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PRODUCTIVITY DIFFERENTIALS AND THE REAL EXCHANGE RATE: EMPIRICAL EVIDENCE FROM INDIA

Purna Chandra Parida
B Kamaiah
Maathai K Mathiyazhagan

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PRODUCTIVITY DIFFERENTIALS AND THE REAL EXCHANGE RATE: EMPIRICAL EVIDENCE FROM INDIA[a]

Purna Chandra Parida[b]

B Kamaiah[c]

Maathai K Mathiyazhagan[d]

Abstract

This paper examines the long-run relationship between the real exchange rate and productivity differentials on traded and non-traded goods in India and Japan by using the data relating to the period from 1974 to 1998. The study uses the co-integration technique and finds that there is evidence for the Balassa-Samuelson hypothesis, which stipulates that productivity differences in the traded and non-traded goods have a stable long-run equilibrium relationship with real exchange rate.

Introduction

The first and most important model of long-run deviations of the real exchange rate from the 'Purchasing Power Parity' (PPP) was advanced more than 35 years ago by Balassa (1964) and Samuelson (1964). They argued that when all countries' price levels are translated to dollars at prevailing nominal exchange rates, rich countries tend to have higher price levels than the poor countries. The reason for this phenomenon has not been merely that rich countries have higher absolute productivity levels than the poor countries, but that rich countries have relatively more productivity in the traded goods sector. A pertinent question that may arise here is: how is the general price level higher in the rich countries than poor countries, when the former are productively more advantageous

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b Research Fellow, RBI Endowment Unit, Institute for Social and Economic Change (ISEC), Nagarbhavi, Bangalore-72.

c Professor, Department of Economics, University of Hyderabad, Hyderabad-46.

d Assistant Professor, Economics Unit, ISEC, Nagarbhavi, Bangalore-72

in the traded goods sector. The reason may be due to the fact that productivity differential between traded and non-traded goods in the rich countries is relatively higher than that in the poor countries. Higher the productivity differential between the traded and non-traded goods, higher would be the general price level, viz., increase in prices of non-traded goods. Thus, the mechanism of this process shows that an increase in productivity of traded goods sector may have a neutral effect on the general price level, when the exchange rate is fixed and domestic price level is tied down by the world price level. However, increase of productivity in the traded goods sector fuels the wage level to move upward. In fact, if there has been no corresponding increase of productivity in the non-traded sector in order to match the higher wages in the production of tradables, the non-traded goods producers must raise their prices. With one component of the general price level being constant while the other is higher, would naturally result in an increase in the overall price level. To sum up, the Balassa-Samuelson hypothesis suggests that a positive innovation in the traded productivity leads to an increase in the relative price of non-tradables, which in turn would cause an increase of the general price level and appreciation of both external as well as internal real exchange rates.

The empirical evidence of Balassa-Samuelson (B-L) hypothesis is mixed in the existing literature. In a more comprehensive study, Kravis et al (1982) compared the real gross domestic products of 34 countries in the world, constructing data for UN-sponsored International comparison program (ICP) and supported the proposition of Balassa- Samuelson. Arriving at the same conclusion in a different way, Kravis and Lipsey (1983), and Bhagwati (1984) stated that it is the difference in capital-labour ratio rather than productivity differences between the countries that causes price level to be higher in the rich countries.

A study by Asea and Mendoza (1994) verified the validity of B-L hypothesis in the context of fourteen OECD countries using disaggregated sectoral data over the period from 1975 to 1990. The study used a general equilibrium model incorporating the adjustment cost of moving factors across sectors. The results of the study suggest that sectoral differences in productivity growth help to explain the trend rise in service prices within OECD countries, but have much less power in explaining the relative price of non-traded versus traded goods across countries.

De Gregorio and Wolf (1994) attempted to decompose short-term real exchange rate movements into the component caused by changes in the relative price of non-traded goods (the B-L effect), and changes in the relative price of traded goods (changes in the terms of trade). The study found that terms of trade shift account for a very substantial component of real exchange rate movements and B-L effect is important only over longer-term horizons.

