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ABSTRACT

A three country two commodity Ricardian made model is developed in a game–theoretic setting where the technologically superior nation transfers better technology to the technologically backward nations. We try to rationalize why one of the receiving countries will actually like to incur a real income loss through the transfer and how self–immiserization turns out to be a strategic choice. We discuss an alternative subgame perfect equilibrium when the receiving country can decide not to use the technology in the post–transfer situation. However, it turns out that the country concerned will actually try to precommit to a strategy which implies self–immiserization in the resultant equilibrium. This paper attempts to show why results similar to 'Transfer Paradox' as developed in international trade theory, can be conscious equilibrium outcomes in a strategic framework.

Introduction

In recent years a considerable amount of work has been devoted to analyzing the notion of "Transfer Paradox" in international trade theory. Although many scholars have written at length on this topic, we would like to point out to a representative bundle comprising of Samuelson (1971), Jones (1975, 1984), Yano (1983). Bhagwati, Brecher and Hatta (1983), etc. Many of these authors deal with the possibility that following a transfer, the donor might gain and the receiver might loose in a multi–agent setting. Such donor–enriching and receiver–impoverishing transfer, even though a possibility, begs a very fundamental question. If this is so, why should the recipient be interested in such a 'damnifying' (to quote Edgeworth) transfer? In other words, why does the receiver choose to accept such a possibility?

The purpose of this paper is to discuss a situation where an agent will choose to be recipient as an optimal strategy. In that event, that agent might actually incur a real income loss but still that can be an optimal decision on his part. The basic logic of the arguments is quite straight forward. Suppose there are three countries involved in the deal, A, B, and C. A is the typical donor. Also, suppose that A can make a transfer either to B or to C but not to both. If A gains more by transferring to B than to C, he will transfer to B. But B has a choice to refuse such a transfer because it might reduce his real income. Now if B does not accept A's offer, A goes to C. C might gain and, hence, will agree to A's proposal. Suppose that also reduces B's real income. B will now compare his loss from a transfer received from A and a loss incurred through the transfer A makes to C. If the former is lower, B will opt to receive the transfer from A. Given that B is willing, A will transfer to B and a situation will emerge where a gains, B and C both loose. But the resultant immiserization suffered by B is an outcome of optimal strategic choice.

To prove what we discussed in the foregoing section, we use a simple three country Ricardian trade model and consider the transfer of technology from the advanced to the backward countries. Transfer of know–how changes the terms of trade in the general equilibrium of the system and then under certain conditions, forces the receiving country to adopt self–immiserization on a strategic choice.

We have three countries A, B and C. A exports commodity X to B and C. B and C export commodity Y to A. X and Y are produced using only labor and fixed coefficient technology. Markets are competitive and resources are fully employed. We assume that although A has a comparative advantage in X, it has absolute advantage in producing both goods vis–a–vis B and C. Therefore, in free–trade, even if A is not producing Y, it can transfer the knowledge or the blue–print embedded in the technological coefficient to B or C. We shall assume that such a transfer, if it takes place at all, is once and for all.

The following symbols will be useful for the formal presentation of the model.

L_i – labor force in the with country i = A, B, C

a_y – labor output ratio for y in A.

b_y – labor output ratio for y in B.

c_y – labor output ratio for y in C.

Also note that by assumption $a_y < b_y$, $a_y < c_y$.

P_k – price of commodity k, k = x, y

σ_D – elasticity of substitution in demand.

y_j – production of y in country j, j = B, C.

w_i – wage–rate in country i, i = A, B, C.

Full employment conditions imply,

$$y_B = \frac{L_B}{b_y} \tag{1}$$

$$y_C = \frac{L_C}{c_y} \tag{2}$$

Competitive equilibrium conditions are given by

$$P_y = w_B b_y \tag{3}$$

$$P_y = w_c c_y \tag{4}$$

$$\frac{y_B + y_C}{x} = f(P_y/P_x) \tag{5}$$

[Assuming identical homothetic demand function for each country.] $f(\cdot)$ is the relative demand function for two goods with $f' < 0$. Note that we have deliberately ignored full employment condition for L_A or the competitive condition for X industry just because they are left untouched in the following comparative static analysis.

