Rochester Center for Economic Research

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I. Introduction

The classic portrayal of international trade envisions final commodities being exchanged between countries, each possessing its own technology with a fixed bundle of available resources which are assumed to be immobile in the international market. In the modern world economy, by contrast, trade in producer goods, intermediate inputs, raw materials and other middle products is ubiquitous, estimated by some to be at least 80% of world trade. The pure theory of trade has, at least since the time of Mundell's classic (1957) article, considered explicit possibilities of international capital movements and exports and imports of other inputs into the production process. Less attention has been paid to the possibility that technological knowledge may be appropriable and firms in one country may be able to sell or transfer technology to another country.[1] Of the various production structures used in trade theory, the Ricardian model stands out both for its simplicity and for its emphasis on the fact that countries can differ from each other in their technologies, and such a difference leads to positions of comparative advantage and the possibility of mutually advantageous trade in final commodities. The purpose of this note is to sketch out in this simple framework what the consequences of an alternative trading pattern might be, one involving an exchange or sale of technology instead of commodity trade.

In a Ricardian setting a country's technology is captured by the set of labor input coefficients per unit of output of each commodity, a_{Lj}. But such numbers reflect a mixture of technical knowledge (blueprints), climate, and labor skills. Of these three, the latter could be transferred between countries if labor is internationally mobile, and that kind of transfer is ruled out in this treatment. Climate seems less transferable, and therefore we

concentrate on the possibility that inter-country differences in the a_{Lj} coefficients represent the blueprint variety, in which firms in one country possess the knowledge, and are able to keep it to themselves or sell it abroad. To keep things simple, assume that all such transfers are undertaken by a central authority so as to maintain the convenient assumption of competitive markets. In what follows we consider two separate cases. In the first of these one country (call it the home country) possesses an *absolute advantage* in the production of all commodities, but nonetheless imports a subset in which it has a *comparative disadvantage*. In the second case we assume that each of two countries has an absolute advantage in the commodity it exports and is completely specialized in that commodity. In such a case, is there any rationale in technological knowledge being shared or sold? The surprising result is that the answer typically lies in the affirmative.

II. Home Country Has Absolute Advantage in Both Commodities

Consider, first, the case in which the home country possesses an absolute advantage in each of a pair of commodities, but a comparative advantage in commodity X, which it exports to the foreign country in exchange for commodity Y. At issue is a comparison of a free-trade-in-commodities equilibrium with one in which the home country makes available at a price, or perhaps gives away (or even subsidizes) its own (better) technology for producing Y. Figure 1 illustrates by the solid broken line the world production possibilities schedule before the transfer of technology, and by the dashed broken line the schedule after the home country's superior technology in producing Y is made available to the foreign country. Clearly the world gains by such a transfer or sale, since the new locus lies

everywhere outside the old (except at the X-axis). The distribution of such gains (not counting any payment for the technology transfer) is uncertain, but if the relative price of Y falls, the home country experiences a terms of trade improvement. That is, any payment which the home country would receive for sales of its superior technology for producing its import commodity, Y, is enhanced by the fact that world production of Y is increased and its price driven down.

Figure 2 is designed to highlight the required relative price change by illustrating relative demand and supply schedules for (Y/X). In situation A initially in Figure 1 and 2, each country is completely specialized and the technology sale lowers Y's relative price (to B in Figure 2). In situation A' the home country produces some Y with free trade, and as a consequence of the sale of technology it is driven out of the Y sector as the price of Y once again falls (to B' in Figure 2).

How much could the foreign country pay for this technology and still come out ahead? Its terms of trade deteriorate, and this serves to offset the gains from possessing better Y-technology. Indeed, the possibility of immiserizing growth is present, in which case the home country would have to do better than give away its superior technology - it would have to make a positive side payment as well in order to encourage the foreign country to utilize the better technology. Given the nature of the supply curve shift illustrated in Figure 2, the terms of trade cannot move in favor of the foreign country, so that it would not be willing to pay as much for the better technology as the improvement in world real income.

The case in which the home country transfers its superior technology in producing *both* commodities is somewhat different. The effect of this on the world production-

possibilities curve is shown in Figure 3. If, before the transfer, trade in commodities resulted in each country being specialized completely at a terms of trade strictly between the cost ratios in the two countries, it is clear that such a technology transfer must serve to worsen the home country's terms of trade. Basically, the home country faces the same price ratio it did in autarky, so that the entire gains from trade at home from the move to free trade in commodities is wiped out. In order to gain from such a transfer, the home country would have to charge at least the amount of this gain for such a sale. We have already noted that if the home country does not transfer its technology in X, it could gain by *giving away* its Y-technology. It follows that by receiving the superior technology in a commodity (X) which it does *not* produce in a free trade equilibrium, the foreign country would be forced to pay more than it would if it only received the superior technology in the good which it does produce with free trade.

