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Richard A. Brecher
Ehsan U. Choudhri

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Richard A. Brecher
and
Ehsan U. Choudhri

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DEPARTMENT OF ECONOMICS
UNIVERSITY OF WESTERN ONTARIO
LONDON, CANADA
N6A 5C2
NEW PRODUCTS AND THE FACTOR CONTENT OF INTERNATIONAL TRADE*

Richard A. Brecher and Ehsan U. Choudhri

Department of Economics
Carleton University

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I. Introduction

Vernon's (1966) product-cycle hypothesis and related analyses [e.g., Hufbauer (1966, 1970), Kravis (1956) and Posner (1961)] have stimulated considerable interest in the role of "new products" for determining the factor content of international commodity trade, and for understanding the Leontief Paradox. While there is a substantial literature emphasizing the empirical importance of these goods, they still need to be incorporated formally into the standard factor-content theory of world trade, in the tradition of Melvin (1968) and Vanek (1968).

To address this need, the present paper extends the multi-commodity two-input version of the Heckscher-Ohlin model to include new products, defined here as goods whose technology is available in only one country. In Section II, the extended model is used to re-examine the implications of relative factor abundance for the capital and labour content of world trade. As explained in Section III, the presence of new products might in principle resolve the Leontief Paradox under certain specific conditions.

II. The Extended Model

Start with the standard Heckscher-Ohlin model of a two-country two-factor world, in which capital and labour are used to produce any number of "old products", defined here as goods whose technology is identical internationally. Now, extend this model to incorporate one or more new products (defined above). As usual, assume constant returns to scale in production, absence of factor-intensity reversals, identical homothetic tastes for the home and foreign countries, international immobility of capital and labour, perfect competition, and free trade.

To highlight certain stylized features of Vernon's (1966) discussion, we restrict our attention to the interesting case in which the following three assumptions also hold. First, the (physically) capital-abundant country is the sole producer of all new goods. Second, this country has a higher wage-rental ratio
than the rest of the world. Third, new products are labour intensive in relation to old goods, when the two types of commodities are compared at the same wage-rental ratio.

Letting the home country be the relatively capital-abundant one,

$$\frac{\bar{K}}{\bar{K}^W} > \frac{\bar{L}}{\bar{L}^W},$$  \hspace{1cm} (1)

where $\bar{K}$ and $\bar{L}$ represent the fixed endowments of capital and labour, respectively, for this economy; while $\bar{K}^W$ and $\bar{L}^W$ denote the corresponding endowments for the world as a whole. As we shall now proceed to show, predictions about the factor content of international trade in the extended (unlike the standard) model depend on whether any (old) good is produced in common by both countries.

To dispense first with the simpler case, begin by supposing that there is no "common product", defined here as a good produced in both countries. In this case, the factor requirements per dollar's worth of each good are unique in world production and hence consumption. Therefore, the presence of new commodities does nothing to upset the following condition used by Leamer (1980):

$$F_c = \alpha \bar{F}^W, \hspace{0.5cm} F = K, L,$$  \hspace{1cm} (2)

where $K_c$ and $L_c$ are the total amounts of capital and labour, respectively, embodied in home consumption; and $\alpha$ is the home country's relative share of total world expenditure.

From (1) and (2), $L_c / \bar{L} > K_c / \bar{K}$ or, equivalently, $K_T / \bar{K} > L_T / \bar{L}$; where $K_T (\equiv \bar{K} - K_c)$ and $L_T (\equiv \bar{L} - L_c)$ denote net exports of capital and labour, respectively, embodied in the commodity trade of the home country. Thus, despite our introduction of new products, there is not yet any violation of Vanek's (1968) well-known proposition concerning the factor-content "chain of comparative advantage", which may be expressed generally as follows: Ranking the factors of a country (say the home one) by relative domestic abundance ($\bar{F} / \bar{F}^W$) is the same as ranking them by
relative net exports \( \left( \frac{F_n}{F} \right) \).

