

# Real Exchange Rate and the Productivity Growth Rates using Panel Data

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## **Abstract**

In this paper, we try to explain the fluctuation of real exchange rates using the Balassa-Samuelson (B-S) theory. According to the B-S theory, if a country has a higher productivity growth rate than does its trading partner, then the country's real exchange rate will appreciate. This paper is tested using panel data and the differences in the labor productivity growth rates of the tradable-goods and non-tradable sectors between two countries. The results may be summarized as follows. (1) The variation in the real exchange rate is affected by the between-country difference in the labor productivity growth rate of the non-tradable sector rather than that of the tradable sector. (2) In most countries, the expected signs hold.

## I. INTRODUCTION

The Balassa-Samuelson (B-S) theory, which describes fluctuations in real exchange rates, has been tested in empirical studies in the past. According to the B-S theory, if a country has a higher productivity growth rate than its trading partner, then the country's real exchange rate will appreciate. Studies that support the B-S theory include DeGregorio et al. (1994), Chinn et al. (1996), and Canzoneri et al. (1996). Froot et al. (1991) disputes the theory. DeGregorio et al. (1994) found that for short run fluctuations of real exchange rates, both the tradable-goods and non-tradable sectors are important. They also found that the difference in the productivity growth rate of the tradable sector was more important in explaining long run fluctuations.

In this paper, we try to explain exchange rate fluctuations by the between-country differences in productivity growth rates of the tradable and non-tradable sectors using the B-S theory. We find that our analysis supports the Balassa-Samuelson effect but differs from the result of DeGregorio et al. (1994), since we find that the difference in the productivity growth rate of the non-tradable goods sector is the more important factor. The expected signs hold for Random Coefficients Model.

This paper is composed of four sections. In the next section we describe the model. We explain the B-S theory and the econometric analysis used. These econometric analysis use panel data and three different models: the Dummy Variable Model (DVM), the Error Components Model (ECM), and Swamy's Random Coefficients Model (Swamy's RCM)(Swamy (1970)). In section III we report the estimated results after describing the data sets and the estimated models. Conclusions are presented in section IV.

## II. MODELS

Figure 1 and 2 shows the rates of change of the real exchange rates of major industrialized countries. These rates of change are obviously inconstant. As is clear in Figure 1 - 2, the variation of the nominal exchange rate causes short run variations in the real exchange rate due to short run nominal price rigidities<sup>1</sup>, but in the long run real exchange rate variations have to be explained by real factors. One theory explaining the deviation of the real exchange rate from its long-run purchasing power parity (PPP) was proposed by Balassa (1964) and Samuelson (1964).

We consider a small country producing both tradable-goods and non-tradable goods<sup>2</sup>, where both goods are produced under the constant returns to scale production function:

$$Y_T = A_T F(K_T, L_T), Y_N = A_N G(K_N, L_N), \quad (1)$$

where T(N) is the tradable (non-tradable) good;  $K_i$  and  $L_i$  are the  $i$ -th sector's capital and labor input, respectively; and  $A_i$  is the  $i$ -th sector's productivity parameter ( $i=T,N$ ). Labor is completely mobile between sectors, but not between countries. Thus within a country each sector has the

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<sup>1</sup> For example, the U.K. and Italy have similar fluctuations to Germany and France until 1992, but very different fluctuations from 1993 onwards following withdrawal from the European Monetary System.

<sup>2</sup> The explanation here refers to Obstfeld et al. (1996), Chap.4 and Froot et al. (1995).

same wage  $w$ . Capital is completely mobile between sectors and between countries. Thus the domestic rate of return on capital is equal to the world interest rate,  $r$ .

The rate of change of the real exchange rate can be decomposed into various components:

$$\begin{aligned}\hat{q} &= -\gamma(\hat{p} - \hat{p}^*) \\ &= -\gamma\left(\frac{\theta_{LN}}{\theta_{LT}}\hat{A}_T - \frac{\theta_{LN}^*}{\theta_{LT}^*}\hat{A}_T^*\right) + \gamma(\hat{A}_N - \hat{A}_N^*)\end{aligned}\quad (2)$$

This paper uses panel data. Most papers use time series data, and very few use cross sectional data or panel data. There are two main advantages in using panel data instead of time series or cross sectional data. First, in the case of small sample sizes, panel data enables larger degrees of freedom than do either cross sectional or time series methods. Second, panel data allows us to analyze effects that cannot be handled by cross sectional or time series methods. For example, dynamic movements cannot be analyzed using cross-sectional data, and time series approaches lead to analysis only about each country and not the specific effects within each country.

