y_i^T = n_i q_{ii} + n_j q_{ji}$, where q_{ii} and q_{ji} are the outputs sold in country i by representative firms from, respectively, country i and country j, and $j \neq i$.

Let q_i^i be the total output sold in country i by all the firms from country i, q_i^j be the total output sold in country i by all the firms from country j, and $y_i = q_i^i + q_i^j$. The typical firm in country i will then choose its output, q_{ii}, to maximize $\pi_{ii} = [p^T - c_i]q_{ii}$, its profit of sales in country i. The typical firm in country j will have analogous problem. Solving first order conditions, we have the equilibrium price, outputs, trade balance, welfare as follows.

For country 1,

$$p^T = \frac{a + bnc_1 + bmc_2}{b\left(m+n+1\right)}$$

$$q_1^1 = \frac{n}{m+n+1}\left(a - b\left(m+1\right)c_1 + bmc_2\right)$$

$$q_1^2 = \frac{m}{m+n+1}\left(a - b\left(n+1\right)c_2 + bnc_1\right)$$

$$x_1 = q_1^1 + q_2^1 = \left(1+\gamma\right)\frac{n}{m+n+1}\left(a - b\left(m+1\right)c_1 + bmc_2\right)$$

$$TB_1 = q_2^1 - q_1^2$$

$$\begin{aligned} W_1^T &= \pi_1^T + CS_1^T \\ &= \frac{1+\gamma}{b}n\left[\frac{a - b\left(m+1\right)c_1 + bmc_2}{m+n+1}\right]^2 + \frac{1}{2b}\left[\frac{\left(n+m\right)a - bnc_1 - bmc_2}{m+n+1}\right]^2 \end{aligned} \tag{3}$$

where x_1 is the total output of firms, π_1^T the total profit of frims, and CS_1^T the consumer surplus in country 1.

For country 2,

$$p^T = \frac{a + bnc_1 + bmc_2}{b\left(m+n+1\right)}$$

$$q_2^2 = \gamma\frac{m}{m+n+1}\left(a - b\left(n+1\right)c_2 + bnc_1\right)$$

$$q_2^1 = \gamma\frac{n}{m+n+1}\left(a - b\left(m+1\right)c_1 + bmc_2\right)$$

$$x_2 = \left(1+\gamma\right)\frac{m}{m+n+1}\left(a - b\left(n+1\right)c_2 + bnc_1\right)$$

$$TB_2 = -TB_1$$

$$\begin{aligned} W_2^T &= \pi_2^T + CS_2^T \\ &= \frac{1+\gamma}{b}m\left[\frac{a - b\left(n+1\right)c_2 + bnc_1}{m+n+1}\right]^2 + \frac{\gamma}{2b}\left[\frac{\left(m+n\right)a - bnc_1 - bmc_2}{m+n+1}\right]^2 \end{aligned} \tag{4}$$

where x_2 is the total output of firms, π_2^T the total profit of frims, and CS_2^T the consumer surplus in country 2.

World welfare is the sum of that of the individual countries: $W^T = W_1^T + W_2^T$.

In Figure 1, the area ABG represents the first term and CDFG the second term. Since $p_1^A > p_1^T$ and $\Delta y_1 > 0$, the first term of the above expression is always positive. The sign of the second term depends on that of the change in output of the home country, Δx_1. Home country gains from trade if its output does not decrease under trade.

From an efficient resource allocation standpoint, it can shown that under some conditions, free trade may result a deterioration of resouce allocation compared with autarky.

Proposition 2.1 (Resource Substitution Effect) *Free trade will result country with low marginal cost to shrink its production relative to the Autarky case, if*

$$\frac{a - bc_2}{c_1 - c_2} > \frac{bm\,(m+1)\,(1+\gamma)}{\gamma n - m - 1}. \tag{5}$$

Proposition 2.1 is a central result we obtain from this model. Basically, it implies that when the South country's technology is inefficient, but not too inefficient, she will be able to compete for some market shares in the North that results production displacement to the degree that the North will shrink his total production (by advanced technology).

3 Gains from Free Trade

In this section, we first examine the gain of the individual countries from trade, and then the global gain, which is simply the sum of gains of individual countries. We consider both single country welfare and global welfare, since both may be relevant in setting trade policy. If there is no mechanism for compensation between countries in trade which harm one party and benefit the other, then clearly the relevant test is whether both countries benefit from trade. However, if there is some compensating mechanism, then the effect on global welfare will be the more appropriate measure of whether trade is desirable.

