The Product Cycle Hypothesis and the Heckscher-Ohlin-Samuelson Theory of International Trade

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THE PRODUCT CYCLE HYPOTHESIS AND THE HECKSCHER-OHLIN-SAMUELSON THEORY OF INTERNATIONAL TRADE

by

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ABSTRACT

This paper builds up a neo-classical trade model to explain the 'product-cycle' hypothesis originally proposed by Raymond Vernon. As the skill intensity of a product falls over time, the more capital-abundant North tends to export 'new' goods and the less developed South exports 'old' goods. The trade pattern remains invariant over time although the product mix changes as the 'new' goods become old, and this exhibits the product-cycle type phenomenon. Thus, it is shown that, with reasonable assumptions, the traditional factor-abundance model is sufficient to generate a product cycle type trade pattern.

In a seminal paper, Vernon (1966) analyzed international trade in new and old goods. This has been referred to as the 'product cycle' hypothesis in the existing trade literature. The idea behind the product cycle is as follows. New goods are developed in the advanced countries (North) and are exported to the less developed countries (South). Later, when the goods become old, production location changes and the comparative advantage ranking is reversed. The South starts exporting old goods to the North, and the North starts selling some other new goods to the South. Therefore, the 'product-cycle' trade has two features. First, the North has a comparative advantage in exporting the new goods. Second, the product-mix of trade changes over time as new goods become old.

Krugman (1979) has developed a Ricardian model of trade to explain the product-cycle hypothesis in which the North has a monopoly over the new good technology and hence has a comparative advantage in the new good. The South is forced to specialize in the old good because of the lack of knowledge in innovating a new product. He also assumes an exogeneous diffusion function which determines the rate at which new goods are transferred to the South. Dollar (1986) extends the analysis of Krugman (1979) by bringing in capital as a distinct factor of production. However, he retains the assumption regarding the asymmetry of technological knowledge between North and South. Both these papers seem to suggest that the Heckscher-Ohlin-Samuelson (H-O-S) theory of trade is incapable of explaining the product-cycle hypothesis because it never highlighted technological asymmetry as the basis for trade. One problem of both of these papers is that they never really explain the pattern of trade. North's comparative advantage in new goods seems to follow directly from the

assumption that South does not have the ability to produce new goods. The speed at which goods are transferred to the South is also exogenously given and eventually the whole pattern of product cycle trade seems to fall out directly from the basic assumptions.

The purpose of this paper is to follow a traditional route of analysis in terms of a H-O-S model. In a simple two-dimensional model we shall show that even if technological knowledge is the same across the borders, the trade pattern will be determined by factor abundance and the product cycle will automatically emerge. The basic idea of the paper rests on the fact that the input-mix required to produce a particular product changes over time. A host of special skills that is utilized to innovate a new product may not be required to that extent as the production process gets standardized over time. This fact was taken into account by Hirsch (1967) and by Jones (1970) while analyzing H-O-S interpretation of Vernon's product-cycle hypothesis. Even if the South has the potential ability to develop a new product it may not be cost-minimizing for them to do so because of its factor endowment position. In the forthcoming analysis the following scenario is introduced. Consider a world economy comprising of two countries N (North) and S (South). In every period there is a new good that can be developed in either region. Every good lives for two periods and then dies away (no further utility is derived). Relative skill intensity of a good falls as the good gets old. All new goods have the same production functions. Therefore, in any period we have a new good and an old good different in terms of skill intensity. With 'skill' being a capital intensive product and homothetic identical tastes in two countries, capital-abundant North exports the new good and imports the old

good. In every period the same trade pattern prevails. However, the 'new' good changes to 'old' and the product cycle continues.

This paper is divided into three sections. In section I, we build up the basic model of a closed economy and discuss the trade pattern in terms of the difference in the endowment positions of two countries. In section II, we discuss the productivity differential and the relative wages of North and South. In section III we suggest some generalizations and conclude the paper.

Section I

We have two countries in the world, North (N) and South (S). Each has endowment of two primary factors of production capital (K) and labor (L). The production process of a commodity requires capital and labor to produce skill in the early stage of production and then skill and labor produce the final commodity. Production function of a good obeys constant returns to scale and diminishing returns to inputs. We assume a competitive industry. To describe the formal structure of the model, we need the following symbols.

