Modifications of the Balassa-Samuelson Model: The Effects of Balanced Growth and Capital Accumulation

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Abstract

We develop modified versions of the Balassa-Samuelson model. The effects of balanced productivity growth and capital accumulation is stressed. Empirical estimates using 1970-1990 sectoral data for the OECD show that our modified models are more suited to the data than the commonly-used Balassa-Samuelson model.

Keywords: Real Exchange Rate; Productivity Growth; Capital Accumulation; Sectoral Inflation

JEL classification: F36; F41; F43

1 Introduction

This paper explores the determinants of the relative price of non-tradables to tradables. It is often pointed out that in understanding the fluctuations in real exchange rates, the changes in the relative price of non-tradables must

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play an important role. A body of empirical studies has tried to explain the fluctuations, focusing on supply side factors.[1] The most commonly used framework to evaluate the effect of supply side factors is due to Harrod (1939), Balassa (1964) and Samuelson (1964). They argue that high productivity growth of the tradables sector compared to the non-tradables sector leads to a rise in the relative price of non-tradables, and that this puts upward pressure on a country's real exchange rate.

The commonly-used framework in empirical studies based on the Balassa-Samuelson model assume that the rental rate of capital is exogenous and the wage rate is endogenous. However, there are other empirical studies which show that the international capital mobility is not perfect.[2] If this is true, it is not appropriate to assume that the rental rate of capital is exogenous. In addition, it is often pointed out that the wage rate is sticky, especially in the short run. In this case, it is not appropriate to assume that the wage rate is endogenous. We see in the following sections that modifications of the commonly-used Balassa-Samuelson model enable us to analyze the case of imperfect international financial markets and/or sticky wage rate.

In the Balassa-Samuelson framework, differential productivity growth between tradables and non-tradables plays an important role. Our empirical analyses also support this view. What we want to emphasize in this paper is, however, balanced growth effect and capital accumulation effect. Those effects are overlooked or not fully exploited in other studies. Our theoretical analyses show that the effects of balanced growth change with the assumptions about the factor prices. In addition, it is proved that capital accumulation can be another important determinant of the relative price of non-tradables.

Our theoretical analysis about capital accumulation effect is based on the insights of Kravis and Lipsey (1983) and Bhagwati (1984). They argue that if international capital mobility is imperfect and the wage rate is flexible, factor endowments affect the relative price of non-tradables to tradables through the relative price of capital and labor.

The modified models are very simple and can be easily examined empirically. Our estimates using 1970-1990 sectoral data for 14 OECD countries show that the commonly-used framework is not suited to the data both in the short run and in the long run, and that our modifications are supported.

[1] For example, Hsieh (1982), Yoshikawa (1990), Gregorio et al. (1994).

[2] See, for example, Feldstein and Horioka (1980).

This paper proceeds as follows: Section 2 presents the Balassa-Samuelson model and then introduces modifications to the model. Section 3 compares three models empirically. Section 4 concludes.

2 Basic Models

2.1 The Balassa-Samuelson model

In this subsection we present a framework due to Harrod (1939), Balassa (1964), and Samuelson (1964) that was used to understand the determinants of real exchange rates in many existing studies. We see below that the inflation rates of tradable and non-tradable goods are determined by the productivity of the tradable and non-tradable goods sectors, under the assumption of a small economy and perfect international capital mobility. Demand factors do not affect any of the prices of the economy. The constant returns to scale production technologies for the two sectors are specified as follows:

$$Y_T = A_T L_T^{\theta_T} K_T^{1-\theta_T} \tag{1}$$

and

$$Y_N = A_N L_N^{\theta_N} K_N^{1-\theta_N}, \tag{2}$$

where the subscripts T and N denote tradable and non-tradable goods, and Y, A, L and K are output, productivity, labor and capital, respectively. Under the assumption of perfect competition and perfect factor mobility across sectors, the following conditions for profit maximization of firms are satisfied.

$$r = (1-\theta_T) A_T k_T^{-\theta_T}, \tag{3}$$

$$r = P_N (1-\theta_N) A_N k_N^{-\theta_N}, \tag{4}$$

$$w = \theta_T A_T k_T^{1-\theta_T}, \tag{5}$$

$$w = P_N \theta_N A_N k_N^{1-\theta_N}, \tag{6}$$

where r is the rental rate of capital, w is the wage rate, k is the capital-labor ratio and P_N is the relative price of non-tradables to tradables. We take the price of tradables as a numeraire. The rental rate of capital is determined in world markets and is exogenous due to the assumption of a small open economy. Labor is assumed to be immobile across borders, and wage rates are determined in the labor markets of each country.

