THE INTERNATIONAL DIFFUSION OF THE FRUITS OF TECHNICAL PROGRESS*

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The Hicks-Ikema theorem, that a uniform expansion of a trading country’s production set must benefit its trading partner if the preferences of the expanding country are homothetic, has been demonstrated under assumptions of the Lerner-Samuelson kind. It is here shown that the theorem remains valid if one of the trading partners imposes an optimal tariff, if there are produced inputs, and if factors of production are internationally mobile.

1. INTRODUCTION

Hicks (1953) suggested that any uniform expansion of a country’s production set would normally benefit its trading partners via an enhancement of the partner’s terms of trade. More precise statements, and formal proofs, were provided by Kemp (1955), for economies suffering from Keynesian unemployment, and by Ikema (1969), for economies with homothetic preferences, full employment of resources and incomplete specialization of production. More recently, Kemp and Shimomura (1988) have observed that, as an important implication of the Hicks-Ikema (H-I) theorem, neither country can hold a continuing global absolute advantage over the other. Any temporary advantage would be dissipated by self-serving gifts of technical information by the owners of firms in the more advanced country.

Ikema’s (1969) analysis was conducted in the narrow textbook setting of two countries, two produced goods, no produced inputs and internationally immobile primary factors of production; moreover it is implicit in Ikema’s demonstration that all markets are competitive and that trade is completely free of tariffs and other artificial obstacles to trade. Since then it has been shown by Shimomura (1991) that the theorem can accommodate more than two goods, not all of which need be tradeable. Moreover Kemp and Shimomura (1988) have noted that allowance can be made for additional trading partners. (The theorem then asserts only that a uniform expansion of one country necessarily benefits at least one other country.) In the present note we further clarify the scope of the H-I theorem by showing that it remains valid when capital is internationally mobile, when there are produced inputs and when one of the trading partners takes advantage of its market power by imposing an optimal tariff.

2. FREE TRADE

Let us begin with the conventional world in which two countries $\alpha$ and $\beta$ trade in two commodities produced under constant returns by means of two or more

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primary factors of production. Let \( \alpha \) be technically progressive, \( \beta \) unprogressive, and let preferences in \( \alpha \) (but not necessarily in \( \beta \)) be homothetic. The second commodity will serve as numeraire.

The following notation will be used.

\[ p \] the world price of the first commodity in terms of the second,

\[ u^j \] the wellbeing of the \( j \)th country, \( j = \alpha, \beta \),

\[ e^j(p, u^j) \] the expenditure function of the \( j \)th country, \( j = \alpha, \beta \),

\[ r^j(p) \] the revenue or GNP function of the \( j \)th country, \( j = \alpha, \beta \),

\[ z^{j1} \] the excess demand of the \( j \)th country for the first commodity,

\( \lambda \) a technical parameter, initially equal to one.

Recalling Shepherd's lemma,

\[ z^{j1}(p, u^j) = e^j(p, u^j) - r^j(p) \quad j = \alpha, \beta \]

where subscripts indicate partial or total differentiation.

Our model contains the two national budget constraints

\[ e^\alpha(p, u^\alpha) - \lambda r^\alpha(p) = 0 \]

and

\[ e^\beta(p, u^\beta) - r^\beta(p) = 0 \]

as well as the market-clearing condition which, recalling (1), can be written as

\[ e^\alpha(p, u^\alpha) - \lambda r^\alpha(p) + e^\beta(p, u^\beta) - r^\beta(p) = 0. \]

This formulation is sufficiently general to accommodate produced inputs; if there are produced inputs, \( r^j \) must be interpreted as the value of net outputs and \( r^p \) as the possibly negative net output of the first commodity. The formulation also allows for the possibility of complete specialization in production, that is, for zero gross output of either commodity.

We seek to show that an unbiased technical improvement in \( \alpha \) necessarily benefits \( \beta \). Differentiating (2) through (4) with respect to \( \lambda \),

\[ \begin{bmatrix} e_u^\alpha & 0 & e_p^\alpha - r_p^\alpha \\ 0 & e_u^\beta & e_p^\beta - r_p^\beta \\ e_p^{\alpha} & e_p^{\beta} + r_p^{\alpha}e_{pp}^{\beta} - r_p^{\beta} \end{bmatrix} \begin{bmatrix} du^\alpha \\ du^\beta \\ dp \end{bmatrix} = \begin{bmatrix} r_p^\alpha \\ r_p^\beta \end{bmatrix} \]

Solving,

\[ \Delta(du^\beta/d\lambda) = -(e_p^\beta - r_p^\beta)(e_u^\alpha r_p^{\alpha} - e_u^{\alpha} r_p^{\alpha}) \]

where \( \Delta \) is the determinant of the Jacobian matrix in (5) and, as a sufficient and almost necessary condition of Walrasian stability, is negative. Now
DIFFUSION OF TECHNICAL PROGRESS

383

$$0 = e^\alpha_p - r^\alpha_p + e^\beta_p - r^\beta_p$$

[from (4)]

$$= (e^\alpha_p/e^\alpha_u)e^\alpha - r^\alpha_p + e^\beta_p - r^\beta_p$$

$$= (e^\alpha_p/e^\alpha_u)r^\alpha - r^\alpha_p + e^\beta_p - r^\beta_p$$

[homotheticity of $\alpha$-preferences]

$$= (1/e^\alpha_u)(e^\alpha_p r^\alpha - r^\alpha_p e^\alpha_u) + e^\beta_p - r^\beta_p.$$ 

Hence

$$(e^\beta_p - r^\beta_p)(e^\alpha_p r^\alpha - r^\alpha_p e^\alpha_u) < 0$$

and $d\alpha / d\lambda > 0$.