ℓ_{ij} - per unit requirement of labor to produce a jth period commodity innovated at the ith period.

h_{ij} - per unit requirement of skill to produce a jth period commodity innovated at ith period.

ℓ_h - per unit requirement of labor to produce skill.

k_h - per unit requirement of capital to produce skill.

x_{ij} - amount of a jth period good innovated at ith period.

k - stock of capital

L-given labor force

w - wage

r - rental to capital and

P_h - price of skill.

P_{ij} - price of a jth period good innovated at the ith period.

We assume that in every period a new good is innovated. It lives for two periods and then fails to generate any utility to the consumers in either country. Therefore, if i=j, it is a new product; and if i=j-1, it is an old product. We also assume that skill intensity of a product falls as it grows old. This can be intuitively justified in the following way. As a product grows old, unskilled labor (L) becomes more productive. Therefore, at given $\frac{w}{P_h}$, producers tend to substitute more unskilled labor relative to the skilled input. Therefore, for any given w/P_h the following holds

$$\frac{h_{j-1,j}}{\ell_{j-1,j}} < \frac{h_{jj}}{\ell_{jj}} \tag{1}$$

This is due to the fact that all new goods and old goods have the same production function. Now we can proceed to describe the equational structure of the model.

Competitive equilibrium implies in any period

$$P_h h_{jj} + w\ell_{jj} = P_{jj} \tag{2}$$

$$P_h h_{j-1,j} + w\ell_{j-1,j} = P_{j-1,j} \tag{3}$$

$$rk_h + w\ell_h = P_h \tag{4}$$

Substituting (4) into (2) and (3) we get,

$$rk_h h_{jj} + w(\ell_h h_{jj} + \ell_{jj}) = P_{jj} \tag{5}$$

$$rk_h h_{j-1,j} + w(\ell_h h_{j-i,j} + \ell_{j-1,j}) = P_{j-1,j} \tag{6}$$

Full employment conditions imply

$$k_h h_{jj} X_{jj} + k_h h_{j-1,j} X_{j-1,j} = K \tag{7}$$

$$(\ell_h h_{jj} + \ell_{jj}) X_{jj} + (\ell_h h_{j-1,j} + \ell_{j-1,j}) X_{j-1,j} = L \tag{8}$$

Given prices and endowments (5) - (8) determine the factor prices, intensities and output levels.

Proposition 1. Given (1), X_{jj} is capital intensive and $X_{j-1,j}$ is labor intensive. Proof is simple. The capital intensity of X_{jj} and $X_{j-1,j}$ are given by,

$$\frac{k_h h_{jj}}{\ell_h h_{jj} + \ell_{jj}} \quad \text{and} \quad \frac{k_h h_{j-1,j}}{\ell_h h_{j-1,j} + \ell_{j-1,j}}.$$

Now,

$$\frac{k_h h_{jj}}{\ell_h h_{jj}+\ell_{jj}} = \frac{k_h}{\frac{\ell_{jj}}{\ell_h+\overline{h_{jj}}}}$$

and

$$\frac{k_h h_{j-1,j}}{\ell_h h_{j-1,j}+\ell_{j-1,j}} = \frac{k_h}{\frac{\ell_{j-1,j}}{\ell_h+\overline{h_{j-1,j}}}}.$$

Required inequality (9) follows directly from (1):

$$\frac{k_h h_{jj}}{\ell_h h_{jj}+\ell_{jj}} > \frac{k_h h_{j-1,j}}{\ell_h h_{j-1,j}+\ell_{j-1,j}} \qquad (9)$$

Let us define the following concepts.

$$a_{Lj} = (\ell_h h_{jj}+\ell_{jj})$$

$$a_{Kj} = (k_h h_{jj})$$

$$a_{Lj-1} = (\ell_h h_{j-1,j}+\ell_{j-1,j})$$

$$a_{Kj-1} = (k_j h_{j-1,j})$$

Distributive shares, θ_{ij}, and factor allocation fractions, λ_{ij}, are defined in comparable fashion. For example, θ_{Lj} equals $\frac{wa_{LJ}}{P_{jj}}$ and $\lambda_{L,j-1}$ equals $\frac{a_{L,j-1}X_{j-1}}{L}$.

