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A Note on Factor Price Equalization

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Abstract

An aggregated phenomenon and its corresponding phenomenon under firm level are supposed to be analogous. For example, the aggregate growth and the growth of the firm are analogous. This paper, therefore, studies Heckscher-Ohlin theorem and factor price equalization under two firms. Identical production function does not imply identical cost function because labor abundant countries have lower wage level than capital abundant countries. The difference in cost between two countries makes factor prices be different between two countries although international trade makes product price be equalized.

Keywords: Factor price equalization; Exchange rate; Purchasing power parity

JEL: F11, F31

Introduction

Heckscher-Ohlin (H-O) model studies the case that two countries have different factor endowments under identical production function and identical preference. The difference in factor endowment also makes two countries have different factor prices in the beginning. Consequently, H-O model implies that two countries have different cost functions. In other words, the assumption of identical production function does not imply identical cost function. Since economists have never investigated what will happen in H-O model under different cost functions, H-O model is incomplete and unsound.

H-O model has two famous inferences. One is Factor Price Equalization (FPE). The other is that the capital abundant country exports capital intensive goods and the labor abundant country exports labor intensive goods. It is reasonable to assume that the labor (capital) abundant country has advantage of low wage (low return rate on capital) so that the labor (capital) abundant country exports labor (capital) intensive good. If wage of labor abundant country is much lower than capital abundant country, the labor abundant country may also have cost advantage to export capital intensive good. Thus, H-O model itself does not deny the possibility that labor (capital) abundant countries export capital (labor) intensive goods. It explains the paradox of Wassily Leontief [1] without factor-intensity reversal.

Paul Samuelson [2] demonstrated that factor prices equalize when free trade equalizes product prices. It means that product mobility and factor mobility are perfect substitutes as Mundell [1956] addressed. Regional trade and international trade are analogous. If Mundell's argument is correct, factor prices will be equalized cross-region in a country. But empirical studies find that factor mobility cannot be replaced by free trade. Eiichi Tomiura [3] found that cross-region wage gap remains large in Japan because cross-region labor mobility is inactive in Japan. Andrew et al. [4] showed that wage did not converge in American. Yun-kwong Kwok and Chunwei Lai Kwok [5] found that labor mobility and market integration make wage converge in China.

Moreover, Farhad Rassekh and Henry Thompson [6] surveyed theories and evidences of FPE. They found that Samuelson's prediction does not coincide with the reality completely. Those empirical evidences raise an interesting question. Did Paul Samuelson [2] make mistake? Samuelson ignored the possibility that two countries have identical production function but one country has higher cost functions than the other country. Thus, two countries have different marginal products, given the relative price of products. Consequently, the difference in marginal product leads to difference in factor prices because factor prices depend on marginal product in microeconomics. In short, Samuelson's proof is incomplete.

These empirical studies above, especially Kwok and Lai, seem to suggest an issue. That is, it is possible to derive a new theory from H-O model: factor price do not equalize but factor price gap between two countries shrinks. In addition, Rassekh and Thompson mentioned factor price convergence to be a dynamic characteristic of FPE in their paper. If the issue above is true, factor price convergence cannot be interpreted as an evidence for FPE.

That commodities outnumber factors seems not to be the answer for the issue. Alan V Deardorff [7] proved the necessary and sufficient condition for PFE when commodities outnumber factors. But Deardorff did not believe that the necessary and sufficient condition exists in the real world. It implies that FPE is completely ineffective in the real world, not likelihood. Then, how to explain wage convergence between two countries? Thus, I do not apply the outnumber approach to study H-O model under different cost functions.

Economists usually introduce extra assumptions to show that factor prices do not equalize in the real world. There are plenty of examples. Balassa [1964] introduced non-trade goods into his theory to explain why factor prices will not be equalized. Product cycle (Raymond Vernon [8]), technology gap (Michael Posner [9]) and increasing return to scale (Paul Krugman [10]) are applied to build up new international theories from which factor prices equalization cannot be deduced. But the purpose of this paper is not to construct a new international trade theory. The purpose of this paper is to derive not only factor prices non-equalization but also factor price convergence from H-O model.

What is the key idea to distinguish this paper from the published papers about FPE? An aggregated phenomenon and its corresponding phenomenon under firm level are supposed to be analogous. For

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instance, Chao-Chiung Ting [11] demonstrated that the growth of the firm is analogous to the aggregate growth. If factor prices do not equalize under firm level, it is impossible that factor prices equalize under aggregate level. Thus, the approach of this paper is microeconomic.

I organize this paper as below. The dynamic process of factor price convergence is discussed in section 2. Section 3 is conclusion remarks.

