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Why Trade When You Can Transfer the Technology: Revisiting Smith and Ricardo

Abstract

This paper explores the possibility of international technology transfer in lieu of trade in a model with absolute and comparative advantage. Countries having absolute advantage in producing a good may offer that technology to a possible trading partner against a fee and both the countries might gain. Thus, gains from trade might be dominated by gains from technology transfer depending on the extent of comparative and absolute advantages. We provide detailed conditions under which free trade equilibrium will be pre-empted by technology transfer. Such an avenue of fruitful exchange remains unexplored in the Ricardian model of trade.

JEL-Codes: F100.

Keywords: technology transfer, absolute advantage, comparative advantage, Smith, Ricardo.

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1. Introduction

Ricardian model of comparative advantage is acknowledged as the fundamental building block for the theory of international trade. That absolute advantage may not lead to trade is also well known and is considered as a drawback of an earlier conjecture due to Adam Smith. The idea that countries having absolute advantage in all goods should choose to produce only a few is the core wisdom of the Ricardian model and hailed as a phenomenal contribution. Trade in Ricardian model is driven by differences in technology. Thus before countries engage in trade in goods the technologically superior nation can offer to transfer the technologies to the other country against a bargained price. To the other country such transfer is lucrative as it increases their real income and hence they will be in a position to offer a share of that increase to the transferring country and hence both will gain. But there would be no further scope for trade in goods as technological differences would vanish. Can we compare gains from technology transfer (GFTT) with conventional gains from trade (GFT) to assess which one is bigger? This is the question this paper proposes to answer.

International technology transfer has been a major area of research, primarily in the field of industrial organization, applied game theory and development economics and continues to thrive as an active area of academic engagement. One can refer to an early reader on the topic by Singh and Marjit (2003) and papers by Glass and Saggi (1998), Marjit (1988, 1991), Kabiraj and Marjit (1993, 2003), Mukherjee (Economic Theory), Sinha (2010), Saggi (2000), Mukherjee and Pennings (2004), Mukhopadhyay, Kabiraj and Mukherjee (1999), Hong, Marjit and Peng (2016), Kollias, Marjit and Michelacakis (2019).

The idea that even after free trade in goods is accomplished countries may end up with unused technologies which could be sold out to other countries, was explored in Beladi, Jones and Marjit (1997). But post-trade technology sale is a very different proposition from the pre-trade negotiations because as technology transfer eliminates the possibility of trade in a Ricardian structure, it will not have any terms of trade effects. If gains from technology transfer (GFTT) dominate gains from trade (GFT), trade will not take place and countries will gain more by transacting in technology. We are concerned with this initial choice. If technology could be traded, contrary to the Ricardian idea, will it be a preferred choice to trade in goods? Our answer is in the affirmative. As our arguments will reveal that there is a natural case where a large country would be reluctant to engage in trade and would be happy to transfer the technology against a price and allow the other country to produce and sell.

Technology could be offered for sale if a country has an absolute advantage in producing a good putting the idea of Adam Smith in use even if that might be irrelevant for determining comparative advantage. If the countries were not allowed to trade, the opportunity cost of the transferring nation will be zero. For the receiving nations it is just like technological progress and more advanced the technology i.e. smaller is unit labor coefficient to produce the goods, greater will be her gain in real income. Thus it is clear that the distance between countries in terms of initial technological endowment will determine the extent of maximum price that transfer can generate. However, the loss of not being able to trade will assign a critical role to the degree of comparative advantage as the opportunity lost in the process. Thus the condition which determines whether GFTT is greater than GFT, will comprise of both. This is reflected precisely in the technical condition we propose.

Another important aspect is relative country size. It is well known, but often discarded as an exception rather than a rule in a Ricardian model, that if a country is large enough relative to the other small sized nation, she cannot specialize because her demand for the other good could not be satisfied by the tiny production of the other country. In fact GFT will be zero for the large country as it has to trade at her autarkic relative price. This will be a clear case to go for technology transfer leading to a win-win situation for both. This is a clear case where GFTT will dominate GFT and is a significant example rather than a pathological case as in a conventional Ricardian model. Thus country size features prominently in the condition we derive.