With these symbols, following Jones (1965) it can be shown that

$$\hat{X}_{jj} - \hat{X}_{j-1,j} = -\frac{1}{|\lambda|}(\hat{K}-\hat{L}) + \sigma_S(\hat{P}_{jj}-\hat{P}_{j-1,j}) \qquad (10)$$

where $\sigma_S \equiv \frac{1}{|\lambda||\theta|}(\delta_L+\delta_K)$

and '^' denotes proportional change.

δ_L is the aggregate percentage saving in labor inputs at unchanged outputs associated with a 1% rise in the relative wage rate. δ_K stands for the same in capital.

$$|\lambda| \equiv \begin{vmatrix} \lambda_{Lj} & \lambda_{Lj-1} \\ \lambda_{Kj} & \lambda_{Kj-1} \end{vmatrix} < 0 \qquad \text{from (9)}$$

$$|\theta| \equiv \begin{vmatrix} \theta_{Lj} & \theta_{Kj} \\ \theta_{Lj-1} & \theta_{Kj-1} \end{vmatrix} < 0 \qquad \text{from (9)}$$

we assume the taste pattern to be homothetic.

$$\hat{X}_{jj} - \hat{X}_{j-1,j} = -\sigma_D(\hat{P}_{jj} - \hat{P}_{j-1,j}) \qquad (11)$$

$\sigma_D > 0$ denote elasticity of substitution. From (10) and (11) in equilibrium

$$-\sigma_D(\hat{P}_{jj}-\hat{P}_{j-1,j}) = -\frac{1}{|\lambda|}(\hat{K}-\hat{L}) + \sigma_S(\hat{P}_{jj}-\hat{P}_{j-1,j})$$

or
$$(\hat{P}_{jj}-\hat{P}_{j-1,j}) = \frac{(\hat{K}-\hat{L})}{|\lambda|(\sigma_S+\sigma_D)} \qquad (12)$$

Proposition 2

Given the same technology and the same preferences in North and South, if North is relatively capital abundant it will export X_{jj} and import $X_{j-1,j}$ for all j. This proposition follows from (12). If $(\frac{K}{L})_N > (\frac{K}{L})_S$, $(P_{jj}/P_{j-1,j})_N < (P_{jj}/P_{j-1,j})_S$. Hence, the North will have a comparative advantage in new goods and the South will be exporting old goods. Now X_{jj} will be an old good in (j+1)th period. But every period is the same otherwise. Therefore, in (j+1)th period South will export the good innovated at jth period. This would generate the product cycle type of trade pattern. In the post-trade situation, two countries may remain incompletely specialized or they can completely specialize in production. As in any H-O-S model, here also,

difference in relative endowments nail down the pattern of specialization. If the endowments are more similar in the sense that the factor endowment ratio in each country lies within the cone of diversification determined by capital intensities, we shall have incomplete specialization. Factor prices will be equalized as endowments do not influence factor prices once commodity prices are given. Therefore, if we observe trade between roughly similar countries, we shall observe some new good being produced in both countries. However, one of the countries emerges as net exporter of the new good. When endowment ratios are wide apart, we shall have complete specialization in at least one country. The North will be producing the new good only and/or the South will completely specialize in old good production. This pattern of production is similar to the assumed pattern of production in Krugman (1979) and Dollar (1986). We are invoking traditional logic to argue that even if the North has the ability to produce the old good and the South is capable of generating the new good, in post trade situation production, diversification might not be a cost-minimizing decision. With complete specialization, factor prices will be different and this will tend to induce further factor mobility. The lesson of this analysis is that if we observe trade between high-capital-rich countries and low-capital-poor countries, we shall have production of each good remarkably localized. Eventually, capital will tend to move or at least have the incentive to move from capital rich to capital poor economies. Production patterns have been described in Figure 1.

Section II

In this section we shall try to highlight the relative wage in North and South when both are engaged in trading new and old goods. It has been argued in Krugman (1979) and Dollar (1986) that a reasonable theory of trade should be able to explain why wages in the North are generally higher than wages in the South. This fact emerges even when rate of return to capital tends to get equalized across countries. The general argument proposed by earlier papers rests heavily on North's ability to appropriate monopoly advantage in new goods. North is able to maintain a high wage rate because South cannot compete in the new product.