By log-differentiating (3)-(6), we have the central equation of the 'Generalized' version of the Balassa-Samuelson model.

$$\widehat{P}_N = (\widehat{A}_T - \widehat{A}_N) + \frac{\theta_N - \theta_T}{\theta_T}\widehat{A}_T \tag{7}$$

where $\widehat{}$ denotes the rate of change. (7) implies that the relative price of non-tradables is determined by the productivity changes of the tradables and non-tradables sectors. We call this commonly-used Balassa-Samuelson model as the 'GBS1 model' in the following. As Froot and Rogoff (1995) pointed out, the determinants of $\widehat{P}_N$ are not only the productivity growth differential of the tradables and non-tradables sectors, but also the balanced productivity growth of the two sectors. It should be noted that existing empirical studies (e.g., Gregorio et al. 1994) do not distinguish the two effects and evaluate only the mixed effect.

The effect of balanced productivity growth is due to the assumption of an exogenous rental rate of capital. Under the assumption, balanced growth leads to a rise in the wage rate only, while it does not affect the rental rate of capital. When the non-tradables sector is more labor intensive than the tradables sector, the rise in the wage rate pushes up the relative price of non-tradables. We call this balanced productivity growth effect as the 'BG effect' in the following.

The assumption of an exogenous rental rate of capital is, however, not realistic when we consider actual frictions in financial transactions across borders. If international financial markets are imperfect and the rental rate of capital is not equalized to the value in world markets, it is determined in the capital markets of each country. As for the wage rate, we assum in the GBS1 model that it is endogenous. It is often pointed out, however, that the wage rate is sticky, especially in the short run. In this case, it is not appropriate to assume that the wage rate is endogenous. In sum, it seems reasonable to assume that the rental rate of capital is endogenous and the wage is exogenous, contrary to the GBS1 model. Under those assumptions, it is straightforward to show from (3)-(6) the following equation.

$$\widehat{P}_N = (\widehat{A}_T - \widehat{A}_N) - \frac{\theta_N - \theta_T}{1 - \theta_T}\widehat{A}_T \tag{8}$$

Please note that the BG effect is negative in (8), while it is positive in (7). Under endogenous rental rate of capital and exogenous wage rate, balanced productivity growth leads to a rise in the rental rate of capital only, which pushes down the relative price of non-tradables. Thus the BG effect is negative in (8) while it is positive in (7). The effect of the productivity growth differential is the same in the two equations. We call the Balassa-Samuelson model under endogenous rental rate of capital and exogenous wage rate represented by (8) as the 'GBS2' model in the following.

The assumption in the GBS2 model that the wage rate is totally exogenous is, however, not realistic, especially in the long run. In the next subsection we will analyze the case that both of the wage rate and the rental rate of capital is endogenous introducing insights due to Kravis and Lipsey (1983) and Bhagwati (1984).[3]

2.2 The Kravis-Lipsey-Bhagwati effect

If international financial markets are not perfect and the rental rate of capital in a country is not determined in world markets, it is determined in the domestic financial markets. The wage rate is also determined in the domestic labor markets under the assumption that labor is immobile across borders and the wage rate is flexible. Then the rental rate of capital and the wage rate are determined endogenously in each country. Kravis and Lipsey (1983) and Bhagwati (1984) argue that if international financial markets are imperfect and the wage rate is flexible, factor endowments affect the relative price of non-tradables. In this subsection, we introduce their insight into the Balassa-Samuelson model.

When the rental rate of capital and the wage rate is endogenous, supply side conditions (3)-(6) do not pin down the inflation rate of the relative price of non-tradables. We specify the demand side of the economy by the following period utility function of a representative agent.

$$U(C_T, C_N) = C_T^{\alpha} C_N^{1-\alpha}, \tag{9}$$

[3] Gregorio and Wolf (1994) analyze under the assumption that capital is immobile both internationally and intersectorally.

where C_T and C_N denote the consumption of tradables and non-tradables.

To consider imperfect international financial markets, we assume for simplicity that there are no international financial transactions. Thus the rental rate of capital is determined by the capital markets of each country. Countries can export or import tradable goods, but they cannot have current account deficits or surpluses of tradables due to the non-existence of international financial markets. The current account of non-tradables is also equal to zero by assumption. Therefore, the dynamic optimization of a representative agent coincides with his period-by-period optimization.

In addition to (9), which assumes unit elasticity of substitution, we assume that the amount of investment and government expenditure are a constant portion of tradables and non-tradables. Under those assumptions, the ratio of tradables to non-tradables in production of a country becomes always constant.

$$\frac{Y_T}{P_N Y_N} = (const). \tag{10}$$

Market clearing conditions for labor and capital are

$$L_T + L_N = L, \tag{11}$$

$$K_T + K_N = K, \tag{12}$$

where L and K are the amount of labor and capital in the economy.