Figure 4 is designed to illustrate that both countries can gain by this transfer of technology even in the extreme case in which both countries initially shared exactly the same technology for producing Y, but the home country had an absolute advantage in producing X. Before technology transfer the initial equilibrium terms of trade are depicted by line BC, with world production at kink-point A. Taste patterns at home dictate consumption point, B, with consumption measured relative to the home consumption origin, O_H, which represents gains from commodity trade over autarky. Point C, with distance BA equal to distance AC, must reveal a tangency between line BC and a foreign indifference curve, relative to the foreign consumption origin, O^*, since trade is balanced at these terms of trade. These individual tangencies are captured for the world as a whole by the world

indifference curve at A, with world consumption relative to the O origin. The world production-possibilities curve after the transfer of technology of producing commodity X to the foreign country is shown by the line through A with the same slope as the home country's transformation schedule. It is as if the world economy, originally consuming and producing at point A (i.e. as if the world were in autarky), is now allowed to trade at different prices than prevailed in the pre-technology-transfer situation. This entails gains from trade as each county substitutes X for Y in its consumption bundle; the world produces southeast of A on the world transformation locus (e.g. at point D), an option it did not have before the transfer of technology. Thus the foreign country has more than enough to compensate the home country for its deterioration in the terms of trade. The argument is strengthened if, as in Figure 3, the home country also transfers technology of its superior Y-sector.

III. Multiple Imports

Suppose the home country is specialized in commodity X, but imports two commodities from abroad, Y and Z. Assume that the home country possesses an absolute advantage in producing all three commodities, and once again contemplates transferring its superior technology in Y-production (alone) to the foreign country. Will its terms of trade improve as in the more simple case just contemplated, so that the home country would gain even if it gave its technology away? Not necessarily. Take commodity Z as numeraire. Then Y's price relative to the Z must fall by the extent of the improvement in technology, and if the price of home exports, p_x, remained unchanged, once again the home country

would benefit by an improvement in its terms of trade. But the price of X may fall.

At issue is the relative strength of substitution effects and income effects for the world as a whole. At the initial price of X the transfer of technology raises world incomes and this increases the demand for commodity X. On the other hand, if X and Y (the commodity which has become cheaper by virtue of the technology transfer) are particularly good substitutes, demand for X could fall, thus lowering the price of X. If all commodities are substitutes, the price of X will not fall by as much as the price of Y. This does not guarantee that the home (transferring) country gains, since X represents the entire export menu while Y represents only one of the commodities imported. Therefore three possibilities emerge: (i) The price of X may be dragged down a little or raised a little, in which case both countries can gain even if the superior technology for Y is freely given away; (ii) The price of X may fall so much that the home country's "net" terms of trade deteriorate. Unless the foreign country pays sufficiently for the technology, the home country would lose. Since the world gains, there is always enough to make such a payment; (iii) Income effects may dominate substitution effects sufficiently that the foreign country would be immiserized *unless* the home country "bribes" the foreign country to accept the technology transfer. Here our assumption that central authorities in each country make decisions is crucial. Otherwise, individual foreign producers would gladly accept a gift of better Y-technology, and would not factor into their decision the subsequent deterioration in terms of trade (of a rise in P_x as well as fall in P_y).[2]

IV. Each Country has an Absolute Advantage

The preceding argument serves as a useful prelude to the case in which each of two countries is originally exporting a commodity in which it possesses not only a comparative advantage but also an absolute advantage. Consider Figure 5, with an original free-trade world production and consumption bundle represented by point A, and the terms of trade by line 1, strictly in between the relative prices ruling in autarky in each of the countries. Obviously each country gains from the move to free trade. Also shown is the straight dashed line through point A, which represents what the world transformation locus would be if each country made the superior technology embedded in its production of its export commodity available to the other country. Recall that for each country this means that it gets access to better technology for the commodity it does *not* produce in the free-trade equilibrium. Nonetheless, as long as the original free trade terms of trade are *different* from the ratio a_{LX}/a^*_{LY}, representing the slope of the world transformation schedule reflecting the best technology available in the world, the world as a whole gains from this technology transfer over and above its initial gains from free trade in commodities.