The flavour of the result we derive is loaded heavily in favour of technology transfer. We show that there would always exist a set of free trade prices for which GFTT would dominate GFT and a payoff for technology could be worked out between the countries.

The rest of the paper is organized as follows. In Section 2 we set up the standard two-country Ricardian model with specific assumptions regarding cross-country technological asymmetry and ensuing absolute and comparative advantages there from. Section 3 specifies welfare of nations if they exchange goods (trade) and gains thereof. In section 4 we specify gains the countries will have if they agree to transfer technologies for a fee instead of exchanging goods at the given technological conditions. We provide precise algebraic conditions under which technology transfer will be mutually beneficial and will be preferred over exchange of (or trade in) goods. Finally, Section 5 concludes.

2. The Set up

Consider the standard textbook representation of the Ricardian model with two goods, 1 and 2, and two countries, H and F. Labour is the only factor of production which is homogeneous and mobile within each country but immobile internationally. Goods are produced under perfectly competitive conditions by country-specific production technologies captured through fixed labour-output ratios: a_{L1} and a_{L1} in the home country and a_{L1}^* and a_{L1}^* in the foreign country. It is straightforward to check that competitive prices that the producers everywhere charge are determined by the technology and the (country-specific) wage rate:

$$P_j = a_{Lj}W,\ P_j^* = a_{Lj}^*W^*,\ j = 1,2 \qquad (1)$$

Since mobility of labour within each country ensures the same wage rate being earned by labour in both sectors in each country, so the relative supply prices for good 1 in the two countries before trade is solely determined by the technology, or relative labour-output ratios:

$$p = \frac{a_{L1}}{a_{L2}},\ p^* = \frac{a_{L1}^*}{a_{L2}^*} \qquad (2)$$

Condition (2) essentially gives us a “flat” relative supply curve so that domestic demand in either country will have no role. The equilibrium autarchic prices will be the same as the supply prices in (2).

Suppose, the home country has inferior technology relative to the foreign country in both lines of production:

$$a_{Lj} > a_{Lj}^*,\ \forall\ j = 1,2 \qquad (3)$$

That is, it has absolute disadvantage in the language of Adam Smith in both goods. However, suppose its inferiority is least in good 1 so that it has a *comparative* (cost) advantage in good 1:

$$\frac{a_{L1}}{a_{L2}} < \frac{a_{L1}^{*}}{a_{L2}^{*}} \qquad (4)$$

Given these specifications, let us first consider pattern of production and levels of welfare for the two countries when they engage in commodity trade between them, and thereafter we will discuss the welfare implications if they had agreed to, if at all, technology transfer instead of trade.

3. Commodity Trade

According to David Ricardo (1817), despite being technologically backward in both lines of production as defined in (3), the home country can still engage in commodity trade if its inferiority is not uniform in the sense defined in (4). In (4), we assume that home country's technological inferiority is least in good 1 so that it has actually a comparative advantage in it. Conversely, foreign country's technological superiority being assumed to be the largest in good 2 establishes her comparative advantage in it. Accordingly, given (4), the home country will export good 1 and the foreign country good 2. Post trade, if the (world) relative price of good 1 settles strictly between the autarchic relative prices, $\frac{a_{L1}}{a_{L2}}$ and $\frac{a_{L1}^{*}}{a_{L2}^{*}}$, then both the countries will be completely specialized in their respective comparative advantage goods, and experience gains from trade. In general, if p_f denotes the post-trade world relative price of good 1, then it must be such that,

$$p_a = \frac{a_{L1}}{a_{L2}} \leq p_f \leq \frac{a_{L1}^{*}}{a_{L2}^{*}} = p_a^{*} \qquad (5)$$

Strict inequality implies complete specialization by "both", whereas equality on either side will imply one country is incompletely specialized.