From (1)-(6) and (10)-(12) we obtain the following equation.

$$\widehat{P}_N = (\widehat{A}_T - \widehat{A}_N) + (\theta_N - \theta_T)\widehat{k} \tag{13}$$

where k is the capital-labor ratio of the economy. This is the central equation of our modified version of the Balassa-Samuelson model using capital accumulation (hereafter the 'MBS model'). The result implies that the relative price of non-tradables are affected not only by productivity differentials, but also by capital accumulation. The second term in the right hand side of (13) corresponds to the insights of Kravis and Lipsey (1983) and Bhagwati (1984). Therefore, we refer to the effect of capital accumulation on the relative price of non-tradables as the 'KLB effect' in the following. The relative price of non-tradables is governed entirely by the production side of the economy, even under the assumption of an endogenous capital rental rate.

Let us compare the GBS1 model, the GBS2 model, and the MBS model, which correspond to (7), (8) and (13), respectively. The first terms in the three equations are the same, i.e., the higher productivity growth in the tradables sector relative to the non-tradables sector leads to a rise in the relative price of non-tradables in all of the three models.

The difference between the GBS models and the MBS model comes from the second terms in (7), (8) and (13). In the MBS model, there is no BG effect. Balanced productivity growth does not affect the relative price of capital and labor, and the relative price of non-tradables does not change either. On the other hand, there is the KLB effect in the MBS model. A higher k leads to a fall in the relative price of capital, and this price change pushes up the relative price of labor intensive goods, namely, non-tradables. This effect is represented by the second term in (13). The difference between the GBS1 model and the GBS2 model is the sign of the BG effect. It is positive in the GBS1 model while it is negative in the GBS2 model. Table 1 (a) summarizes the functions of the three models.

Table 1 (b) shows the difference in assumption about factor prices. The GBS1 model and the GBS2 model assume that one of the two factor prices is exogenous, while they are both endogenous in the MBS model.

Existing empirical studies evaluate only the mixed effect of the first and the second terms of the right hand side of (7). Moreover, these studies do not take into account the negative BG effect and the KLB effect. In this paper we want to determine which of the three models, GBS1, GBS2, or MBS, is the most appropriate one for explaining changes in the relative price of non-tradables. In the next section, we answer this question using empirical analyses.

3 Empirical Analyses

Our regression analyses use data from the International Sectoral Data Base (ISDB) comprising 14 OECD countries.[4] We obtain data on total factor productivity and on the inflation rate for the tradables and the non-tradables sectors from 1970-1990. Gross capital stock of all industries is employed to calculate capital-labor ratio. The ISDB is augmented by data on population

[4] Australia, Belgium, Canada, Denmark, Finland, France, Germany (West), Italy, Japan, Netherlands, Norway, Sweden, the United Kingdom, and the United States.

taken from Penn World Tables 5.6 to calculate per-capita output, which we employ in the second half of this section.

We divide commodities into tradables and non-tradables, in line with Gregorio et al. (1994), except for the exclusion of the 'agriculture, hunting, forestry and fishing' industries from the tradables sector, and 'real estate and business services' from the non-tradables sector. This is because these industries are highly land-intensive and do not conform to the specifications of the GBS1, GBS2, and MBS models.

We consider the combination of (7), (8) and (13).

$$\widehat{P}_N = \beta_1(\widehat{A}_T - \widehat{A}_N)_{i,\tau} + \beta_2 BG1_{i,\tau} + \beta_3 BG2_{i,\tau} + \beta_4 KLB_{i,\tau}, \qquad (14)$$

where

$$BG1_{i,\tau} = \frac{\theta_{Ni} - \theta_{Ti}}{\theta_{Ti}} \widehat{A}_{T\tau},$$

$$BG2_{i,\tau} = \frac{\theta_{Ni} - \theta_{Ti}}{1 - \theta_{Ti}} \widehat{A}_{T\tau},$$

$$KLB_{i,\tau} = (\theta_{Ni} - \theta_{Ti})\widehat{k}_{\tau},$$

and subscript i and τ indicate country and year. $BG1$, $BG2$, and KLB correspond to the GBS1 model, GBS2 model, and the MBS model, respectively. We estimate the parameters using panel data from 14 countries for the period of 1970-1990. We first estimate using SUR with common coefficients across countries. To see the long-run effects, the estimation is also executed for average values over the sample period.