The possibility that both countries gain, of course, presumes that the country whose terms of trade improve as a consequence of technology transfer sufficiently compensates the other country. Thus in Figure 5 technology transfer has improved the terms of trade for the home country since the relative price of Y, the commodity for which it was relying entirely on imports in the free-trade situation, has been reduced. Without a side payment to the foreign country the latter would lose by the technology transfer, but as the world indifference curves in Figure 5 reveal, both could gain by having the world transfer some

resources from X-production to Y-production using the superior technology which initially was not available to the home country.

V. Concluding Remarks

Free trade in commodities has often been considered to lead to the optimum allocation of resources between countries. If factor returns are not equalized by such trade, further gains can be obtained by allowing national factors access to world markets. But if technology, in the form of blueprints, is different between countries, sale or gifts of such technology from advanced to less advanced countries can lead to further gains. Indeed, in the Ricardian model developed in this paper the only asymmetry between countries that would affect relative prices is technology, so that if transfers are allowed, the basis for commodity trade is removed (except for any payments for technology transfer or bribes to persuade recipients to adopt the superior technology).

The potential for gaining from such a technology transfer is perhaps most obvious in the case in which some country has an absolute advantage in producing some commodity which it nonetheless imports in a free trade equilibrium because its absolute advantage in its export good is even greater. In such a case the superior country's transfer improves its terms of trade (in the two-commodity case) since it encourages an increase in the world output of its importable. Therefore it would gain even by giving away its superior technology. This strong result needs to be qualified if the superior country transfers its better technology only in one of several commodities which it imports. The reason such qualification may be necessary is that the price reduction for such a commodity could result

in price falls as well in the country's export items if consumers world-wide find these to be very good substitutes for the commodity which has fallen in price.

World gains from technology transfer are also possible even when each country has an absolute advantage in its export commodity and produces none of the other commodity in a free-trade equilibrium. The potential for such gain resides in the fact that the "best-technology" price ratio can differ from that determined in a free-trade equilibrium. If so, the world can gain by moving to this new price in a manner precisely parallel to the gains which an individual country can obtain by trading at prices different from those ruling in autarky. However, such a situation worsens the terms of trade for one of the parties, so that compensation from the other country is required in order that both actually gain, and such compensation is possible.

Superior technology is sometimes embedded in capital equipment, so that sales of such capital or foreign investment may be required in order to effect the technology transfer. A similar remark could be made about human capital. The purpose of the present note is to isolate the technology transfer *per se* and to identify the nature of the extra gains possible over free trade. The details of the payments made for such transfer depend on such things as the bargaining position of each of the parties, and we have not gone into an analysis of this problem. Instead, we have emphasized that although the world gains from such transfer, exports of superior technology may have to be accompanied by side payments instead of revenue receipts, since changes in the terms of trade are important.

Footnotes

* We apologize for the variation in the title used by Grossman and Helpman (1994).

1. Using a Heckscher-Ohlin framework, Koji Shimomura and Murray Kemp (1988) argue that a country with an absolute advantage in every industry could gain by giving away some of its technology. However, their's seems to be a special case in which the transferred improvement in technology is of the same relative extent in all sectors so that in the recipient country the production-possibilities set expands uniformly outwards. But this corresponds to a standard textbook case showing how uniform expansion of all supplies in one country, coupled with homothetic tastes, improves the terms of trade of the other country in a two-country world. (For example, see Caves, Frankel and Jones, 1996, pp. 66, 67). In our present note the technology transfer does not cause a uniform expansion in the recipient country's transformation schedule.

2. Details of the Ricardian scenario with three commodities and technical progress in one commodity when production ranges have no overlap are provided in Jones (1979), ch. 17.

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2. Grossman, Gene and Elhanan Helpman, (1994), "Protection for Sale", *American Economic Review*, Vol. 84, pp. 833-50.

3. Jones, Ronald W. (1979), "Technical Progress and Real Income in a Ricardian Trade Model", Ch. 17 in Jones, *International Trade: Essays in Theory* (North Holland).

4. Kemp, Murray C. and Koji Shimomura, (1988), "The Impossibility of Global Absolute Advantage in the Heckscher-Ohlin Model of Trade", *Oxford Economic Papers*, Vol. 40, pp. 575-76.