Study by De Gregorio, Giovannini, and Wolf (1994) examined the productivity differential issue in the context of 14 OECD countries during the period 1970 to 1985. The empirical evidence of the study suggests that there was faster productivity growth in the traded goods sector. Indeed, it was associated with an increase in domestic relative price of non-traded goods for some sample countries. Further, the study also finds that an increase in the relative price of non-traded goods was associated with an increase in the relative size in the non-traded-goods sector. From this type of result, the study speculates that the demand-side factors may also have some role in the determination of the RER for those countries.

The study by Faruqee (1995) tested the long-run real exchange rate in the context of two developed countries such as Japan and US. The study identified two supply-side determinants of real exchange rate, namely, net foreign assets and productivity differentials. Employing cointegration technique, the study concluded that both the determinants have long-run relationship with real exchange rate in the case of US. However, the only relationship between productivity differentials and real exchange rate is found in case of Japan.

Reviewing a wide range of empirical studies on the validity of Balassa-Samuleson hypothesis, Rogoff (1996) concludes that 'overall, there is substantial empirical support for the B-L hypothesis, especially in comparisons between very poor and very rich countries, and in time-series data for a select number of countries, including especially Japan'.

A study by Canzoneri, Cumby, and Diba (1996) found that B-L hypothesis is not applicable to industrial countries, especially in the medium-term. The study assumed two reasons: (1) the production technology of industrial countries, implies that the relative price of non-traded goods in each country (its internal RER) may reflect the relative productivity in the traded- and non-traded-goods sectors and (2) the 'Law of One Price' holds only for traded goods. Using data from a panel of OECD countries, the study found that internal relative prices reflected the relative labour productivity. However, it found that the 'Law of One Price' does not explain the variation in traded-goods prices very effectively, especially for the US Dollar and more favourable for the German Mark. Hence, it concludes that the problem with the B-L hypothesis for external RERs is due to the failure of the 'Law of One Price' for traded goods. While other studies by Froot and Rogoff (1991) and Gordon (1994) fail to find any support for B-L hypothesis, Hsieh (1982), Loayza and Lopez (1997) found evidence in favour of it (for more detailed reviews see Edwards and Savastano (1999), Henkle and Montiel (1999)).

In the Indian context, there are no studies to date, with the exception of that by Paul and Kulkarni (1991), who tested the random walk behaviour of real exchange rate and its fundamental determinants in the context of India and some developed countries. Testing the unit roots tests of six constructed real exchange rates and four fundamentals such as relative prices of tradable and non-tradable goods, productivity differentials, cumulative trade balance differences, and differentials of real short-term and long-term interest rates, the study concluded that all the exchange rates followed random walk. However, from cointegration tests, the study found mixed evidence of long-run relationship between real exchange rate series of different currencies and different fundamentals. Indeed, the study did not find any evidence of long-run relationship between real exchange rate and any of the fundamentals in the Indian context. As far as the productivity differential is concerned, it found evidence only in the context of US, Germany, and Japan. In the light of the above discussion, a pertinent question arises that are real factors solely responsible for deviation of RER from PPP? In this regard, there are no studies in India, which examined the above issue. The present study tries to examine the productivity differentials in both the traded and non-traded goods in the context of India. It is imperative to note that the productivity differentials are more pronounced between developed and developing countries than either among industrialized countries or developing countries taken separately as a group (Rogoff, 1996). In this context, the present study also considered Japan to examine this issue.

A Simple Model of Productivity Differential

From the 'Law of One Price', we have

$$e = p / p^* \qquad \ldots (1)$$

where e is bilateral nominal exchange rate (defined as units of domestic currency per unit of foreign currency). p is general price level of domestic country and p^* is general price level of the foreign country. The real exchange rate (E) may be defined as:

$$E = e\, p^* / p \qquad \ldots (2)$$

A productivity differential of Hsieh (1982) and Strauss (1999) type is adopted in the present study. It is assumed here that there are two sectors, viz., traded goods and non-traded goods. It is assumed further that labour is the only factor used in the production process and which is perfectly mobile between the two sectors within a country (and not between the two countries). The production functions are assumed to exhibit constant returns to scale. Further, the general price levels of the domestic and foreign countries comprise prices of traded and non-traded goods built up in the following form :

$$p = (p_t)^{1-\alpha} (p_n)^{\alpha} \qquad \ldots (3)$$

$$p^* = (p^*_t)^{1-\beta} (p^*_n)^{\beta} \qquad \ldots (4)$$

where α and β are constants (between zero and unity), p_t and p_n are the price of traded and non-traded goods in the domestic country. The asterisk denotes similar variables for the foreign country.