The use of panel data does have its limitations, however. There is the possibility that estimates vary greatly depending on the model used. The models used in this paper include the DVM, the ECM, and Swamy's RCM. However, the assumptions satisfying each case were not found to exist. Therefore, the DVM estimates are used as a benchmark, and the estimated results in the ECM and Swamy's RCM are reported when the parameter lies at right angles to the explanatory variables<sup>3</sup>.

### III. ESTIMATION of MODELS

All data are annual observations from 1973 to 1991. The U.S. dollar Nominal Exchange Rate (rf(or rh)) and the Consumer Price Index (CPI, 64) are taken from the IMF's *International Financial Statistics*. All data are in natural log form. The CPI is computed from data for the following eleven countries: Japan, Italy, Germany, France, the United Kingdom, Belgium, Denmark, Finland, Netherlands, Norway and Sweden.

The labor productivity growth rates of both the tradable and non-tradable goods sectors are based on the OECD's *National Account*<sup>4</sup>. Industries that are included in the tradable and non-tradable sectors use the classification of DeGregorio et al. (1994)<sup>5</sup>. The tradable sector includes "Agriculture, hunting, forestry and fishing", "Mining and quarrying", "Manufacturing",

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<sup>3</sup> Though Swamy's RCM is replaced by a Seemingly Unrelated Regression (SUR), if the orthogonality assumption is not satisfied, then we report the SUR result since it accepts orthogonality in all cases.

<sup>4</sup> The growth rate of labor productivity is determined by taking the natural log of GDP divided by the number of employees in both the tradable goods and non-tradable goods sectors, and taking the lag of order one.

<sup>5</sup> DeGregorio et al. (1994) defined and classified tradable goods. Tradable goods are the ratio of the total exports among the 14 OECD countries to total output of these countries exceeding 10 percent.

“Transport, storage and communication”. The non-tradable goods sector includes “Electricity, gas and water”, “Construction”, “Wholesale and retail trade, restaurants and hotels”, “Finance, insurance, real estate and business services” and “Community, social and personal services”; and “Producers of Government Services” and “Other Producers” as non-market services.

It matters whether data are consistent. (1) In the USA, the United Kingdom and Norway, “Other Producers” are not included. (2) In Italy, France and Belgium, “Mining and quarrying”, “Community, social and personal services” are not included. (3) In France, “Wholesale and retail trade, restaurants and hotels”, “Transport, storage and communication”, “Finance, insurance real estate and business services” are not included.

We briefly show the results of our models here. The DVM is estimated using equation (3); the ECM is estimated using equation (4); and Swamy’s RCM is estimated using equation (5).

$$\Delta q_{it} = \beta_1 + \beta_2 (\Delta A_T - \Delta A^*_T)_{it} + \beta_3 (\Delta A_N - \Delta A^*_N)_{it} + \sum_{i=1}^{N-1} \mu_i D_i + \sum_{t=1}^{T-1} \lambda_t D_t + u_{it} \quad (3)$$

$$\Delta q_{it} = \beta_1 + \beta_2 (\Delta A_T - \Delta A^*_T)_{it} + \beta_3 (\Delta A_N - \Delta A^*_N)_{it} + \sum_{i=1}^N \mu_i d_i + \sum_{t=1}^T \lambda_t d_t + u_{it} \quad (4)$$

$$\Delta q_{it} = \beta_1 + \beta_2 (\Delta A_T - \Delta A^*_T)_{it} + \beta_3 (\Delta A_N - \Delta A^*_N)_{it} + \sum_{i=1}^N \mu_{1i} d_i + \sum_{i=1}^N \mu_{2i} (\Delta A_T - \Delta A^*_T)_i + \sum_{i=1}^N \mu_{3i} (\Delta A_N - \Delta A^*_N)_i + u_{it} \quad (5)$$

where  $q$  is the real exchange rate ( $q=e-(p-p^*)$ );  $\Delta$  is the lag operator of difference 1;  $i$  represents country  $i$ ;  $t$  is time;  $e$  is the natural log of the nominal exchange rate to the US dollar;  $p(p^*)$  is the natural log of the price level in the  $i$ -th country’s currency (the USA);  $D_i(D_t)$  is the country-specific (time-specific) “fixed effect” dummy variable;  $d_i(d_t)$  is the “random effect” variable;  $\Delta A_T(\Delta A^*_T)$  is the rate of labor productivity growth of the tradable sector in country  $i$ (the USA);  $\Delta A_N(\Delta A^*_N)$  is the productivity growth of the non-tradable goods sector in country  $i$ (the USA); and  $u_{it}$  is the stationary disturbance term.