The short-run estimations using (14) are presented in Table 2. Regression 6 is estimated under the constraint that $\beta_1 = \beta_2$, which is implicitly assumed in other existing studies, for example, in Gregorio et al. (1994). The estimated coefficients on $(\widehat{A}_T - \widehat{A}_N)$ are consistent with our theoretical analyses and are statistically significant in all regressions. The coefficients on the BG effect denoted by β_2 and β_3 are statistically significant and negative in sign in regressions 1-5. This result is consistent with the GBS2 model and contradicts with the commonly-used GBS1 model. The coefficient on the KLB effect denoted by β_4 is not statistically significant except for regression 4, and the sign of β_2 is wrong in the regression.

Comparing the results of regressions 1 and 6 indicates that entangling the two factors - productivity differential and balanced productivity growth - may mislead us into the adoption of the GBS1 model.

To evaluate the long-run effects, we also perform analyses using average values over 20 years. The results of the OLS estimation are presented in Table 3. The coefficients on productivity differentials have the expected positive sign and are statistically significant in all regressions. Comparing Tables 2 and 3, we can see that β_1s are larger in the long run than in the short run. This implies that the effect of productivity differential shows up gradually.

As for the BG effect, it is statistically significant in regression 1. The positive sign of β_2 in the regression is consistent with the GBS1 model. On the other hand, the KLB effect, which is related to the MBS model, is statistically significant and has positive sign in all regressions. The compound model of the GBS1 model and the MBS model is tested in regression 4, which shows that the MBS model dominates the GBS1 model. Over the 1970s and the 1980s, capital accumulation contributed to lower the relative price of capital and to raise the relative price of non-tradables through the KLB effect. Our empirical evidence for the MBS model also implies that the assumptions of the model, imperfect international financial markets and flexible wage rate, is appropriate in the long run.

Thus far we have assumed in the MBS model that the elasticity of substitution of demand is equal to 1. Here we relax this assumption and allow the proportion of non-tradables in consumers' expenditures to be increasing with respect to their income. Consequently, an increase in per capita output leads to a rise in the relative price of non-tradables in the MBS model. As for the GBS1 model or the GBS2 model, they are not affected by the change in the demand side assumption. However, under the additional assumption of imperfect factor mobility across sectors, the relative price of non-tradables is affected by income change in the GBS models. Adding this demand side effect, we have the following equation:

$$\widehat{P}_N = \beta_1(\widehat{A}_T - \widehat{A}_N)_{i,\tau} + \beta_2 BG1_{i,\tau} + \beta_3 BG2_{i,\tau} + \beta_4 KLB_{i,\tau} + \beta_5 y_{i,\tau}, \quad (15)$$

where $y_{i,\tau}$ denotes per capita output.

The estimation results in the short run are presented in Table 4, and the results in the long run using average values over the sample period are in Table 5. Regression 6 in Table 4 is estimated under the constraint that $\beta_1 = \beta_2$. Table 4 shows that the demand side effect is significant and has the correct sign, while the estimated values of β_1, β_2, β_3, and β_4 in the table does not change significantly from those of Table 2, except for the low significance of β_4 in regression 4. Again, the GBS2 model is the most appropriate one to explain the movements of the relative price of non-tradables in the short run.

We see from Table 4 and Table 5 that the demand side effect is more important in the short run than in the long run. Estimates of β_5 in Table 5 show that the demand side effect is not significant in the long run, contrary to the estimates in Table 4. The result is consistent with those obtained in Gregorio et al. (1994). We can conclude from Tables 3 and 5 that the MBS model is the most appropriate one to explain the long-run changes in the relative price of non-tradables.

In sum, the GBS2 model is appropriate in the short run, and the MBS model is appropriate in the long run. The commonly-used Balassa-Samuelson model, namely, the GBS1 model, is not supported both in the short run and in the long run.

4 Conclusions

In this paper, we proposed modifications to commonly-used Balassa-Samuelson model. The modified models show that the effect of balanced growth on the relative price of non-tradables can be positive or negative, and that the effect of capital accumulation should be taken into account. Our empirical analyses suggest that the commonly-used Balassa-Samuelson model is not appropriate. The GBS2 model, which assumes imperfect international financial markets and rigid wage rate, is more suited to explain the changes in the relative price of non-tradables in the short run. In the long run, the MBS model, which assumes imperfect international financial markets and flexible wage rate, is supported.

We did not empirically analyze the effect of inflation in the price of non-tradables on real exchange rates. Asea and Mendoza (1994) claim that the effect of non-tradables goods' inflation on the real exchange rate is insignificant. The modifications proposed in this paper enables more precise estimates of the changes in the price of non-tradables, which can be used to evaluate the effect of inflation of non-tradables on real exchange rates. Estimation of the direct effects of balanced growth and capital accumulation on real exchange rates would also be fruitful.

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