Now substituting the values of p and p* in equation (3) and (4), in equation (2), and rearranging the terms, we get,

$$E = \alpha(p_t - p_n) - \beta(p^*_t - p^*_n) + (e + p^*_t - p_t) \qquad \ldots (5)$$

wherein all variables are expressed in logs. This equation explains real exchange rate as a function of relative price differences between traded and non-traded goods in domestic and foreign country and relative price differences of traded goods between domestic and foreign country. In equation (5), if we assume that there is arbitrage in the traded goods, the term $(e + p^*_t - p_t)$ would be equal to zero, where the deviation of E from PPP happens due to differences in relative prices of non-traded goods. A positive innovation in the traded goods implies an increase in general price level of the foreign country more than that of the domestic country, due to a higher productivity in the former country. This would appreciate the real exchange rate, which implies a fall in E. Hsieh (1982) and Marston (1987) validate this proposition, where as Asea and Mendoza (1994) find only a weak relationship between productivity differentials and real exchange rates. In order to detect the behavior of real exchange rate and the movements of relative price changes of traded and non-traded goods, it is assumed that perfect competition prevails in the market where firms set prices to reflect unit labor cost (expressed in nominal wages adjusted for productivity) in each sector as follows:

$$p_t = w - a_t,\ p_n = w - a_n,\ \ p^*_t = w^* - a^*_t,\ \ p^*_n = w^* - a^*_n \qquad \ldots (6)$$

where a_t and a_n are respectively productivities of traded and non-traded goods, and w is the nominal wage rate, which is equalized within the two sectors at home (but not across national boundaries). By substituting values of p_t, p_n, p^*_t, and p^*_n in equation (5), the following form could be obtained:

$$E = -\alpha(a_t - a_n) + \beta(a^*_t - a^*_n) - (a^*_t - a_t - e + w - w^*) \quad ...(7)$$

In equation (7), the first term on the right hand side is the difference in the growth rates of labour productivity between the traded and non-traded sectors at home. The second term is the difference between the two sectors abroad. The third term is the difference in the rate of growth of unit labour costs of traded goods between the two countries. Equation (7) is tested by regressing E on a constant term, the variables $(a_t - a_n)$, $(a^*_t - a^*_n)$ and $(a^*_t - a_t - e + w - w^*)$. That is

$$E = b_0 - b_1(a_t - a_n) + b_2(a^*_t - a^*_n) - b_3(a^*_t - a_t - e + w - w^*) + u_t \quad ...(8)$$

where u_t is the error term of the regression and all other variables are as defined earlier.

Empirical Analysis

The data used in this study are annual observations ranging from 1974 to 1998. Only manufacturing goods are considered as traded goods and non-manufacturing goods are treated as non-traded goods. Although agricultural goods contribute a major share of total traded goods following manufacturing goods in India, it is not included in the traded goods due to two reasons. First, since its share in total traded goods in Japan is very less, to maintain homogeneity the manufacturing sector has been considered as the only traded goods sector. Secondly, the agricultural prices are very much influenced by government policies and hence are not reliable for empirical verification. Data for nominal exchange rates, CPI, and GDP for both India and Japan, and manufacturing employment and output of Japan have been collected from various issues of the IMF's *International Financial Statistics (IFS).* For India, manufacturing output and employment are collected from India's *Economic Survey.* The data for total employment for both countries are collected from OECD and ASEAN data reported by ILO. The data on nominal wages in manufacturing sector of both the countries are obtained from the *Statistics of International Labor Organization.* Productivity is defined as industrial output in manufacturing divided by employment in that sector. Non-Traded productivity is constructed by dividing non-traded output (total GDP minus manufacturing) by non-traded employment (total employment minus manufacturing).