Now consider the following exercise. Suppose A gives his knowledge embedded in a_y to B, then following general equilibrium results can be worked out.

$$\lambda_B\, \hat{y}_B = -\sigma_D(\hat{P}_y - \hat{P}_x) \text{ (where '$\hat{}$' denotes \% change)} \tag{6}$$

$\lambda_B \equiv \dfrac{y_B}{y_B+y_C}$. (Similarly $\lambda_C \equiv \dfrac{y_C}{y_B+y_C}$) from (1), $\hat{y}_B = -\hat{b}y = \alpha_B$. Therefore, from (6),

$$\hat{P}_y - \hat{P}_x = -\frac{\alpha_B \lambda_B}{\sigma_D} \tag{7}$$

Since we have identical homothetic demand function for each country, one can construct the same price index for each country for real income evaluation.

Let

$$\hat{\pi} = \gamma_x \hat{P}_x + \gamma_y \hat{P}_y \tag{8}$$

denote change in such an index where γ_x, γ_y are shares of expenditure on x and y for each country.

Therefore, the change in real income for the transferor is given by,

$$\hat{\omega}_A - \hat{\pi} = \hat{P}_x - \hat{\pi} = -\gamma_y(\hat{P}_y - \hat{P}_x) \tag{9}$$

$$\text{from (7).} \quad \hat{\omega}_A - \hat{\pi} = \gamma_y \frac{\alpha_B \lambda_B}{\sigma_D}. \tag{10}$$

The following proposition is immediate.

Proposition I: <u>If country A has an once and for all choice to transfer a_y to either B or C, it will prefer to transfer it to B, rather than to C provided $\alpha_B \lambda_B > \alpha_C \lambda_C$.</u>

<u>Proof</u>. The benefit of transferring a_y to B is given by $\frac{\alpha_B \lambda_B \gamma_B}{\sigma_D}$ and for the same reason the real income benefit earned by giving it to C is $\frac{\alpha_C \lambda_C \gamma_C}{\sigma_D}$. <u>QED</u>.

Real income change of country C following a transfer to C is given by,

$$\hat{W}_C - \hat{\pi} = \hat{P}_y + \alpha_C - \hat{\pi} = \alpha_C + \gamma_X (\hat{P}_y - \hat{P}_x)$$

$$= \alpha_C - \gamma_x \frac{\alpha_C \lambda_C}{\sigma_D} \tag{11}$$

$$= \alpha_C \left(\frac{\sigma_D - \gamma_x \lambda_C}{\sigma_D}\right)$$

<u>Proposition 2. C will accept a transfer from A if $\sigma_D > \gamma_x \lambda_C$.</u>

<u>Proof</u>. Directly follows from (11) <u>QED</u>.

If the technology is transferred to C, B suffers a real income loss as the terms of trade go against it without any accompanying technological improvement.

$$\hat{\omega}_B - \hat{\pi} = \hat{P}_y - \hat{\pi} = \gamma_x (\hat{P}_y - \hat{P}_x) = - \frac{\gamma_x \alpha_C \lambda_C}{\sigma_D} \tag{12}$$

On the other hand, if the technology is transferred to B, the resultant real income change is given by

$$\hat{\omega}_B - \hat{\pi} = \alpha_B \left(\frac{\sigma_D - \gamma_x \lambda_B}{\sigma_D}\right). \tag{13}$$

If $\sigma_D < \gamma_x \lambda_B$, (13) can be negative an B could be immiserized through transfer. But still, (13) can dominate (12). Therefore, in terms of minimizing loss, B can prefer an outcome such as given in (13) to the one given in (12). Condition for that will be given by,

$$\alpha_B \left(\frac{\sigma_D - \gamma_x \lambda_B}{\sigma_D}\right) > -\frac{\alpha_C \gamma_x \lambda_C}{\sigma_D} \quad \text{or} \quad \sigma_D > (\alpha_B \lambda_B - \alpha_C \gamma_C) \frac{\gamma_x}{\alpha_B}. \tag{14}$$