3.1 Gains of An Individual Country

The welfare gain of the South country from trade, $\Delta W_1 = W_1^T - W_1^A$. It is easy to verify that ΔW_1 can be expressed in terms of the change in consumption Δy_1 (from autarky to trade) and the trade balance TB_1:

$$\Delta W_1 = \left(\frac{1}{2}\left(p_1^T + p_1^A\right) - c_1\right)\Delta y_1 + \left(p_1^T - c_1\right) TB_1 \tag{6}$$

where the first term represents the domestic welfare gain due to expand production and consumption from the autarky level to y_1^T, the second term the gain in profit from net export. This can be illustrated with the help of Figure 1. The area ABEF corresponds to the first term and the area BCDE corresponds to the second term. The net change of welfare is the sum of these two effects.The first term is always positive since consumption is always higher under trade (i. e. $\Delta y_1 > 0$). The second term is positive if trade balance of the South country is positive. Thus, the South country is better off under free trade if it has a positive trade balance.

Notice also that $TB_1 = \Delta x_1 - \Delta y_1$, where $\Delta x_1 = (x_1^T - x_1^A)$. Then,

$$\Delta W_1 = \frac{1}{2}\left(p_1^A - p_1^T\right)\Delta y_1 + \left(p_1^T - c_1\right)\Delta x_1 \tag{7}$$

In Figure 1, the area ABG represents the first term and CDFG the second term. Since $p_1^A > p_1^T$ and $\Delta y_1 > 0$, the first term of the above expression is always positive. The sign of the second term depends on that of the change in output of the South country, Δx_1. The South country gains from trade if its output does not decrease under trade.

Proposition 3.1 *The South country will gain from trade if its trade balance is non negative, or more strictly speaking, if its output does not contract under trade.*

Since the trade balance is non-negative for at least one country , and is in fact zero for both countries if they are symmetric, we have the following corollary:

Corollary 3.1 *At least one country will gain from trade; When two trading countries are symmetric, they both gain in trade.*

An easy test of whether a country loses in intra-industry trade is whether its output declines after opening up trade.

In order to help the exposition, we shall rearrange the welfare change of country 1 into the following two terms:

$$\Delta W_1 = D_1 + \gamma F_1 \tag{8}$$

where $D_1 = \Delta W_1|_{\gamma=0} = \frac{1}{2b}\frac{m(a+nbc_1-(n+1)bc_2)}{(n+1)^2(m+n+1)^2}[(2bmn^2 - 3bmn + bm)(c_1 - c_2) - (2n^2 + 2n - m)(a - bc_1)]$ and $F_1 = \frac{n(a+mbc_2-(m+1)bc_1)^2}{b(m+n+1)^2}$.

In Figure 1, D_1 is represented by the difference of the the area ABG, which is the part of the change in consumer surplus and is positive, and HGFI, which is the change in the profits of home firms from sales in the domestic market and is always negative due to rent shifting and lower prices. D_1 is the net home welfare change in the domestic market. γF_1 is total profit of the home country from sales to the foreign country, which is proportional to the foreign country's size. γF_1 corresponds to area CDIH in Figure 1. D_1 and F_1 are independent of γ, and ΔW_1 is linear in γ.

Proposition 3.2 *Gains of a country always increases with γ, the size of its trading partner.*

The implication of Proposition 2 is that, everything else remaining constant, a country always prefers to trade with a bigger country.

Next, we shall take a closer look at D_1 and F_1. Notice that D_1 is quadratic in c_2. Therefore it is easy to verify that, $D_1 = \Delta W_1|_{\gamma=0} < 0$ requires

$$c_2 > \frac{(m - 2n(n+1))a + bc_1 n(2mn + 2n + 3m + 2)}{bm(n+1)(2n+1)} = c_2^* \tag{9}$$

or

$$m < \frac{2n(n+1)(a - bc_1)}{a - bc_2 + bn(2n+3)(c_1 - c_2)} = m^* \text{ if } c_1 - c_2 > 0. \tag{10}$$

Country 1 has a net gain in the domestic market if the North's firms are efficient enough or the North has a sufficiently large number of firms. Otherwise country 1 incurs a net loss from trade.