The present study uses cointegration techniques to find out the long-run equilibrium relationship among the relevant variables. Before applying and interpreting the results of cointegration as usual of the general time series procedures, the study first examines the stationarity of all variables. In this regard, it applied four well-known unit root tests namely, Dickey-Fuller (DF), Augumented Dickey-Fuller (ADF), Phillips-Perron (PP), and KPSS. The results of unit root tests are reported in Table 1 with level and in Table 2 with first difference.

The results of Table 1 confirm that all variables are non-stationary indicating that they have unit roots. Hence, findings of the present study that real exchange rate is non-stationary supports the findings of the earlier studies (Mark, 1990, Paul and Kulkarni, 1991, Gan, 1994, Calvo, Reinhart and Vegh, 1995 with others). However, in their first difference the null hypothesis of unit root is rejected for all variables (Table 2), signifying that all series are integrated order 1, that is I(1).

The present study employs Johansen maximum likelihood test (see Appendix 1) to find out the long-run equilibrium relationship among the variables. The results reported in Table 3 shows that there is evidence of at least one cointegrating vector. The value of trace statistics evidences that the null hypothesis of no cointegrating vector (r = 0) against the alternative hypothesis of one or more cointegrated vector (r > 0) is rejected at 10 % significance level. This is also evident in λ_{MAX} statistics, where the null hypothesis of no cointegrating vector (r = 0) against the alternative hypothesis of one cointegrating vector is rejected at 10 % significance level.

In general, the presence of at least one cointegrating vector evidences long-run equilibrium relationship among the variables. The presence of a cointegrating vector in the above results implies that there exists a long-run relationship among the concerned variables. The next step is to examine whether the variables are error-correcting to the system or not. This may be ascertained by employing weak exogeneity tests. The results of weak exogeneity tests are reported in Table 4. The results indicate that the real exchange rate (RER) and productivity differential between traded and non-traded goods in India (PDTNTI) are weakly exogenous to the system, where the null hypothesis of weak exogeneity cannot be rejected. On the other hand, productivity differential between traded and non-traded goods in Japan (PDTNTJ) and rate of growth of unit labor cost in traded goods sector between India and Japan (RGULC) are not weakly exogenous to the system. This implies that first two variables RER and PDTNTI only have long run relationship with the other variables in the system, but do not adjust to the short-run disequlibrium. The last two variables viz., PDTNTJ and RGULC are error-correcting to the system. Thus, it could be concluded that productivity differences of traded and non-traded goods in Japan and unit labour costs differentials between India and Japan share a relationship with real exchange rate.

From the above results, it may be also concluded that in addition to unit labour costs differentials, the significant differences of productivity between traded and non-traded goods have a long-run equilibrium relationship with the real exchange rate. The findings of the present study support the hypothesis of Balassa and Samuelson in line with other studies like Hsieh (1982), Kravis and Lipsey (1983) and Rogoff (1996). Hence the study concludes that productivity differential is one of the most important real fundamental which deviated the real exchange rate from PPP par.

Summary and Conclusion

The present study examines the productivity differential hypothesis of Balassa and Samuelson in the context of India, where it has not received much attention in the past. More specifically, this study examines the effects of productivity differences in the traded and non-traded sectors on real exchange rate in the context of India and Japan during the period of 1974 -1998. Applying the cointegration technique, the present study concludes that in addition to the unit labour costs differentials, the productivity differences in the traded and non-traded sectors has a stable long-run equilibrium relationship with real exchange rate. The results of the error-correction model reveal that productivity difference between traded and non-traded goods of Japan and unit labour costs differentials in traded goods sector between the two countries adjust to short-run disequilibrium. It implies that there is relationship between productivity differentials of traded and non-traded goods and unit labour cost with the real exchange rate. Thus, the results of the analysis support the B-L hypothesis in the context of India. It is important to note that the study has not included many traded goods in the traded sector for the analysis and hence the findings of the study may be considered as tentative.