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Figure 1

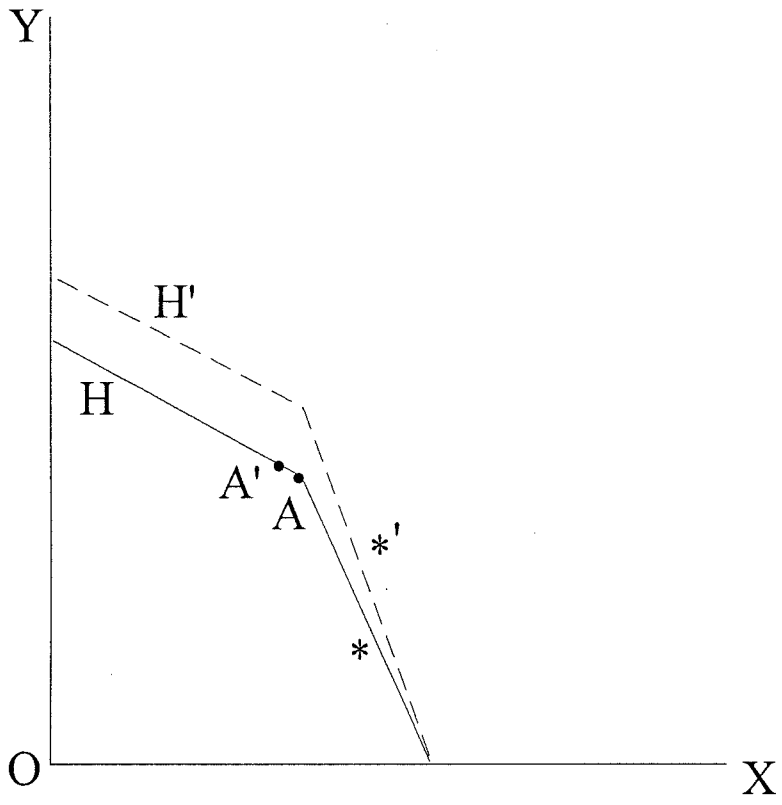

Figure 2