Welfare levels in each country can be defined in terms of the expenditure functions and corresponding real incomes. Let, $e(p_a, U_a)$ denotes the minimum expenditure or real income (measured in terms of good 2) to attain the autarchic welfare at the autarchic relative price of good 1 in the home country; and $e(p_f, U_f)$ denotes the minimum expenditure or real income (measured in terms of good 2) to attain the post-trade welfare at the post-trade relative price of good 1 (or, the TOT) by the home country. The gains from trade (GFT) for the home country from the pattern of trade dictated by the assumed comparative advantage in (4) is given by

$$GFT = e(p_f, U_f) - e(p_a, U_a) \qquad (6)$$

Two comments are warranted at this point. First, if $p_f = p_a$, then post trade there will be no real income gain for the home country and hence no GFT. This is the case where the Home country is very large, measured in terms of the size of its workforce relative to that of the foreign country and other relevant conditions such as demand and technology. We will return to this later. Second, free trade welfare for the home country or its real income, $e(p_f, U_f)$, increases monotonically over the interval $\left(p_a, p_a^*\right]$. To see this, note that for all $p_f > p_a$, the home country produces only good 1. So, given L as the size of its workforce,

$$e(p_f, U_f) = p_f \frac{L}{a_{L1}} \qquad (7)$$

Thus, higher is the post-trade relative price of good 1, larger is the produced real income and hence welfare of the home country. Therefore, the GFT for the home country, hereafter H, defined in (6) is positive and monotonically increasing over the interval $\left(p_a, p_a^*\right]$.

Further note that, pre-trade, the (real) value of production or produced real income of H is the same along its production possibility frontier,

$$L = a_{L1} X_1 + a_{L2} X_2$$

regardless of combinations of good 1 and good 2 produced, and must be equal to the value if it had produced only good 1. That is,

$$e(p_a, U_a) = p_a \frac{L}{a_{L1}} \qquad (8)$$

Thus, the GFT for H in (6) can be rewritten as,

$$GFT = \left(p_f - p_a\right)\frac{L}{a_{L1}} \qquad \text{(6a)}$$

By similar logic, free trade welfare for the foreign country, hereafter F, or its post-trade real income $e(p_f, U_f^*)$, *decreases* monotonically over the interval $\left(p_a, p_a^*\right]$:

$$GFT^* = e(p_f, U_f^*) - e(p_a^*, U_a^*) \qquad \text{(9)}$$

Given that for all post-trade relative price of good 1 strictly less than $p_a^* = \frac{a_{L1}^*}{a_{L2}^*}$, F produces only good 2, (9) boils down to,

$$GFT^* = \left[\frac{1}{p_f} - \frac{1}{p_a^*}\right]\frac{L^*}{a_{L2}^*} \qquad \text{(9a)}$$

where, L^* is the size of the workforce in F.

We can now focus on the equilibrium post-trade relative price of good 1, size of the countries and the pattern of post-trade specialization. To keep things simple, let $d^w(p_f)$ denote the world relative demand for good 1 that varies inversely with the post-trade relative price. Now, p_f^e will be the post trade Walrasian equilibrium price if, $d^w(p_f^e) = \frac{X_1^W}{X_2^W}$.

If countries are completely specialized in their respective comparative advantage goods, for prices within the range of autarchic prices, then the world relative supply equals,

$$\frac{X_1^W}{X_2^W} = \frac{L}{L^*}\frac{a_{L2}^*}{a_{L1}} \qquad \text{(10)}$$

Hence, by the Walrasian equilibrium condition stated above,

$$d^w(p_f^e) = \frac{L}{L^*}\frac{a_{L2}^*}{a_{L1}} \qquad \text{(11)}$$

The following Lemma 1 brings out the role of relative country sizes:

Lemma 1: Post-trade equilibrium relative price varies inversely with the relative size of H.

Proof: Since by the law of demand, d^W is larger the smaller is p_f^e, so from (11) it follows that $\frac{\partial p_f^e}{\partial l} < 0$, where $l = \frac{L}{L^*}$. □

Given the condition for complete specialization as stated in (5), Lemma 1 then suggests that H produces both goods beyond a very large relative size of it, whereas F produces both the goods when H is critically small (or conversely, beyond a very large relative size of F). Otherwise, both produce one good each. In particular, countries are completely specialized for the following range of relative size of H:

$$\frac{a_{L1}}{a_{L2}} < d^{-1}\left(\frac{L}{L^*}\frac{a_{L2}^*}{a_{L1}}\right) < \frac{a_{L1}^*}{a_{L2}^*} \tag{12}$$

Example: If aggregate utility function is given by $U = D_1^{\alpha} D_2^{\beta}$, then, as shown in the appendix, (12) boils down to,

$$\frac{\alpha}{\beta}\frac{a_{L1}}{a_{L1}^*} < \frac{L}{L^*} < \frac{\alpha}{\beta}\frac{a_{L2}}{a_{L2}^*} \tag{13}$$

Thus, given the technologies, the demand parameters also influence the critical sizes of the countries for complete specialization.