Suppose we assume that northern laborers become uniformly more productive in both sectors relative to southern labor. Let $\hat{\bar{a}}_{Lj} = \hat{\bar{a}}_{Lj-1} = \alpha$ denote decline in labor coefficient in the North [$\alpha<0$]. The equations of change in the North can be written as

$$\theta_{Lj}\hat{w}_N + \theta_{Kj}\hat{r}_N = -\theta_{Lj}\alpha \qquad (13)$$

$$\theta_{Lj-1}\hat{w}_N + \theta_{K,j-1}\hat{r}_N = -\theta_{L,j-1}\alpha \qquad (14)$$

where w_N, r_N are northern wages and rental. For the time being, we assume that relative prices of new and old goods are fixed. We shall relax this assumption and prove the general result in the appendix.

From (13) and (14) we get,

$$\hat{w}_N = -\alpha > 0.$$

Similarly, $\hat{r}_N = 0$.

In the South prices are fixed and there is no productivity shift. Therefore, $\hat{w}_S = 0$, $\hat{r}_S = 0$. This implies $\frac{w_N}{w_S}$ goes up. We observe a stationary state with higher relative wage of North to South. [Even if we let the price change, the general direction of the result will be unchanged.] As labor becomes more productive in the North, the labor intensive old good sector expands relatively more. At given world prices, this causes an increase in the supply of the old good. It reduces the relative price of the old good. South's terms of trade decline. Moreover, Southern wages must go down in absolute terms due to the magnification effect of the price change. r increases in both countries although the increase in w_N is choked off somewhat by the price movement, $\frac{w_N}{w_S}$ rises. (This result has been derived starting from an incomplete specialization set up.)

Suppose we consider a situation where free capital mobility is allowed, such that even if countries were completely specialized to start with, capital mobility ensures equalization of returns to capital. Now if we repeat the same exercise as before, we can show an increase in $\frac{w_N}{w_S}$. [The basic point to be made is that if there is a productivity gap between labor of two regions, it will be reflected in a wage gap and product cycle type trade will be consistent with such a wage gap.]

Section III

In the last two sections we talked about a neo-classical explanation of product cycle trade. In this section we shall see how far we can get away from the 'two-dimensionality' of the problem and still be able to explain the same phenomenon. Consider a world where at any point of time there are many new and old goods and also there are a large number of countries. However, suppose each country is too 'small' to affect the prices of these goods. Under these circumstances one can invoke a theorem following Jones (1974) that each country would be specialized in at most two goods. The most capital-abundant economy will tend to produce the most capital intensive good. If we rank the goods according to their capital intensities, the most capital abundant economy will produce the most recently innovated good and so on. However, the systematic change in the input mix tends to change the scenario in subsequent periods. As the new good becomes old, less capital-rich countries will start producing those, generating product cycle trade. This is suggested as an extension of the basic 2X2 model developed in the paper.

The basic purpose of this paper has been to show the capacity of a traditional model to explain the trade in goods with different vintage. Of course, this model does not capture all of the elements of product-cycle type trade. It is based on some stylized fact extensively discussed by Hirsch (1967). Extreme asymmetry in technology may generate a particular trade pattern. However, even without technological leadership, North is capable of having a comparative advantage in new goods. To the South, specialization in new goods may be utterly cost-inefficient depending on its endowment position. To the extent that skill formation is important in generating innovation and to the

extent capital is required heavily to form skill, H-O-S theory can be a successful competitor of the existing technology theories of product cycle trade.

Appendix

Wage gap with changes in terms of trade.