Foreign competition[1] has two opposite effects on the domestic gains. First, foreign competition reduces domestic price and in turn increases consumer surplus. Second, foreign competition shifts profit away from domestic firms. The conditions above show that the rent-shifting effect dominates the consumer surplus effect when there are sufficiently small number of foreign firms or they are sufficiently inefficient.

However, the relationship between the domestic gains for the South and the efficiency of North's firms is not a simple one. Notice that D_1 is U-shaped in c_2, when $c_2^* < c_2 < p_1^A$,

[1]Here we treat the South country as home country.

$D_1 < 0$. D_1 decreases with c_2 initially, reaches minimum at $\frac{1}{2}(c_2^* + p_1^A)$, and then increases with c_2. Everything else remaining unchanged, the worst scenario for domestic gains is when the foreign firms are not too competitive. When the foreign firms are very inefficient (c_2 is closer to p_1^A), the rent-shifting effect is relatively weak. The domestic loss is then minimal.

Given that $c_2^* < c_2 < p_1^A$, $\Delta W_1 < 0$ if $\gamma < \gamma^*$,

where

$$\gamma^* = \frac{\left(\begin{array}{c} m(a + nbc_1 - (n+1)bc_2)[(2a + 2bmc_2 - 2b(m+1)c_1)n^2 \\ +(2a + 3bmc_2 - b(2+3m)c_1)n - m(a - bc_2)] \end{array} \right)}{2n(n+1)^2(a + mbc_2 - (m+1)bc_1)^2} \tag{11}$$

Proposition 3.3 *Given that $c_2^* < c_2 < p_1^A$, country 1 incurs a net loss in trade if its trading partner is small enough.*

This implies that the smaller country can be a net loser: $\gamma > 1$ and $c_1 = c_2 = c$. $\Delta W_1 = \frac{(a-bc)^2}{2b(n+1)^2(m+n+1)^2}[m^2 - 2nm(n+1) + 2\gamma n(n+1)^2] < 0$ if $\underline{m} < m < \overline{m}$ where $\underline{m} = (n+1)(n - \sqrt{n^2 - 2\gamma n})$ and $\overline{m} = (n+1)(n + \sqrt{n^2 - 2\gamma n})$.

Proposition 3.4 *A small country can be a net loser in trade. However, if $c_1 = c_2 = c$ and $m = n$, the smaller country always gains from trade.*

The findings above have some important implications. They provide an alternative explanation for an empirical puzzle noted by Helpman (1987) and analyzed more completely by Hummels and Levinsohn (1995). They observe that trade volume between any two countries is negatively correlated with the dispersion in size between the two countries. The theory advanced by Helpman to explain this correlation is that with differentiated products, costless transportation, and a consumer taste for variety, countries will be able to trade more when their market sizes are similar. Hummels and Levinsohn argue that this explanation fails since the correlation holds even for countries which seem ill-suited to the theory. They also note that much intra-industry trade appears to be specific to country pairs, a point which is not consistent with Helpman's explanation.

Our analysis provides an alternative explanation to this puzzle. Let us assume that the criteria for free intra-industry trade is that both trading countries benefit from it. We

know that two symmetric countries will always benefit from trade. With heterogeneity, one country is very likely to lose from free trade. Each country wishes to trade with larger countries and dislikes to trade with small countries. This implies that countries will find matches with other countries of similar size; and much of this trade will be specific to country pairs, as found by Hummels and Levinsohn.

Proposition 3.4 is an extention of a result obtained by Markusen (1981), who found, in a comparable framework, that if two countries each had a single firm producing a good, switching from autarky to free trade would lead to the smaller country exporting the good. From this, he was able to show that the smaller country always gains but the larger country might suffer a welfare loss from free intra-industry trade. His results is of course limited by his assumptions that $m = n = 1$ and $c_1 = c_2$. However, when countries differ in technologies, concentration and size, we show that the bigger country can be the net exporter and the smaller country can suffer a net welfare loss relative to autarky.