4. Technology Transfer

Now consider the technology transfer as an alternative to free trade. By the assumption in (3), suppose F transfers technologies of both goods to H at a fee V. If H accepts then there will be no trade since relative price in both countries will be the same. Let p_T denote the post technology transfer relative price of good 1 and by construction,

$$p_T = \frac{a_{L1}^*}{a_{L2}^*} \tag{14}$$

We study unilateral incentives for such a transfer for both countries, and the aggregate welfare. Of course, if the aggregate welfare under technology transfer is higher than the aggregate welfare when the countries trade with each other, then there will exist a fee V for which technology transfer will be mutually beneficial and will be agreed upon. Alternatively, if there exists a mutually beneficial and agreed upon fee V, then aggregate welfare will be higher under technology transfer than under free trade between them. We examine whether such a V exists for all possible equilibrium prices under free trade. Note that GFT, which varies asymmetrically for the two countries over the interval $\left[p_a, p_a^*\right]$, is the reservation utility for both the countries while deciding about the technology transfer at a fee V.

First consider the incentives for F. Since after the transfer of technology for both goods there will be no trade opportunity, so F gets the autarchic utility and thus loses without the fee V for all $p_f < p_a^* = \frac{a_{L1}^*}{a_{L2}^*}$. The transfer fee V brings about higher real income and welfare level than the autarchic level and must be high enough to compensate her for the loss of GFT. In particular, F will transfer the technology if the fee V is such that:

$$V \geq e(p_f, U_f^*) - e(p_T, U_a^*) \qquad (15)$$

Strict equality defines the minimum V that F will charge as,

$$V_{\min} = e(p_f, U_f^*) - e(p_T, U_a^*) \qquad (16)$$

On the other hand, H will be willing to pay **if and only if** her gross welfare from receiving the technology is larger than what she would get by trading (with her backward technology but CA):

$$e(p_T, U_T) > e(p_f, U_f)$$

Thus, H will pay a fee which does not exceed the gross gains from technology transfer (if at all):

$$V \leq e(p_T, U_T) - e(p_f, U_f) \qquad (17)$$

Strict equality in (6) defines the maximum V that H will be willing to pay:

$$V_{\max} = e(p_T, U_T) - e(p_f, U_f) \qquad (18)$$

Now, for any given p_f, if $V_{max} > V_{min}$ then there exists a license fee $V \in \left[V_{\min}, V_{\max}\right]$ for which both will agree upon the technology transfer. That is, technology transfer is mutually beneficial implying that the aggregate welfare must be higher under technology transfer relative to free trade. Hence,

Lemma 2: If $V_{max} > V_{min}$, aggregate welfare under technology transfer is higher than that under free trade.

Proof: Subtracting (16) from (18) we obtain,

$$\begin{aligned} V_{\max} - V_{\min} &= \left[e(p_T, U_T) - e(p_f, U_f)\right] - \left[e(p_f, U_f^*) - e(p_T, U_a^*)\right] \\ &= \left[e(p_T, U_T) + e(p_T, U_a^*)\right] - \left[e(p_f, U_f) + e(p_f, U_f^*)\right] \\ &= y_T^W - y_f^W \end{aligned}$$

where, y_h^W denotes aggregate real income or welfare under regime *h* = {*T* (technology transfer), *f* (free trade)}. □

Note that Lemma 2 also implies that the countries together will gain more under technology transfer than under free trade between them: $GFTT^W > GFT^W$. Does a license fee $V \in [V_{\min}, V_{\max}]$ exist for all $p_f \in [p_a, p_a^*]$? To find an answer, the following Lemma will be helpful:

Lemma 3:

(a) Both V_{max} and V_{min} decrease monotonically over the interval $(p_a, p_a^*]$.