It has been implicit in our analysis that primary factors are internationally immobile. Suppose however that one of two distinct industries employs just one factor (capital) to produce (capital) services which may be used as inputs to the other industry and imported or exported. Then it becomes clear that the analysis can be interpreted as accommodating international factor mobility.

3. TRADE RESTRICTED BY OPTIMAL TARIFFS

We now vary our analysis by allowing for the possibility that one of the two countries imposes an optimal tariff.

Suppose that the progressive country $\alpha$ imposes a tariff. For concreteness, let us assume that $\alpha$ imports the first commodity. If the tariff-inclusive relative price of that commodity in $\alpha$ is denoted by $q$ then the tariff revenue of $\alpha$ in terms of the second commodity (the numeraire) is $-(q - p)z^\beta_1 = -(q - p)(e^\beta_p - r^\beta_p)$ and equations (2) and (4) must be replaced by

$$(7) \quad e^\alpha(q, u^\alpha) - \lambda r^\alpha(q) - (q - p)[-z^\beta_1(p, u^\beta)] = 0$$

and

$$(8) \quad e^\alpha(q, u^\alpha) - \lambda r^\alpha(q) + e^\beta(p, u^\beta) - r^\beta(p) = 0$$

respectively. To complete the model, we introduce an implication of the assumption that $\alpha$ imposes an optimal tariff, by way of

$$z^\beta_1 - (q - p)(z^\beta_1 - z^\beta_1 z_u^\beta_1) \equiv z^\beta_1 - (q - p)z^\beta_1 = 0$$

where $z^\beta_1$ is the price slope of $\beta$'s Marshallian excess demand function for the first commodity. Thus we have the four equations (3), (7) through (9) in the four variables $u^\alpha, u^\beta, p, q$ and the parameter $\lambda$.

Differentiating that system with respect of $\lambda$, we obtain

1 See Bhagwati et al. (1983).
\[
\begin{bmatrix}
1 & (q - p)z^{\beta 1} & 0 \\
0 & 1 & 0 \\
\frac{z^{\beta 1}}{z_u} & \frac{z^{\beta 1}}{z_q} & \frac{1}{z_p} \\
0 & \frac{z^{\beta 1}}{z_u} & -\frac{z^{\beta 1}}{z_p} \\
\end{bmatrix}
\begin{bmatrix}
\frac{du^\alpha}{dz} \\
\frac{du^\beta}{dq} \\
\frac{dx^\alpha}{dp} \\
\end{bmatrix}
= 
\begin{bmatrix}
\frac{r^\alpha}{z} \\
0 \\
\end{bmatrix}
\]

where use is made of (1) and the normalizations \( e_u^\alpha = 1 = e_u^\beta \), and where \( x^\alpha = r_p^\alpha \) is the output in \( \alpha \) of the first commodity. Solving,

\[
\Delta'\left(\frac{du^\beta}{d\lambda}\right) = r^\alpha z^{\beta 1} z_p^{\beta 1} \left[ z_u^{\alpha 1} - x^{\alpha 1}/r^\alpha \right]
\]

where \( \Delta' \) is the Jacobian determinant of the system and as a sufficient condition of Walrasian stability is positive. Moreover, \( z^{\beta 1} < 0 \) by assumption; \( z_p^{\beta 1} < 0 \) as an implication of \( \alpha \)'s optimal tariff; and the square-bracketed term is positive as an implication of the homotheticity of \( \alpha \)-preferences and of the assumption that \( \alpha \) imports the first commodity. Hence \( du^\beta/d\lambda > 0 \).

The above finding can be understood in terms of Meade’s trade indifference curve. After the technical improvement there emerges a new family of \( \alpha \)-trade indifference curves. However the new curve through the old tariff-ridden equilibrium trading point represents greater welfare than the old curve through that point. Moreover the two curves generally differ in slope at that point, implying that the old tariff is no longer optimal and that further gains can be achieved by resetting it at its new optimal level.

If \( \beta \) instead of \( \alpha \) maintains an optimal tariff, and if \( \alpha \)-preferences are homothetic, it remains true that a technical improvement in \( \alpha \) benefits \( \beta \). A mathematical proof, of the type provided above, could be fashioned. For a proof based on simple offer-curve techniques, see Kemp et al. (1990).

4. IMPLICATIONS

It has been shown that the H-I theorem is valid under quite general conditions. It follows from the reasoning of Kemp and Shimomura (1988) that, under the same general conditions, no country can hold a global advantage over all other countries.

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