Proposition 3.5 has considerable practical importance. It implies that large countries may be less interested in joining free trade agreements than smaller countries. Even in a partial equilibrium setting, assuming that domestic firms have some lobbying power, concentrated industries in large countries may exert lobbying pressure on their government to limit trade with less concentrated industries in other countries. This problem is considerably mitigated when the other country is large, even if it is more concentrated. Of course, there is considerable variance in market size across countries. For example, in the American hemisphere, the United States has a market 10, 100 or even 1000 times as large as its trading partners. One solution to this problem is multilateral trade agreements, since then the large country can benefit from free trade not with a country smaller than it, but with a bloc of countries whose aggregate market may be larger than its own:

Corollary 3.2 *Holding the ratio γ/m constant, the welfare differential of the large country may increase the larger is γ.*

Corollary 3.2 suggests that multilateral trade agreements may be able to create trade which could never be accomplished on a bilateral basis. Table 6? shows the results of simulations of our model, with $a = 100$, $b = 1$, $c_1 = 15$, $c_2 = \alpha c_1$, $n = 10$, $m = 30\gamma$, γ

ranging from 0.1 to 1, and α ranging from 0.5 to 1.5. It shows the welfare ratio W_1^T/W_1^A. An interpretation of these parameters is that a large country with ten firms in an industry is contemplating opening up trade with a country 10% its size which has three firms. The welfare ratios from trade with this one country are provided in the first column, which shows that unless the large country has much lower costs of production than the small country, it will lose from trade. The second column provides the applicable welfare ratios if it opens up trade with two small countries, and so on. Evidently, the more small countries it trades with, the higher the welfare gains from trade for the large country, and in some cases the welfare losses from trade turn into welfare gains. We hypothesize that this effect is at least partly behind the multilateral trade agreements which are becoming increasingly important.

3.2 The Global Gain

How does switching from autarky to free trade change global welfare? Define the change in world welfare as $\Delta W = \Delta W_1 + \Delta W_2$. This may be rewritten in terms of the trade balances (TB_i) and the change in consumption (Δy_i) in each country as

$$\begin{aligned} \Delta W &= \left(\frac{1}{2}\left(p_1^T + p_1^A\right) - c_1\right)\Delta y_1 + TB_1\left(p_1^T - c_1\right) && (12) \\ &\quad + \left(\frac{1}{2}\left(p_2^T + p_2^A\right) - c_2\right)\Delta y_2 - TB_1\left(p_2^T - c_2\right) && (13) \end{aligned}$$

and rearranged in the form:

$$\Delta W = \left(\frac{1}{2}\left(p^T + p_1^A\right) - c_1\right)\Delta y_1 + \left(\frac{1}{2}\left(p^T + p_2^A\right) - c_2\right)\Delta y_2 + TB_1\left(c_2 - c_1\right) \qquad (14)$$

Proposition 3.5 *When two trading countries are symmetric in technology, trade generates a net global gain; When the output of the more efficient country does not contract, trade generates a net global gain; When the South country is a net exporter, more strictly speaking, the output of the North country contracts, trade might generates a net global loss.*

When two trading partners are symmetric in technology, size and concentration, each country increases its output by the same amount. Export cancells each other out. The

net gain for each country is the difference between the gross consumer surplus and the production cost of the additional consumption. When two trading partners are symmetric in technology, the global gains are the sum of gains in consumer surplus in both countries and the profits in producing the additional output. When the output of the more efficient country does not contract after trade, the production cost for aggregate autarky output does not increase, the increase in gross consumer surplus is greater than the production cost due to the increase in aggregate output. Thus, trade generates net global gain. When the output of the North country contracts, the world average production cost of the aggregate autarky output increases and thus the aggregate social welfare at the autarky consumption level decreases. When this effect dominates the gain due to increases output of the inefficient country, trade generates a net global loss. This scenario is likely to occur when the South country is small and relatively less concentrated. Trading with a small country with relatively more firms, a country will more likely give up a bigger share of its market and less likely to generate much export.