The situation changes dramatically, however, as we now introduce a common good, produced with factor requirements that differ between countries (given the international divergence in wage-rental ratios). To preserve (2) in the face of these differences, we would clearly need to have equality of \( \theta \) and \( \theta^* \), which respectively denote the proportions of home and foreign consumption of the common good met from home production. Given the conventional assumption that international trade of each (homogeneous) good is unidirectional, however, it is easy to see that \( \theta > \theta^* \) unambiguously. Thus, home consumption of the common good is definitely biased in favour of home production, which (per dollar's worth of output) uses more capital and less labour than foreign production, given that the wage-rental ratio is higher at home than abroad. Consequently, (2) must be replaced by

\[
F_c = \beta^F a^F \frac{F}{W}, \quad F = K_L,
\]

where \( \beta^K > 1 > \beta^L \) necessarily. If \( \beta^K \) is sufficiently greater than \( \beta^L \), then from (1) and (2') we now can have \( L_T/L > K_T/K \), in clear violation of the chain proposition stated above.

The possibility of this violation is illustrated dramatically (with \( L_T > 0 > K_T \)) in Figure 1 for the case of balanced commodity trade. In this diagram, HH' and FF' are unit isocost lines in the home and foreign countries, respectively. The unit-value isoquants 1, 2 and 3 represent a dollar's worth of output for old goods 1 and 2 and new good 3. (For now, no other commodities exist, and hence isoquant 4 should be ignored.) The slopes of (undrawn) rays OE and (flatter) OD give, respectively, the capital-labour endowment ratios of the home and foreign countries. For simplicity, (common) good 1 is not traded internationally. Since point N lies southeast of point B, every dollar's worth of home exports (of good 3) uses more labour and less capital than every equal-valued
amount of foreign exports (of good 2). Thus, the home country is a net exporter of labour and importer of capital!

It is important to stress that the relative labour intensity of new products is not itself enough to ensure this violation of the chain proposition. Given their presence, the crucial issue is the magnitude of biases (β^K and β^L) created by common-good production. Only if these biases are sufficiently great can the chain be reversed as in the above example.

III. The Leontief Paradox

Although Leamer (1980) has shed considerable light on the Leontief Paradox, Leontief's (1954) data for the United States include some features which are not satisfactorily explained in the model with only old products. For instance, as Brecher and Choudhri (1982b) have shown, it was paradoxical that L_T > 0 (despite \( \bar{L}/\bar{W} < \alpha \)) for the U.S. Also, since Leontief's estimates show U.S. capital (labour) requirements per million dollars to be less (greater) for exports than imports, his figures suggest the paradox that L_T > 0 > K_T if commodity trade were balanced.\(^{10}\)

As is clear from Section II above, an explanation of these paradoxical findings is possible if new products are incorporated into the model. In this case, the labour bias (β^L) due to common-good production might be sufficiently pronounced to yield \( \bar{L} > \beta^L \bar{W} \) for the U.S., thereby implying that L_T > 0 [in view of (2')]. Also, the capital bias (β^K) for the U.S. might at the same time be great enough to cause K_T < 0 under balanced commodity trade (as illustrated above in Figure 1). Thus, the presence of new products can in principle explain an apparent failure of the Heckscher-Ohlin Theorem in its Melvin (1968)-Vanek (1968) factor-content version, which predicts that K_T > 0 > L_T if commodity trade is balanced.

Finally, with (but not without) new products we can intriguingly have the following new possibility: The Leontief Paradox might simply be a measurement error,
due to Leontief's (1954) method of using home rather than foreign requirements to estimate the factor content of U.S. imports. Even when \( K_T > 0 > L_T \), we may observe \( \hat{L}_T > 0 > \hat{K}_T \), where a circumflex over a variable indicates the Leontief estimate (based wholly on home requirements of factors). Although this combination of true and estimated outcomes cannot arise when all goods are old, the following example illustrates the possibility of this combination in the presence of new products.