Appendix 1

The multivariate cointegration framework is used in the present study as consider a standard one for the VAR systems. The whole system of this framework may be summarized as follows (see Johansen 1988, and Johansen and Juselius 1990).

Let Z_t is a vector of n potentially endogenous variables with k-lags and can be written in VAR form as:

$$Z_t = A_1 Z_{t-1} + \ldots + A_k Z_{t-k} + u_t \qquad u_t \sim IN(0, \Sigma) \qquad \ldots(1)$$

(or)

$$Z_t = \Sigma^k_{i=1} A_i Z_{t-i} + u_t \qquad (t = 1, 2, \ldots T) \qquad \ldots(1)$$

Where Z_t is (n ´ 1) matrix, A_i are matrices of parameters, u_t is a Gaussian error term and T is the total number of observations. The system implies that in reduced form with each variable Z_t regressed not only its lagged values but also lagged values all other variables in the system.

Equation (1) can be reformulated into a vector error-correction model (VECM) form as:

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \ldots + \Gamma_{k-1} \Delta Z_{t-k+1} + \Pi Z_{t-k} + u_t \ \ldots \qquad (2)$$

(or)

$$\Delta Z_t = \Sigma^{k}_{i=1} \Gamma_1 \Delta Z_{t-i} + \Pi Z_{t-k} + u_t \ \ldots \qquad (2)$$

Where Δ is the first difference operator, $\Gamma_i = -(I - A_i - \ldots - A_i)$, (i = 1, . . . k -1), and $\Pi = -(I - A_1 - \ldots - A_k)$. This system contains information on both the short-run adjustment to changes in Z_t, via the estimates of $\hat{\Gamma}$ and $\hat{\Pi}$ respectively. On this line, Π may be factorized as $\Pi = \alpha\beta'$, where α represents the speed of adjustment to disequilibrium and β is a matrix of long-run coefficients such that the term $\beta' Z_{t-k}$ represents up to (n - 1) cointegration relationships in the multivariate model. It ensures that the Z_t converge to their long-run steady state solutions.

The number of distinct cointegraing vectors can be obtained by checking the significance of the characteristic roots of Π. It states that the rank of a matrix is equal to the number of its characteristic roots that differ from zero. Suppose the matrix Π contains order of n characteristic roots such that $\lambda_1 > \lambda_2 > \lambda_3 > \ldots > \lambda_n$. If the variables in Z_t are not cointegrated, the rank of Π is zero and all these characteristic roots will equal unity. Since In (1) = 0, each of the expressions In $(1 - \lambda_i)$ will equal to zero if the variables are not cointegrated. Similarly, if the rank of Π is unity, the first expression in $(1 - \lambda_1)$ will be negative and all the other expressions are such that In $(1 - \lambda_1)$ = In $(1 - \lambda_2)$ =...... = In $(1 - \lambda_n) = 0$.

The test for the number of characteristic roots that are insignificantly different from unity can be conducted using the following test two statistics as:

$$\lambda_{trace}(r) = -T \Sigma^{n}_{i=r+1} \log(1 - \hat{\lambda}_i) \quad r = 0, 1, 2, \ldots, n-2, n-1 \ \ldots \ (3)$$

$$\lambda_{tmax}(r, r+1) = -T \log(1 - \hat{\lambda}_{r+1}) \quad r = 0, 1, 2, \ldots, n-2, n-1 \ \ldots \ (4)$$

where $\hat{\lambda}_i$ are the estimated values of the characteristic roots (also called eigen values) obtained from the estimated Π matrix; and T is the number of usable observations. When the appropriate values of r clear, these statistics are simply referred to as λ_{ttrace} and λ_{tmax}.

In the first statistic tests, the null hypothesis: the number of distinct cointegrating vectors is less than or equal to r against a general alternative. From the previous discussion, it should be clear that λ_{trace} equals to zero when all $\lambda i = 0$. Further the estimated characteristic roots are from 0, the larger will be the ltrace statistic. In the second statistic tests, the null hypothesis: the number of cointegrating vectors is r against the alternative of r + 1 cointegrating vectors. If the estimated value of the characteristic root is close to zero, λ_{tmax} statistic will be small.