We are now in a position to discuss the main result of the paper. If (13) dominates (12) in spite of $\sigma_D < \gamma_x \lambda_B$, B will choose to be immiserized. However, along with this, A has to find it optimal to give it to B rather than to C. So $\alpha_B \gamma_B$ must dominate $\alpha_C \gamma_C$. Let us summarize the set of conditions needed for our result.

$$\alpha_B \gamma_B > \alpha_C \gamma_C \tag{C1}$$

and

$$\frac{\sigma_D}{\gamma_x} \in \left(\max\left\{\lambda_C, \frac{\alpha_B \lambda_B - \alpha_C \lambda_C}{\alpha_B}\right\}, \gamma_B\right) \tag{C2}$$

Proposition 3. <u>If $\lambda_B > \lambda_C$ and $\alpha_B \lambda_B > \alpha_C \lambda_C$, then one can find out a $\frac{\sigma_D}{\gamma_x}$ such that A will transfer the know-how to B and B will choose to be immiserized in such a transfer game.</u>

<u>Proof</u>. To prove the result we have to show that the set defined by (C2) is non-empty because if $\alpha_B \lambda_B > \alpha_C \lambda_C$, A will definitely transfer it to B and the rest of the proof follows from the non-emptiness of the set to which $\frac{\sigma_D}{\gamma_x}$ can potentially belong.

Suppose Max $\left\{\lambda_C, \frac{\alpha_B \lambda_B - \alpha_C \lambda_C}{\alpha_B}\right\} = \lambda_C$ then $\lambda_B > \lambda_C$ will imply that one can find some $\frac{\sigma_D}{\gamma_x} \in (\lambda_C, \lambda_B)$ such that immiserizing technology transfer will take place. Also note that $\lambda_B - \frac{\alpha_B \lambda_B - \alpha_C \lambda_C}{\alpha_B} > 0$. <u>QED</u>.

Proposition 3 points out to a rather interesting result. If λ_B is sufficiently greater than λ_C, B will opt for a technology from A which would lead to a real income loss for B but which will prevent A from transferring it to C where real income loss for B would have been greater. $\lambda_B > \lambda_C$ for $\alpha_B = \alpha_C$ implies a greater gain from transfer for A since B commands a larger share of Y, output impact will be larger and therefore terms of trade decline will be greater. Therefore A will go for such a transfer.

One could check that for high values of σ_D, transfer should be beneficial for parties involved but will definitely be immiserizing for the uninvolved. Self–immiserization as a strategic choice as described by proposition 3 can be sustained as a subgame perfect equilibrium because we do not allow A to transfer the knowledge to C after it has been transferred to B. It is, as if B now holds the patent right to the knowledge. Now once B receives the technology, it does not have the incentive to transfer it to C because it will entail loss of income for B through terms–of–trade decline. Since initial technology transfer is free of charge, A does not have any incentive to give it to C.

Once the technology is transferred, it is optimal for B not to use it because by using it, B will actually lose. But if B does not use it, A will transfer it to C and B will definitely lose. The game in the extensive form has been depicted in figure 1. If we allow B to follow 'not use' strategies, it will definitely choose to do so in the post–transfer situation. But in the foregoing discussion we implicitly assumed that A can monitor the use in the post–transfer situation. In the literature on transfer, it is assumed that if one country receives a foreign aid, it is going to expand consumption initially and then subsequently it might lose. If the process of transfer was such as to allow A to produce directly in country B then 'not use' as a strategy is infeasible. Now we shall see why B will be willing to precommit to follow the 'use' strategy rather than 'not use' strategy.