In Figure 1, now assume that goods 4 (with unit-value isoquant 4) and 1 are the world's only commodities. (Thus, isoquants 2 and 3 should now be ignored.) The home country produces and exports (new) product 4, while producing and importing good 1. [Note that OA' (not drawn) is now the foreign endowment ray, representing a lower capital-labour ratio than the domestic endowment ray, which is still OE (not drawn).] Since point C lies northwest of point A', balanced commodity trade would imply \( K_T > 0 > L_T \). At the same time, however, \( \hat{L}_T > 0 > \hat{K}_T \), because point C lies southeast of point A (which provides the Leontief estimates of the true requirements given by point A').

As suggested by this example, the home country could appear to be exporting capital and importing labour even when the opposite pattern of factor trade actually holds. For this possible outcome to be consistent with Leontief's (1954) data, his estimates of labour and capital content per million dollars would have to be only 7% below and 20% above the true levels, respectively. Although detailed verification of such a possibility would be beyond the scope of the present paper, some readily available data (for labour) suggests that the actual bias may well be considerably greater.
Footnotes

1. See also Krugman (1979) for a (one-factor) model of trade between an innovating "North" and an imitating "South".

2. If factor prices were assumed to remain equal between countries, introducing new products would not essentially affect the standard factor-content theorems of international trade, as explained by Vanek and Bertrand (1971). See also footnote 3 below.

3. Thus, as could readily be shown, the capital-abundant country cannot have a lower wage-rental ratio than the rest of the world.

4. On the lack of such dependence when new products are absent, see Brecher and Choudhri (1982a).

5. More could be said if balanced commodity trade were assumed. Then, letting $P_k$ and $P_l$ denote home (unequal to foreign) prices of capital and labour, respectively, we could readily show that $P_k K_T + P_l L_T < 0$ given cost minimization. From this result and the chain proposition stated above, $L_T < 0$. We could simultaneously have $K_T < 0$, intuitively because the home country's exports of new products embody a "technology content", which might be exchanging internationally for both a capital and labour content.

6. Only one such good is possible in the two-factor free-trade model with international factor-price differences, as noted by Deardorff (1979). The present analysis extends readily, however, to any number of common products in the presence of production tax-cum-subsidies in favour of import-competing goods.

7. As the home country is an exporter, nontrader or importer of the common product, we have $\theta = 1 > \theta^* > 0$, $\theta = 1 > \theta^* = 0$ or $1 > \theta > 0 = \theta^*$, respectively.
8. As could readily be shown, \( \beta^F - 1 = (\Theta - \Theta^*)(a_F^K - a_F^L)C^*/F^*F^*, \) \( F = K, L; \) where \( a_K^* \) and \( a_L^* \) are the inputs of capital and labour, respectively, per dollar's worth of home output of the common good; \( a_K^* \) and \( a_L^* \) are the corresponding requirements in the foreign country; and \( C^* \) is foreign consumption of the common good. If additional common goods were admitted in accordance with footnote 6, we would still have \( \beta^K > 1 > \beta^L. \)

9. This simplification was suggested to us by Alan V. Deardorff, who noted that \( AE/AN = A'D/A'B \) in this case, since the relative share of (nontraded) good \( l \) in national income must be the same for both countries (given balanced commodity trade and equal homothetic tastes).

10. Admittedly, a move to balanced commodity trade (from the position of surplus in Leontief's data) could have changed the commodity composition of U.S. trade, and thus might have altered the factor content per million dollars of exports and imports. There is no reason to expect, however, that such a change would have reversed the signs of \( K_T \) and \( L_T. \) Baldwin (1971) has, in fact, estimated the factor content of U.S. trade for a period in which this country's trade surplus was considerably smaller than in Leontief's period. Baldwin's estimates confirm that, per million dollars, the U.S. was a net exporter of labour and importer of capital.

11. On the inappropriateness of this estimation procedure when factor prices differ internationally, see Deardorff (1982). Nevertheless, without new products, Brecher and Choudhri's (1982a) proof that \( K_T > 0 > L_T \) is qualitatively unaffected if factor requirements of home importables are estimated (à la Leontief) by the points where isoquants for such goods touch the unit isocost line of the home country.

12. For evidence on differences in (direct) labour coefficients between the U.S. and three other countries (India, Japan and the United Kingdom), see Iary's (1968, appendix B) detailed bilateral comparisons of value added per employee.
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