It is worthy to characterize the conditions under which trade reduces global welfare and to discuss plausibility of these conditions.

$$\Delta W = \Delta W|_{\gamma=0} + \gamma F \tag{15}$$

where $D = \Delta W|_{\gamma=0} = \frac{m(a+nbc_1-(n+1)bc_2)}{(m+n+1)}[\frac{a(2n+m+2)+bc_2m(n+1)-bc_1(nm+2m+2n+2)}{2b(n+1)^2(m+n+1)} - (c_2 - c_1)]$ and $F = \frac{n(a+mbc_2-(m+1)bc_1)}{(m+n+1)}[\frac{a(2n+m+2)+bc_1n(m+1)-bc_2(nm+2m+2n+2)}{2b(m+1)^2(m+n+1)} + (c_2 - c_1)]$. D is the total net gains in country 1, including gains in its consumer surplus, gains in profits of its firms from domestic sales, and gains in profits of foreign firms from sales in country 1. F is the counterpart of D for the country 2 standardized at $\gamma = 1$.

It can be shown that $D < 0$ requires

$$c_2 > \frac{(2n+m+2)a + bc_1[2(n+1)^2(m+n+1) - (nm+2m+2n+2)]}{2b(n+1)^3 + bm(n+1)(2n+1)} = c_2^{**}$$

Notice that D is U-shaped in c_2. When $c_2^{**} < c_2 < p_1^A$, $D < 0$. D decreases with c_2 initially, reaches minimum at $\frac{1}{2}(c_2^{**} + p_1^A)$, and then increases with c_2. In such cases, South firms take away a sufficiently large share of the North's market and the difference of the unit cost between the North and South firms is not negligible. Therefore, the displacement

cost is relatively large. When the South firms are very inefficient, the displacement effect is relatively weak, for weak foreign competition does not reduce domestic production by much. When the South firms are sufficiently efficient but still less efficient than the North firms, the displacement effect is also weak, for the difference of unit cost between domestic and foreign firms are small. The gain due to increased output is large. The effect of trade on world welfare may not be negative and can be small if it is. *Different from the conditions for $D_1 = \Delta W_1|_{\gamma=0} < 0$, the total net gain in country 1, given other things unchanged and $c_1 - c_2 > 0$, can always be positive, if there is even one foreign firm. This result indicates that the increase of the consumer surplus of country 1 can always be larger than the net loss of world firms' operating profits in country 1.*

We have shown above how trade's effect on global welfare depends on a number of parameters. As with the welfare effect on the large country alone, the effect of trade on global welfare may be described in terms of the trade balance and the change in output. While the output effect will always be welfare positive, the displacement effect may be welfare-negative, if production from a less-efficient, less concentrated country displaces production from a lower cost country, as Figure 1 suggests may be possible. This possibility is confirmed in the following proposition:

Proposition 3.6 *When $c_2^{**} < c_2 < p_1^A$ and $\gamma < \gamma^{**}$, where $\gamma^{**} = -\frac{D}{F}$, trade results in a net global losses.*

We show that free intra-industry trade may result a net global welfare loss even in the absence of transportation costs. Thus, when countries have heterogeneous technologies, managed trade might increase the world welfare. Furthermore, we know that the potential global loss is due to the displacement of production of the North country by that of the South country. Restriction on the export of the less efficient country can alleviate the adverse displacement effect and world welfare loss. In fact, Anis and Ross (1992), who, in a special case of our model, assume a small country with $\gamma = 0$, show that the imposition of an export tariff (or VER) by the small country can actually increase the welfare of both countries simultaneously if the market share of small country's firms is less than one half, but $n > m + 1$. These conditions, as they show, can only hold when $c_2 > c_1$. The

small country benefits because the tariff increases the effective price received, and the large country benefits from higher production and profits.

3.3 Technology Transfer

It is found in this model that when there is technology gap between the two trading partners, voluntary technology transfer, may occur of which increases global welfare. It is obvious that the South is always willing to receive free technology transfer[2]*. Then the North's interest to transfer some of the production technology is sufficient for technology transfer to occur. Formally, the pair of the condition is* $\frac{\partial W_2^T}{\partial c_1} < 0$*. Differentiating* (4)*, we obtain*

$$\frac{\partial W_2^T}{\partial c_1} = \frac{n\left\{2m[(a-bc_2)+nb(c_1-c_2)]+\gamma[m(a-bc_2)+2mnb(c_1-c_2)-n(a-bc_1)]\right\}}{(m+n+1)^2} \tag{16}$$

In Grossman and Lai (2004), market size is an important factor in determining the optimal national patent policy. They find that, under free trade, the incentives of protecting the property rights change as the market size of each country changes. We also discuss the range of the market size in which free technology transfer would occur.