Table 1: Unit Root Tests at Levels

Variables	DF	ADF	PP	KPSS Eta(mu)	KPSS Eta(tau)
RER	-1.957	-2.748(1)	-2.086(1)	0.784	0.229
PDTNTI	-2.249	-1.779(1)	-2.184(1)	0.860	0.458
PDTNTJ	-2.652	-2.734(1)	-2.571(1)	70.740	0.402
RGULC	-1.811	-2.905(1)	-1.950(1)	2.258	0.327

Note : RER = real exchange rate between India and Japan, PDTNTI = productivity differences between traded and non-traded sectors in India, PDTNTJ = productivity differences between traded and non-traded sectors in Japan, RGULC= rate of growth of unit labour cost in traded goods sector between India and Japan. Critical values for DF, ADF and PP tests for 26 observations are -4.15 (at 1% level), -3.50 (at 5% level), and -3.18 (at 10% level). For KPSS [Eta(mu): 0.739 (at 1% level), 0.463 (at 5% level) and 0.347 (at 10% level); Eta(tau): 0.216 (at 1% level), 0.146 (at 5% level) and 0.119 (at 10% level)]

Table 2: Unit Root Tests at First Difference

Variables	DF	ADF	PP	KPSS	
				Eta(mu)	Eta(tau)
DRER	-4.460	-3.895(1)	-4.459(1)	0.217	0.043
DPDTNTI	-6.550	-3.295(2)	-6.472(1)	0.250	0.056
DPDTNTJ	-6.663	-4.303(1)	-6.735(1)	0.137	0.057
DRGULC	-4.673	-5.147(1)	-4.681(1)	0.137	0.038

Note : RER = real exchange rate between India and Japan, PDTNTI = productivity differences between traded and non-traded sectors in India, PDTNTJ = productivity differences between traded and non-traded sectors in Japan, RGULC= rate of growth of unit labour cost in traded goods sector between India and Japan. Critical values for DF, ADF and PP tests for 26 observations are -4.15 (at 1% level), -3.50 (at 5% level), and -3.18 (at 10% level). For KPSS [Eta(mu): 0.739 (at 1% level), 0.463 (at 5% level) and 0.347 (at 10% level); Eta(tau): 0.216 (at 1% level), 0.146 (at 5% level) and 0.119 (at 10% level)]

Table 3: Johansen Cointegration Results*

Null Hypothesis	Alternative hypothesis		90% Critical Value
λ_{trace} test		λ_{trace} value	
r = 0	r > 0	59.12	49.92
r ≤ 1	r > 1	29.28	31.88
r ≤ 2	r > 2	14.75	17.79
r ≤ 3	r > 3	5.58	7.50
λ_{max} test		λ_{max} value	
r = 0	r = 1	29.85	18.03
r = 1	r = 2	14.06	14.09
r = 2	r = 3	9.17	10.29
r = 3	r = 4	5.58	7.50

Note: r refers to the number of cointegrating vectors.

* Based on the equation: RER = f (PDTNTI, PDTNTJ, and RGULC)

Table 4: Weak Exogeneity Tests

System exogeneity tests: c2(1)	LR Test	P-Value
RER weakly exogenous to system	0.48	0.49
PDTNTI weakly exogenous to system	0.48	0.49
PDTNTJ weakly exogenous to system	9.18	0.01
RGULC weakly exogenous to system	2.92	0.09

Notes

1. Strauss (1999) in his model emphasized more on the effects of relative price differential of non-traded goods and government consumption spending on real exchange rate.
2. In pratice, it is not necessary that price indices are constructed in this manner.

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Prof. V. K. R. V. Rao Road, Nagarbhavi, Bangalore - 560 072, India
Phone : 0091-80 - 3215468, 3215519, 3215592 ; Fax: 0091-80 - 3217008
Grams: ECOSOCI, Bangalore - 560 040
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