(b) $V_{min} = 0$ for $p_f = p_a^*$

(c) $V_{max} > 0$ for $p_f = p_a^*$

(d) $V_{max} > 0$ and $V_{min} > 0$ for $p_f = p_a$.

Proof:

(a) Given (16) and (18), this follows from the result discussed in the earlier section that the free trade welfare for H, or its real income, $e(p_f, U_f)$, increases monotonically and the free trade welfare for F, or its real income, $e(p_f, U_f^*)$, decreases monotonically over the interval $(p_a, p_a^*]$.

(b) GFT for F is zero for $p_f = p_a^*$, so any positive license fee will raise welfare of F over free trade (or autarchy).

(c) When $p_f = p_a^*$, H produces only good 1 and so $e(p_a^*, U_f) = p_a^* \dfrac{L}{a_{L1}}$. Under technology transfer, the PPF of H rotates as well as shifts up. Its slope equals p_a^* and along the new PPF the aggregate value of production or real income is the same regardless of combinations of good 1 and good 2 produced by H, and must be equal to the value if it had produced only good 1: $p_a^* \frac{L}{a_{L1}^*}$. Hence, by

(3), $e(p_T, U_T) = p_a^* \frac{L}{a_{L1}^*} > e(p_a^*, U_f)$. That is, $V_{max} > 0$ for $p_f = p_a^*$

(d) Follows from (a) given the results in (b) and (c).

This completes the proof. □

Lemma 3 has several implications. First, it indicates that $e(p_T, U_T) > e(p_f, U_f)\ \forall\ p_f$. That is, there will always exist a positive fee V for which H will agree to receive the technologies from F instead of trading with F according to her comparative advantage. Second, given Lemma 1, larger is the size of F relative H, greater is her incentive for technology transfer because her GFT will be smaller. This follows from part (a) of Lemma 3. Third, even though it's own incentive for technology transfer is small when its size relative to that of H is small (so that p_f is small), it can extract a larger surplus from H by charging a higher fee.

From Lemma 3, it also appears that if $V_{max} > V_{min}$ for $p_f = p_a$, then technology transfer will be mutually agreed upon for a fee $V \in [V_{\min}, V_{\max}]$ for all $p_f \in [p_a, p_a^*]$. To check this, note that,

$$V_{\max}(p_a) = e(p_T, U_T) - e(p_a, U_f) = e(p_T, U_T) - e(p_a, U_a) \qquad (19)$$

For $p_f = p_a$, even though H is incompletely specialized when she trades, the produced real income for her must be $p_a \frac{L}{a_{L1}} = \frac{L}{a_{L2}}$. Note that, along the PPF, the value of production must be the same regardless of the combinations of the two goods are produced, and thus value of consumption is constrained accordingly for $p_f = p_a$. Hence, $e(p_a, U_f) = \frac{L}{a_{L2}}$. On the other hand, as specified above, under technology transfer, $e(p_T, U_T) = p_a^* \frac{L}{a_{L1}^*} = \frac{L}{a_{L2}^*}$.

Using these expressions (19) can be rewritten as,

$$V_{\max}(p_a) = \frac{L}{a_{L2}^*} - \frac{L}{a_{L2}} \qquad (19a)$$

For $p_f = p_a$, the F country produces only good 2, and so $e(p_a, U_f^*) = \frac{1}{p_a}\frac{L^*}{a_{L2}^*} = \frac{a_{L2}}{a_{L1}}\frac{L^*}{a_{L2}^*}$. On the other hand, for similar logic as the above, the real income (and expenditure) for F under technology transfer (without the fee V) can be written as: $e(p_T, U_T^*) = \frac{1}{p_a^*}\frac{L^*}{a_{L2}^*} = \frac{L^*}{a_{L1}^*}$. Hence,

$$V_{\min}(p_a) = e(p_a, U_f^*) - e(p_T, U_T^*) = \frac{a_{L2}}{a_{L1}}\frac{L^*}{a_{L2}^*} - \frac{L^*}{a_{L1}^*} \qquad (20)$$

Hence, $V_{\max}(p_a) > V_{\min}(p_a)$ if

$$\frac{L}{L^*} > \frac{\left[\frac{a_{L2}}{a_{L1}} - \frac{a_{L2}^*}{a_{L1}^*}\right]}{(a_{L2} - a_{L2}^*)}\frac{a_{L2}^*}{a_{L1}^*}a_{L2} \qquad (21)$$