By (16)*, simple algebraic manipulation yields*

$$\gamma > \frac{2m[(a-bc_2)+nb(c_1-c_2)]}{n(a-bc_1)-m(a-bc_2)-2mnb(c_1-c_2)} \tag{17}$$

Hence when $1 > \gamma > \frac{2m[(a-bc_2)+nb(c_1-c_2)]}{n(a-bc_1)-m(a-bc_2)-2mnb(c_1-c_2)}$*, free technology transfer will take place and both countries will benefit from this transfer. The implication of this condition is that when the market size of the North is large enough, lowerring the cost of the South firms will increase of the North consumer surplus which will outweigh the profit reduction of the Nouth's firms in both domestic and foreign markets.*

[2] *This intuition is straightforward since reducing the cost of South firms improves the consumer surplus of the South and South firms' competitiveness in both foreign and domestic markets.*

4 Trade with Endogenous Tariff

It is one of the central question in trade theory that whether optimal trade policy or managed trade can improve global welfare. Most papers treat it as a typical Prisoner's Dilemma. However, given the existence of Resource Substitution Effect (RSE) in this model, will endogenous trade policies still always harmful? This section makes an effort in answering such questions. Because of the limited scope of the paper, we only consider optimal tariffs.

The welfare functions of each country under trade with endogenously determined tariffs can be written as follows.

$$\begin{aligned} W_1^{TT} &= \frac{n}{b}\left\{\frac{(m+1)(a-bc_1)-m[a-(c_2+t_1)b]}{m+n+1}\right\}^2+\frac{\gamma n}{b}\left\{\frac{(m+1)[a-(c_1+t_2)]-m(a-c_1b)}{m+n+1}\right\}^2 \\ &\quad +\frac{1}{2b}\left\{\frac{m[a-(c_2+t_1)b]+n(a-c_1b)}{m+n+1}\right\}^2+\frac{m(n+1)[a-(c_2+t_1)b]-mn(a-c_1b)}{m+n+1}t_1 \end{aligned}$$

$$\begin{aligned} W_2^{TT} &= \frac{\gamma m}{b}\left\{\frac{(n+1)(a-bc_2)-n[a-(c_1+t_2)b]}{m+n+1}\right\}^2+\frac{m}{b}\left\{\frac{(n+1)[a-(c_2+t_1)]-n(a-c_2b)}{m+n+1}\right\}^2 \\ &\quad +\frac{\gamma}{2b}\left\{\frac{n[a-(c_1+t_2)b]+m(a-c_2b)}{m+n+1}\right\}^2+\gamma\cdot\frac{n(m+1)[a-(c_1+t_2)b]-mn(a-c_2b)}{m+n+1}t_2 \end{aligned}$$

In (**??**) and (**??**)*, the four parts on the RHS are: total profit from domestic market, total profit from market of trade partner, consumer surplus and tariff revenue respectively. By maximizing each individual countries' welfare, the optimal endogenous tariff can be obtained:*

$$t_1^* = \frac{(2n+1)(a-bc_2)+n(n-m)b(c_1-c_2)}{b(2n^2+4n+m+2)} \tag{18}$$

$$t_2^* = \frac{(2m+1)(a-bc_1)+m(m-n)b(c_2-c_1)}{b(2m^2+4m+n+2)} \tag{19}$$

Notice that optimal tariffs are neither simultaneous nor functions of relative market size γ. However technology efficiency levels and market concentration are important factors. We then are able to characterize the condition for Resource Substitution Effect under tariff trade.

Proposition 4.1 (Resource Substitution Effect under Tariff Trade) *Trade with endogenous tariff will result the North country to shrink its production relative to the Autarky case, if*

$$nb\left(1+\gamma\right)\left(c_1-c_2\right)+\left(\gamma bnt_2^*-b\left(1+n\right)t_1^*\right)<\frac{\left[\gamma n-\left(m+1\right)\right]\left(a-bc_2\right)}{m+1} \tag{20}$$

Compared with the conditon for RSE under free trade, i.e., equation (5) *, the exessive term in equation* (20) *is the second term on the LHS. The only difference, in the form* $\gamma bnt_2^* - b(1+n)t_1^*$ *reflects the effect of tariffs on the resource substitution. When it is positive, resource substitution, given othern thinges unchanged, will be less likely to happen; when negative, more likely. We are interested in whether* (20) *is a sufficient or necessary condition for* (5) *.*

However, it can be verified that condition (20) *is neither sufficient nor necessary for* (5) *.*

Now, we are able to summarize the findings in the following proposition.