$\beta_2$  and  $\beta_3$  are parameters. According to B-S theory, if the productivity growth rate of the tradable sector is higher in country  $i$  than in the United States, the real exchange rate appreciates. Therefore, the expected sign of  $\beta_2$  is negative. If it is negative, the B-S theory explains the fluctuation of the real exchange rate and the failure of PPP. On the other hand, the expected sign of  $\beta_3$  is positive. Then if the productivity growth rate of the non-tradable goods sector is higher in country  $i$ , the real exchange rate will depreciate, and B-S theory is supported.

There is a difference in the fluctuation of real exchange rates by country, as shown in Figure 1 - 2.  $\mu_{2i}$ , and  $\mu_{3i}$  show random deviations from  $\beta_2$  and  $\beta_3$  on average, and show the difference,  $\beta_{2i}$ ,  $\beta_{3i}$ , by country<sup>6</sup>.

Table 1 shows the estimated results of the B-S theory. This table is divided into estimates from the DVM (OLS) as a benchmark at the top, from ECM in the middle, and from

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<sup>6</sup> The explanatory power of the B-S theory differs in each country, as pointed out by Obstfeld (1995).

Swamy's RCM at the bottom. The estimated values include the joint country and time effects, country effects only, and time effects only ( $m$  and  $z$  indicate the Hausman test statistic (Hausman (1978)) and the Pudney test statistic (Pudney (1978)), respectively). The DVM (OLS) estimates indicate standard errors modified by MacKinnon and White's HC3 (MacKinnon et al. (1985)) when heteroscedasticity exists. From these latter results, one can say that the differences in the factor in real exchange rate fluctuations, except in the case of Swamy's RCM. The expected signs hold in all cases. The difference in the tradable goods sectors is insignificant, but the domestic currency appreciates 3 to 58 percent relative to the U.S. dollar if this sector's labor productivity growth rate is one percent higher in the domestic country relative to that of the United States. On the other hand, the difference in the non-tradable goods sector is significant in all cases, and the expected signs hold, too. This means that the domestic currency depreciates 10 to 55 percent relative to the U.S. dollar if the non-tradable goods sector has a labor productivity growth rate that is one percent higher in the domestic country than in the United States. These results differ from DeGregorio et al. (1994) in that the between-country difference in labor productivity growth rates of non-tradable goods sector has greater the explanatory power in terms of real exchange rate fluctuations than does the tradable goods sector. These results may be due to the fact that the real exchange rate adjusts the nominal exchange rate by the CPI, and the CPI includes the non-tradable goods sector, which accounts for 50 to 60 percent of each country's output.

However, the explanatory power of the B-S theory varies greatly by country, as pointed out by Obstfeld (1995). Table 2 shows the estimates by country using Swamy's RCM. The expected signs hold in almost all cases, though the use of the RCM model prohibits more detailed comparisons between countries. Moreover, Japan's results suggest that a depreciation of the real exchange rate through the period shown by Figure 1 - 2.

#### **IV. CONCLUSION**

The results in this paper may be summarized as follows.

(1) To explain fluctuations in the real exchange rate, we examine between-country differences in labor productivity growth rates of the tradable goods and non-tradable goods sectors. We find that a change in the real exchange rate is more likely to be influenced by productivity differences in the non-tradable goods sector than by productivity differences in the tradable goods sector. (2) In most countries the impact of between-country differences in sectoral labor productivity growth rates has the expected sign effect on the real exchange rate, consistent with the B-S theory.

Further research includes the following extension. This paper has focused on the supply side of the B-S theory; the analysis can be extended to consider demand side variables, such as consumption, government expenditure and so on.