Under condition (21), $GFTT^W > GFT^W$ for all p_f (which is the case illustrated in panel (b) in the figure below). Note that, given (a) – (c), we can have two cases as illustrated in the following Figure:

(i) When condition (21) does not hold, $V_{\min} < V_{\max}$ only for $p_f \in (\tilde{p}_f, p_a^*)$ where $\tilde{p}_f \ni V_{\min}(\tilde{p}_f) = V_{\max}(\tilde{p}_f)$

(ii) Under condition (21), $V_{\min} < V_{\max}$ for all p_f

In Case (i), technology transfer raises aggregate welfare only for subset of free trade prices, whereas in Case (ii) technology transfer unambiguously raises aggregate welfare.

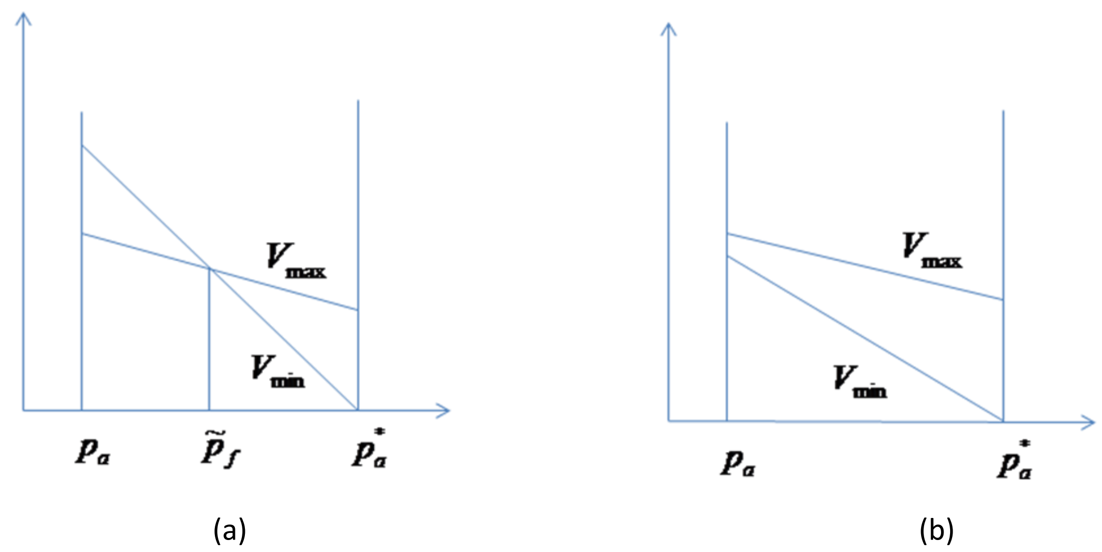

Figure 1: Mutually Beneficial Transfer Fee

Few comments are warranted at this point. First, if the technologically backward H does not have any comparative advantage, then this condition will always be satisfied. Note that in this case no trade will take place, and it is trivial that technology transfer is better. Second, more pronounced is the comparative advantage of technologically backward H, as captured by the larger difference in $\frac{a_{L2}}{a_{L1}} - \frac{a_{L2}^*}{a_{L1}^*}$, more stringent condition (21) will be. This is obvious because a more pronounced comparative advantage for H increases its incentives for exchanging goods instead of receiving the better technologies from F at a fee V. Third, if H is equally efficient in good 2 as F, i.e., $a_{L2} = a_{L2}^*$, condition (21) can never be satisfied. In fact, here by (19), $V_{\max}(p_a) = 0$. For $p_f = p_a$, H does not gain anything from trade. So, she gains trivially from technology transfer, which is larger the more disadvantageous she is in good 2. Technological inferiority in good 2 matters now as the inferiority and resultant comparative advantage is inconsequential in this extreme and incomplete specialization case.[1] Conversely, smaller is technological inferiority of H, smaller will be its gain from technology transfer (over autarky) and thus smaller will be $V_{\max}(p_a)$ that it will be willing to pay.