Non-Equalization

I make following assumptions. First, there are two countries. Country A is capital abundant and country B is labor abundant. Second, each country has two industries and each industry contains many firms. Industry C produces capital intensive good and industry L produces labor intensive good. Third, markets are competitive and firms pursue profit. For each industry, firms in two countries have identical production function due to full information assumption of competitive market. Fourth, country A's industry L has higher cost than country B's industry L because firms located in country B pay lower wage to workers than country A due to labor abundant assumption. Fifth, two countries have identical preference. Sixth, transportation progress integrates four isolated markets and transportation cost is so low that we can ignore.

The fourth assumption and the fifth assumption imply two inferences. First, the price of labor intensive good in labor abundant country is lower than capital abundant country. Second, each firm's output for labor intensive good in labor abundant country is larger than capital abundant country. For instance, there are two marginal cost curves. One is lower than the other. If demand curve is given due to identical preference assumption, the lower marginal cost curve intersects marginal revenue curve at the right hand side of the intersection between marginal revenue curve and the higher marginal cost curve. Consequently, the lower marginal cost curve makes product price lower and quantity of output larger than the higher marginal cost curve. Given production function, marginal product declines when quantity of output expands. Thus, the labor abundant country exports labor intensive good due to lower product price and marginal product of labor intensive industry in labor abundant country is lower than capital abundant country due to marginal product diminishing.

According to maximum profit assumption (i.e., the third assumption in this section), we have following equations for each firm in two countries.

$$Q = f(K,L) \tag{1}$$

$$\text{Max} \quad PQ - wL - rk \tag{2}$$

$$P\frac{\partial Q}{\partial L} = W \tag{3}$$

$$P\frac{\partial Q}{\partial K} = r \tag{4}$$

Let P, Q, w, r, L and K be price, quantity, wage, return rate on capital, labor and capital. Equation (1) is production function. In equation (2), cost function is composed of wage expenditure (wL) and returns on capital (rK). Since demand curve for competitive market is horizontal, price is not a function of quantity. Equation (3) and equation (4) are first order condition for maximum profit assumption, derived from equation (2). These two equations represent the relation between input factors and return on input factors. Note that P is absolute price, not relative price because this paper considers the relation between cost and price and relative cost cannot present the difference in cost between two countries. For example, the absolute cost of capital intensive product (labor intensive product) in country A is US$ 5 (US$ 2). For country B, they are US$ 2 and US$ 1. The cost of labor intensive product in country A is relatively lower than country (5:2 versus 2:1) B although country A's cost is double (US$ 2 versus US$ 1).

The industry L located at country B will produce more labor intensive good than before international trade because the price of labor intensive good in country B rises after international trade. Let P_t^B be the new price of industry L in country B after international trade. $P_t^B = P_{t-1}^B + \Delta P_t^B$ where, ΔP_t^B is change in the price of industry L in country B after international trade and P_{t-1}^B is the price of industry L in country B before international trade. Since output expands and marginal product diminishes, industry L's marginal product of labor in country B declines $\frac{\partial Q_t^B}{\partial L} = \frac{\partial Q_{t-1}^B}{\partial L} - \Delta\frac{\partial Q_t^B}{\partial L}$. Where $\Delta\frac{\partial Q_t^B}{\partial L}$ is the change in marginal product of industry L in country B after international trade and $\frac{\partial Q_{t-1}^B}{\partial L}$ is the marginal product of industry L in country B before international trade. According to equation (3), the new wage of labor abundant country (w_t^B) is equal to

$$w_t^B = \left(P_{t-1}^B + \Delta P_t^B\right)\left(\frac{\partial Q_{t-1}^B}{\partial L} - \Delta\frac{\partial Q_t^B}{\partial L}\right) \sim P_{t-1}^B\frac{\partial Q_{t-1}^B}{\partial L}\left(1 + \frac{\Delta P_t^B}{P_{t-1}^B} - \frac{\Delta\frac{\partial Q_t^B}{\partial L}}{\frac{\partial Q_{t-1}^B}{\partial L}}\right) \tag{5}$$

If wage of labor abundant country rise, it requires

$$\frac{\Delta p_t^B}{p_{t-1}^B} > \frac{\Delta\partial Q_t^B}{\frac{\partial Q_{t-1}^B}{\partial L}} \tag{6}$$