From figure 1 and the analysis in the text we know that the following possibility might emerge. $m_b > m_c$, $n_b < 0$, $q_b < 0$ (when m, n, q are pay-offs to A, B, and C). Similarly $m_c > 0$, $n_c < 0$, $q_c > 0$ with $m_b > m_c$, $|n_b| < |n_c|$. It is obvious that A transferring to C and C using the technology is the only subgame perfect equilibrium. Since A knows that B will not use the technology once the transfer takes place, A will transfer it to C. But in the resultant equilibrium, A gets $m_c < m_b$ and B gets $n_c < 0$ with $|n_c| > |n_b|$. Therefore, both of them could do better if B could credibly precommit to the 'use' strategy. Once B knows that in the resultant equilibrium his loss is greater than what could be if he had followed the 'use' strategy he would like to precommit to the 'use' strategy. Credible precommitment may take the form of direct involvement of A in the production of y in country B i.e., some sort of direct foreign investment or any kind of contract which makes the 'use' strategy optimal in the post–transfer subgame. In absence of such a mechanism, B will not get the technology but self–immiserization continues to be the best choice for him.

Concluding Remarks

This paper is an attempt to merge some of the strategic issues with the problem of transfers in international trade theory. Transfer paradox usually is discussed in terms of general equilibrium exchange models and the results derives in this paper have some applications in that context. The idea of this paper can be extended in various directions such as to incorporate appropriate pricing rule for such technology transfers.[1] We have assumed initially cost–less technology transfer as to draw a similarity between the context of the paper and the standard literature on the 'Transfer paradox.'

One might try to work into the issues related to sustainable collusions among the affected agents against such transfers. In this paper B and C could form a collusion by not accepting the transfer from A. But it will be difficult to sustain such a collusion because C can always cheat B by accepting the technology from A for a positive pay-off and we face the classic problem of 'Prisoners' dilemma! But the fact remains the if C knows that transferring to B and B using the technology can be sustained as a non-cooperative subgame perfect equilibrium, the best thing for C is to enter into a collusion with B which unfortunately cannot be sustained. As a last remark, one would like to mention that the condition described in proposition 3 can hold for a constant elasticity of substitution utility function with $\sigma_D < 1$ and the crucial condition $\lambda_B > \lambda_C$ with similar initial technology levels for B and C boils down to a comparison of relative labor force. Greater is L_B compared to L_C, greater is the possibility that the result will hold.

Footnotes

1. For game theoretic models of technology transfer see Gallin (1984), Marjit (1989a, 1989b). For strategic modelling of endowment-reallocation games and coalition formations see Thompson (1979), Riezman (1985) and Safra (1989).

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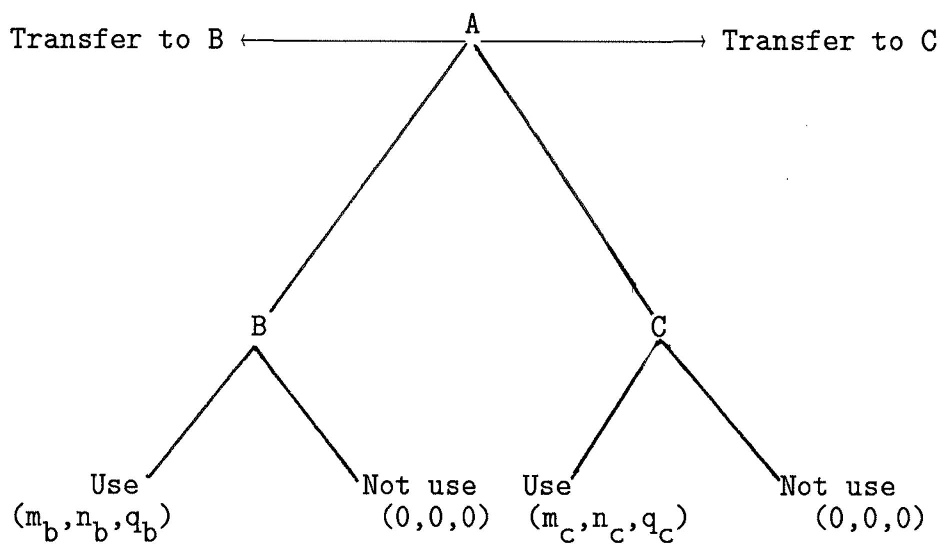
Figure 1


A
Transfer to B
Transfer to C
B
C
Use
(m_b, n_b, q_b)
Not use
(0,0,0)
Use
(m_c, n_c, q_c)
Not use
(0,0,0)