Fourth, condition (21) has to be compatible with the complete specialization condition (12) for $GFTT^W > GFT^W$ for all $p_f \in \left(\tilde{p}_f, p_a^*\right]$. As shown in the appendix, for the Cobb-Douglas utility function, this will be the case if,

$$\bar{l} < l_1 \Rightarrow \frac{a_{L2}}{a_{L1}} - \frac{a_{L2}^*}{a_{L1}^*} < \frac{\alpha}{\beta} \frac{a_{L1}^*}{(a_{L2}^*)^2}(a_{L2} - a_{L2}^*) \qquad (22)$$

where, $l_1 \equiv \frac{\alpha}{\beta}\frac{a_{L2}}{a_{L2}^*}$ is the largest relative size of the home country that can support completely specialization equilibrium, and $\bar{l}$ is the critical relative size of H, as given in condition (21), for which $V_{\max}(p_a) > V_{\min}(p_a)$. Note that, if this condition holds then $V_{\max}(p_a) > V_{\min}(p_a)$ for all $l \in \left(\bar{l}, l_1\right)$, and thus both countries gain under technology transfer than under free trade for all prices for which they are completely specialized. But if condition (22) does not hold, then we cannot ensure that countries will gain from

[1] Also note that, if H has an inferior technology in good 1, then the pattern of trade will be reversed than the one on the basis of which we have defined $V_{\max}$ and $V_{\min}$.

technology transfer for all prices that support complete specialization by both countries. This is illustrated in Figure 2 below. Again, roles of both comparative advantage and absolute advantages are evident.

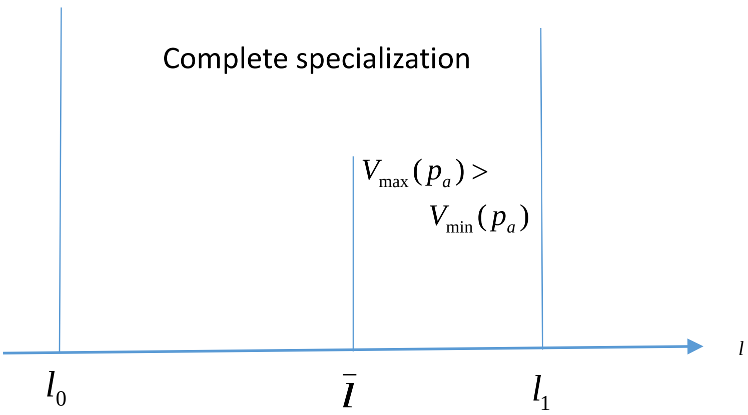

Figure 2: Relative Size of H, Complete Specialization and GFTT

Importance of relative sizes of countries can further be explained in terms of per capita gains. From the definitions and equilibrium values, it is straightforward to check that per capita gross gain from technology receipt for H is $\frac{V_{\max}}{L} = \frac{1}{a_{L2}^*} - p_f \frac{1}{a_{L1}}$, which, by Lemma 1, increases positively with the size of its workforce. So a larger sized technologically backward country will have greater incentive to receive better technologies at a fee from a technologically advanced potential trade partner than a smaller sized technologically backward country. On the other hand, by Lemma 1, the per capita income losses to be compensated through a fee for the technologically advanced F, $\frac{V_{\min}}{L^*} = \frac{1}{p_f} \frac{1}{a_{L2}^*} - \frac{1}{a_{L1}^*}$, will be smaller the larger is its workforce. It is in this sense that a larger sized technologically advanced country will have a larger incentive for technology transfer instead of trading compared to a smaller technologically advanced country. However, its final gain depends on the capacity of the recipient country to pay the fee. Suppose, given the conditions (21) and (22), the fee mutually agreed upon is $\alpha V_{\max} > V_{\min}$, $0 < \alpha < 1$. Then the per capita gain for F, $\frac{\alpha V_{\max}}{L^*} = \frac{L}{L^*}\left[\frac{1}{a_{L2}^*} - p_f \frac{1}{a_{L1}}\right]$, will be smaller the larger will be its workforce, or more precisely, smaller is the relative size of its potential trade partner H. It is in this sense there will be an asymmetric incentive for technology transfer for the larger sized transferor and transferee countries (F and H respectively here).