The firm located at capital abundant country will produce less labor intensive good than before international trade because price of labor intensive good in capital intensive country declines. Thus, marginal product of labor intensive industry rises. The new wage of the country A is

$$w_t^A = \left(P_{t-1}^A + \Delta P_t^A\right)\left(\frac{\partial Q_{t-1}^A}{\partial L} - \Delta\frac{\partial Q_t^A}{\partial L}\right) \sim P_{t-1}^A\frac{\partial Q_{t-1}^A}{\partial L}\left(1 + \frac{\Delta P_t^A}{P_{t-1}^A} - \frac{\Delta\frac{\partial Q_t^A}{\partial L}}{\frac{\partial Q_{t-1}^A}{\partial L}}\right) \tag{7}$$

If wage of capital abundant country declines, it requires

$$\frac{\Delta p_t^A}{p_{t-1}^A} > \frac{\Delta\partial Q_t^A}{\frac{\partial Q_{t-1}^A}{\partial L}} \tag{8}$$

Since we assume that $p_{t-1}^A > p_{t-1}^B$ and $Q_{t-1}^A < Q_{t-1}^B$ (i.e., the fourth assumption and the fifth assumption), the marginal product of labor intensive industry in capital intensive country is larger than labor intensive country.

$$\frac{\partial Q_{t-1}^A}{\partial L} > \frac{\partial Q_{t-1}^B}{\partial L} \tag{9}$$

When product price converges, equation (9) implies

$$\frac{\partial Q_{t-1}^A}{\partial L} + \Delta\frac{\partial Q_t^A}{\partial L} > \frac{\partial Q_{t-1}^B}{\partial L} - \Delta\frac{\partial Q_t^B}{\partial L} \tag{10}$$

Since equation (5), (7) and (10) are valid, $w_t^A w$ is greater than w_t^B when $p_{t-1}^A - \Delta p_t^A$ is equal to $p_{t-1}^B - \Delta p_t^B$. That is, wage will not be equalized by product price equalization even two firms have identical production function. If equation (6) and (8) are valid (i.e., w_t^A declines

and w_t^B rises), wage gap between two countries shrinks. Thus, this paper predicts that FPE will not happen between capital abundant countries and labor abundant countries but wage gap between capital abundant countries and labor abundant countries may shrink.

Economist may criticize conclusions reached above as a short run analysis and argue that FPE is a long run phenomenon because price is not a function of quantity in equation (3). In the long run, firms pursue maximum return rate on capital instead of maximum profit and adjust their own capital toward optimal size according to Ting [2010]. In the long run, wage and return rate on capital are

$$w = P\left(1+\frac{1}{\eta}\right)\frac{\partial Q}{\partial L} \tag{11}$$

$$r = p\left(1+\frac{1}{\eta}\right)\frac{\partial Q}{\partial K} \tag{12}$$

Where η is price elasticity. Marginal product is still the key factor to determine that factor price will equalize or not because market integration makes each firm in two countries face the same demand curve so that each firm faces the same price elasticity. Since I demonstrated above that the difference in marginal product between two countries becomes larger and larger (i.e., equation (10)), wage gap cannot converge to zero according to equation (11). Thus, FPE fails in the long run, either.

Conclusion

Factor price non-equalization suggests a policy for governments and international organizations. We should promote not only free trade but also international investment and labor mobility in order to equalize global income distribution because free trade cannot substitute for factor movement.

The analysis of factor price non-equalization implies a new method to evaluate the manipulation of foreign exchange rate. We can use equation (3) to infer a shadow price level if we know wage (w) and output per worker $\left(\frac{\partial Q}{\partial L}\right)$. If the difference in price level between two countries cannot be explained by the difference in cost between two countries, then foreign exchange rate is manipulated. I use China and American as a simple example to display my proposal. The average value of output per labor and the average wage per labor in American (China) are US$ 60,000 and US$ 40,000 (US$12,000 and US$ 2,400). The shadow price level of American is 0.66 $\left(\frac{40000}{6000}\right)$. China's shadow price level is 0.2 $\left(\frac{2400}{12000}\right)$. Thus, the ratio of the domestic price level of American to the domestic price level of China is supposed to be 3.3. It coincides with 2005 World Bank's estimation, 3.45. Thus, the foreign exchange rate between Renminbi and dollar are almost in equilibrium because the difference in price level is explained by the difference in wage level, not by manipulation of foreign exchange rate. But Penn world Tables, Version 6.1, reported that the ratio of China's price level to American's price level is 0.231. The difference between 4.3 (1/0.231) and 3.3 is the price level explained by foreign exchange rate. In this case, Renminbi is undervalued about 30%, (4.3-3.3)/3.3.

The big Mac index is 1.9 because one big Mac is sold by US$ 3.7 in American and US$ 1.95 in China. The difference in the price of big Mac between American and China could be fully explained by low wage level of China. It is evident that Big Mac index overestimates the manipulation of Renminbi.

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