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Figure 1: Rate of change in real exchange rates in the major industrial countries

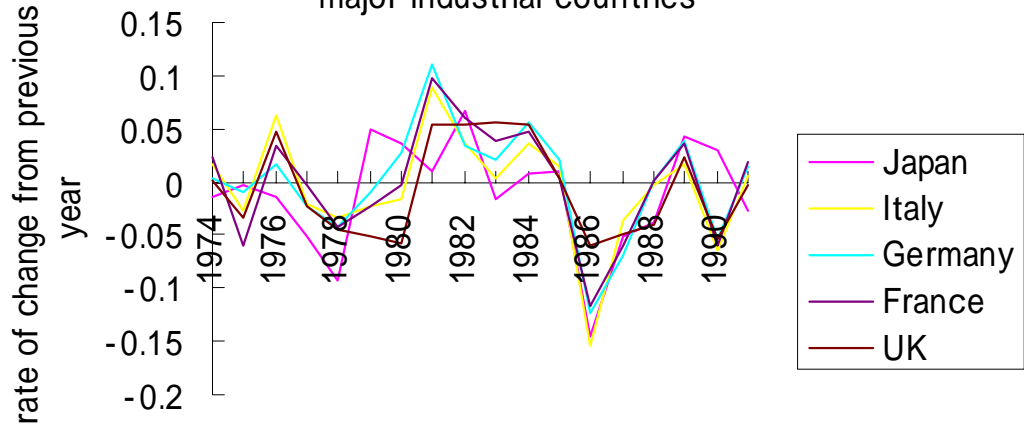


Figure 2: Rate of change in real exchange rates

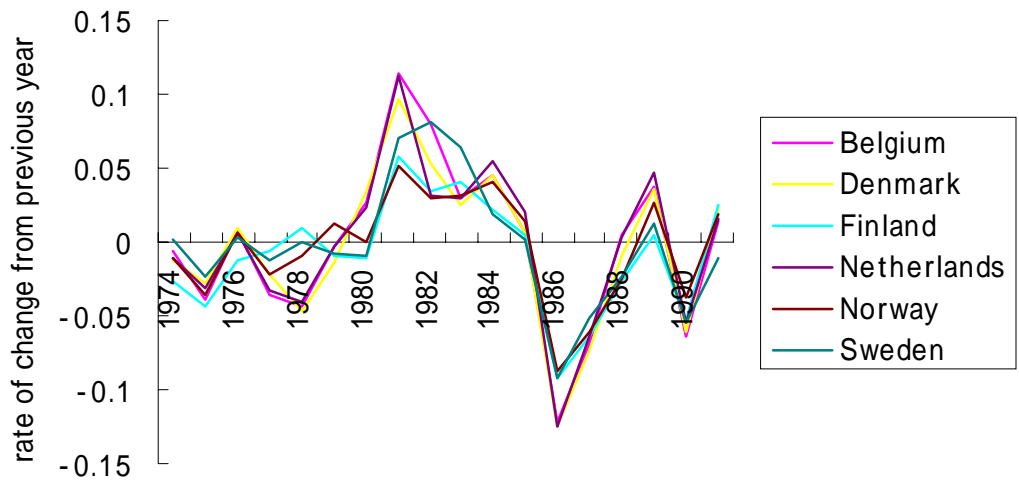


Table 1. Estimated result to Balassa-Samuelson theory

	2	3	sample	
<b>Dummy Variable Model</b>				
	-0.02865	0.09814 <sup>***</sup>		
whole	(0.02483)	(0.03545)	198	
	-0.06682	0.2949 <sup>***</sup>		
country	(0.0514)	(0.0699)	198	
	-0.02608	0.09937 <sup>***</sup>		
time	(0.02388)	(0.03378)	198	
<b>Error Components Model</b>				
	-0.06868	0.2764 <sup>***</sup>		m
whole	(0.04882)	(0.06566)	198	961.5641
	-0.06482	0.2266 <sup>***</sup>		
country	(0.04364)	(0.05696)	198	6.9083
	-0.06747	0.2811 <sup>***</sup>		
time	(0.0494)	(0.06671)	198	2.31E-13
<b>Swamy Random Coefficients Model</b>				
	-0.5861 <sup>*</sup>	0.5568 <sup>**</sup>		z
	(0.3208)	(0.2372)	198	6.5001

Note: Standard error in parenthesis

Three(\*\*\*), two(\*\*) and one(\*) asterisk indicates statistically significant at the 1, 5 and 10 percent levels, respectively.

Base country: USA

Terms: 1974 - 1991

Table2. Factor of the specific effects of Balassa-Samuelson theory (Swamy RCM)

	$2i$	$3i$
Japan	-0.0869	-0.054
Italy	-0.0263	0.1616
Germany	-0.6922	0.6067
France	0.0906	-0.0015
UK	-0.4091	0.9151
Belgium	-0.0594	0.0825
Denmark	-2.0162	0.8249
Finland	-0.1179	0.7038
Netherlands	-2.3691	1.1577
Norway	-0.6525	0.8708
Sweden	-0.1076	0.8574