5. Conclusion

This paper argues that if technology instead of goods could be exported in a standard Ricardian model, technology could be more profitable to export rather than goods under very reasonable conditions. Feasibility of such an exchange would depend on both comparative and absolute advantage. In fact technology trade will be preferred to goods trade under very general conditions. Smith's conjecture of absolute advantage necessarily leading to trade may be misleading, but it is quite relevant when we bring in trade in technology. A weak link in the standard Ricardian model of trade is that it cannot guarantee that a large sized country will gain from trade with a small economy as it cannot specialize. GFTT is naturally greater for the large country than GFT in this case.

The above discussion is placed in the classical tradition of Smith versus Ricardo: Even with a country having all round inferiority but comparative advantage in something, trade may not take place. That is, even with Ricardian CA, we are back to the Smithian world where countries will not trade and prefer to transfer technologies. This result, however, takes us to a larger context of one set of nations (typically the North) specializing in innovation and the other set of countries (typically the South) in production of such innovations under patent protection and licensing. Thus comparative advantage in technology creation will translate into the world getting divided into two hubs, one creating and transferring the technology and the other using it in a production hub.

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Appendix

Let, the aggregate utility function of all consumers taken together be,

$$U = D_1^{\alpha} D_2^{\beta} \qquad \text{(A.1)}$$

Maximizing U s.t. the (world) budget constraint $p_f X_1 + X_2 = p_f C_1 + C_2$ yields the world relative demand function as,

$$d^W \equiv \frac{D_1}{D_2} = \frac{\alpha}{\beta}\frac{1}{p_f} \tag{A.2}$$

Using the relative supply function in (10) in the text, the Walrasian equilibrium world relative price is given by,

$$\frac{X_1^W}{X_2^W} = d^W \Rightarrow \frac{L}{L^*}\frac{a_{L2}^*}{a_{L1}} = \frac{\alpha}{\beta}\frac{1}{p_f^e} \tag{A.3}$$

$$\Rightarrow p_f^e = \frac{L^*}{L}\frac{\beta}{\alpha}\frac{a_{L1}}{a_{L2}^*} \tag{A.4}$$

As specified in (5) in the text, the above complete specialization equilibrium will hold only if

$$p_a = \frac{a_{L1}}{a_{L2}} < p_f^e < \frac{a_{L1}^*}{a_{L2}^*} = p_a^*$$

Using (A.4), this condition boils down to (13) in the text:

$$\frac{\alpha}{\beta}\frac{a_{L1}}{a_{L1}^*} < \frac{L}{L^*} < \frac{\alpha}{\beta}\frac{a_{L2}}{a_{L2}^*}$$

Define $l_0 \equiv \frac{\alpha}{\beta}\frac{a_{L1}}{a_{L1}^*}$ and $l_1 \equiv \frac{\alpha}{\beta}\frac{a_{L2}}{a_{L2}^*}$ as the critical relative sizes of H for countries to be completely specialized, and $\bar{l} \equiv \frac{\left[\frac{a_{L2}}{a_{L1}} - \frac{a_{L2}^*}{a_{L1}^*}\right]}{(a_{L2} - a_{L2}^*)}\frac{a_{L2}^*}{a_{L1}^*}a_{L2}$ as the critical relative size of H for which $V_{\max}(p_a) > V_{\min}(p_a)$ by condition (21). Hence, condition (21) will be compatible with the condition for complete specialization only if $\bar{l} < l_1$. Now, by definitions,

$$\bar{l} - l_1 = \frac{\left[\frac{a_{L2}}{a_{L1}} - \frac{a_{L2}^*}{a_{L1}^*}\right]}{(a_{L2} - a_{L2}^*)}\frac{a_{L2}^*}{a_{L1}^*}a_{L2} - \frac{\alpha}{\beta}\frac{a_{L2}}{a_{L2}^*}$$

$$\Rightarrow \bar{l} < l_1 \;\; if \;\; \frac{a_{L2}}{a_{L1}} - \frac{a_{L2}^*}{a_{L1}^*} < \frac{\alpha}{\beta}\frac{a_{L1}^*}{(a_{L2}^*)^2}(a_{L2} - a_{L2}^*) .$$