From competitive equilibrium in each country it follows.

$$\hat{w}_N = -\alpha + \frac{\hat{P}_{jj}\theta_{Kj-1} - \hat{P}_{j-1,j}\theta_{Kj}}{|\theta|}$$

$$\hat{w}_S = \frac{\hat{P}_{jj}\theta_{Kj-1} + \theta_{Kj}\hat{P}_{j-1,j}}{|\theta|}$$

on $\quad \hat{w}_N - \hat{w}_S = -\alpha > 0.$

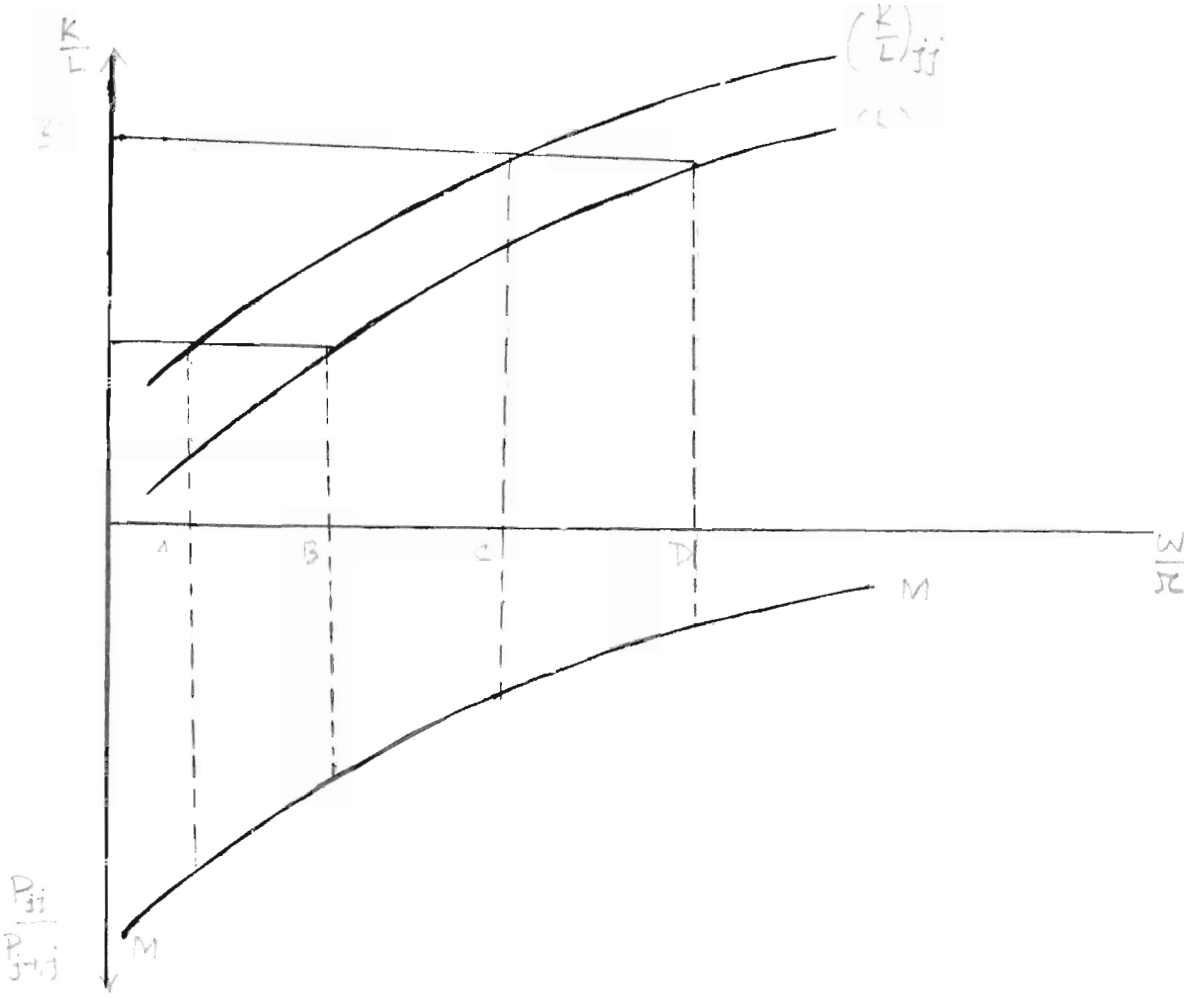

Figure 1

$(\frac{K}{L})_{j-1,j}$ and $(\frac{K}{L})_{jj}$ denote intensity ranking of new good and old good. The MM curve denotes the factor price and commodity price relationship. Since $(\frac{K}{L})$ ratios widely differ, incomplete specialization is not possible (AB and CD do not coincide).

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