Proposition 4.2 (1) Under free trade, global loss is a sufficient condition for resource substitution effect (RSE);

(2) Under optimal tariff trade, global loss is a sufficient condition for RSE;

(3) Both individual and global welfare under tariff trade is (weakly) greater than that under free trade.

It can be then concluded that with cross country technology asymmetry, although the introduction of tariff may not improve RSE, it helps to reduce global welfare loss. The following graph provides an illustrative presentation of the results.

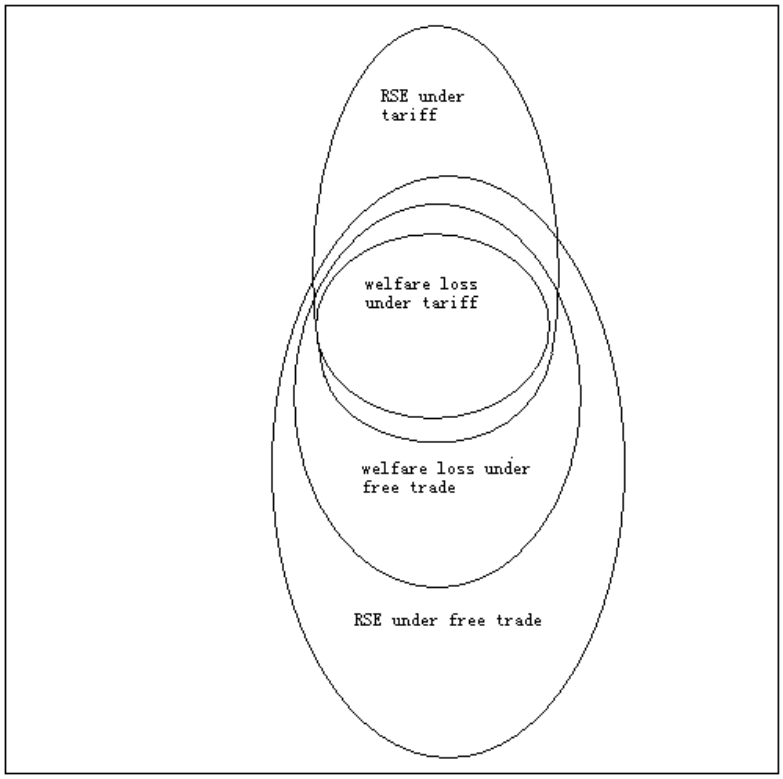

Figure 2. Global Welfare and Resource Substitution Effect

5 Conclusions

To the best of our knowledge, this paper is the first one that formally present the so-called "resource substitution" effect where intra-industry trade may displace productions by advanced technology to that by inferior technology. This challanges the conventional wisdom in international trade theory where trade is thought to be always promoting efficient allocation of resources. Although our model considers only one input and one homogeneous product, it can be straightforwardly extended to traditional two factor two output trade case where under some modest conditions, "comparative advantage" does not prevail.

This paper distinguishes itself from existing literature by putting emphasis on the occurance of trade *per se*, instead of derivation of optimal strategic trade policies upfront.

The U-shape relationship for individual country's trade gain against her trading partner's marginal cost of production can help to interpret many stylized facts such as the optimal amount of technology transfer and FDI flows.

The monotonic relationship between a country's gain from trade and her trading partner's market size, discovered in this paper, offers an alternative explanation for the empirical puzzle noted by Helpman (1987) where trade volume between any two countries is negatively correlated with the dispersion in size between the two countries.

The above listed findings may be quite useful in explaining many characteristics of current North-South trade including trade deficit incurred to the developed countries such as US-China trade deficit. Despite the fact of gigantic North-South trade deficit predicted by the current model, it may be ironically be the North's interest to form such trade because consumers gains outweigh the production shifting effect.

It may also explain that despite the increasing operation costs in less developed countries, there is still a strong incentive for the developed countries to invest and produce in LDCs. Further research using this approach to build theoretical foundation for the ownership based trade balance models appears convincing.

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