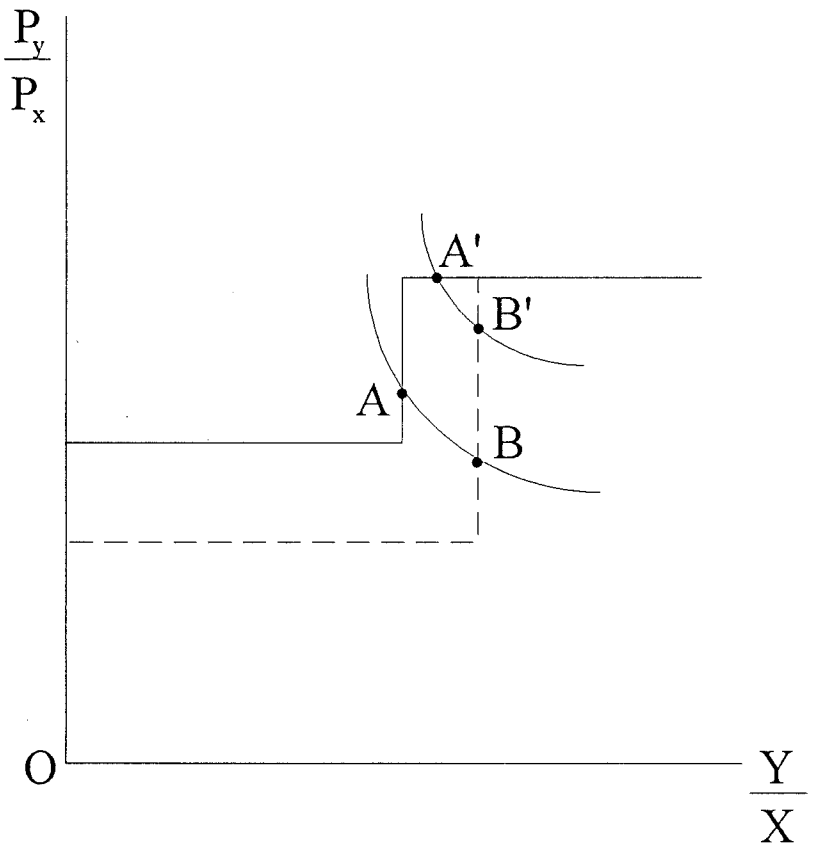

Figure 3

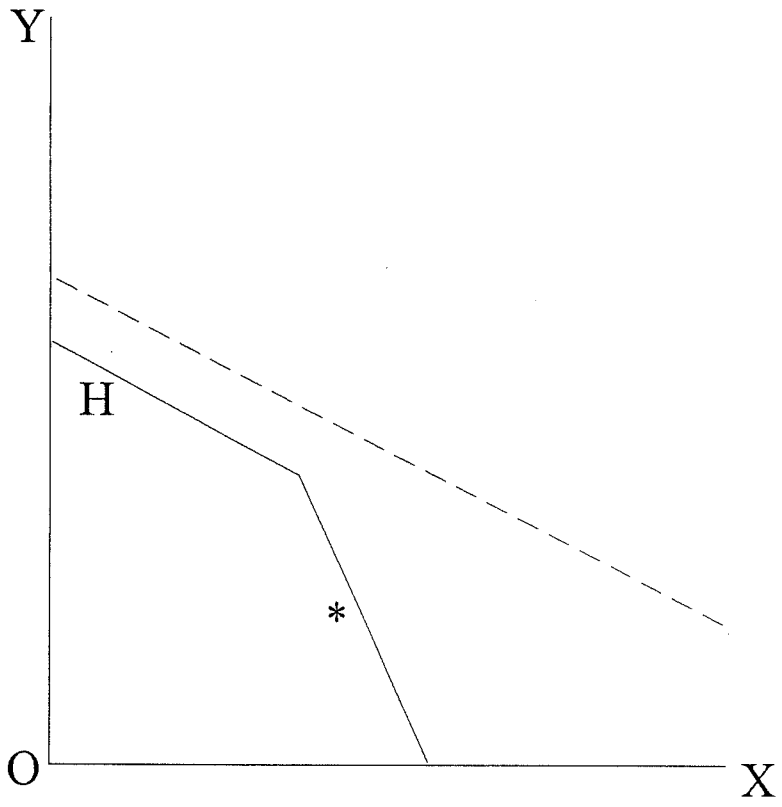

Figure 4

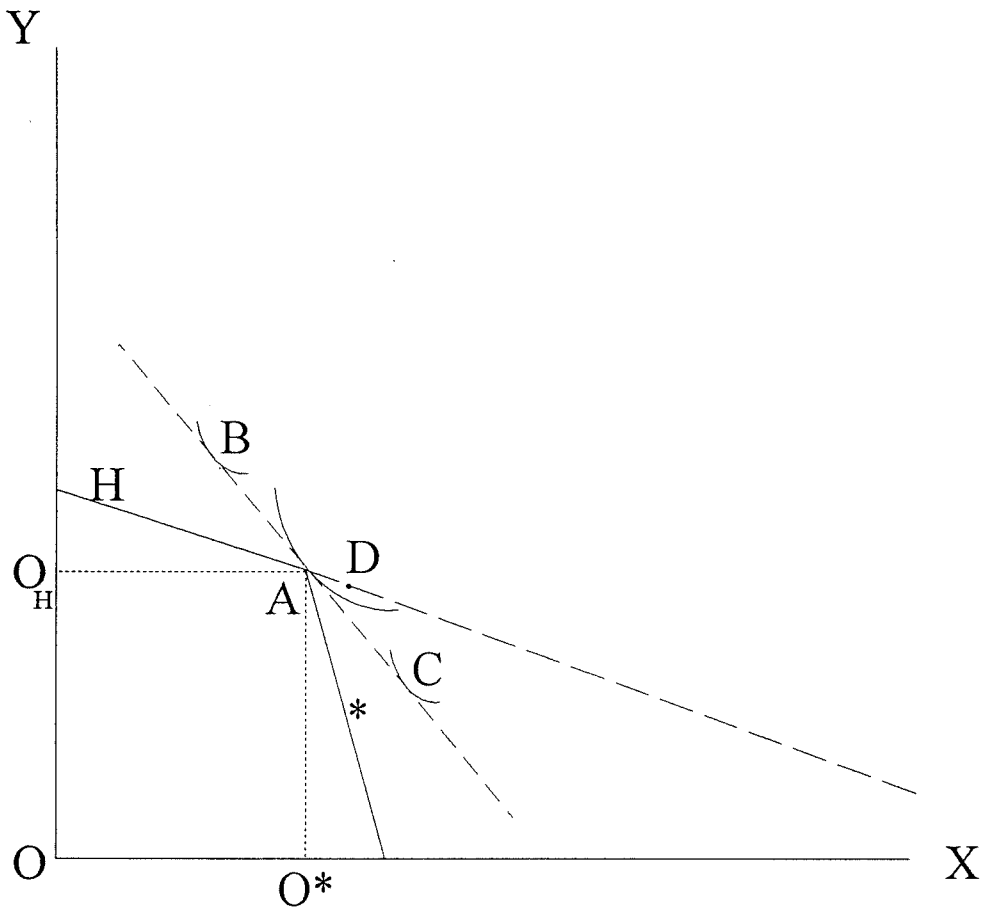

Figure 5