The Balassa-Samuelson Productivity Bias Hypothesis: Further Evidence Using Panel Data

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Abstract

Using panel data for fifty-nine industrialized and developing countries, this paper examines the Balassa-Samuelson productivity bias hypothesis. A random coefficients model that allows for country- and time-specific productivity effects is estimated covering the period 1965-1992. The advantage of such an approach is that it enables us to undertake the country-by-country empirical examination of the productivity bias hypothesis. Indeed, our findings show that there exists considerable variability in the productivity effect across countries and that for the overall period 1965-1992 the hypothesis fails to hold for most African and some Latin American countries while it holds for OECD countries and Asia. Our analysis also supports that time-effects are important, more specifically we find that during the seventies the effect of labour productivity on real exchange rates was weakened probably mainly due to the end of the Bretton-Woods agreement and the first oil crisis.

Introduction

The last twenty years have witnessed a considerable effort devoted to the analysis of exchange rate behavior and in particular of purchasing power parity (PPP) as an aggregate interpretation of the law of one price hypothesis. However, the idea that in the long-run PPPs tend to approximate equilibrium exchange rates has not been verified by the data in most of the cases.[1] In fact, as noted by Clague (1985; 1986) and Kravis and Lipsey (1983), the data reveal a strong positive relationship between price levels and real per capita income. The explanation of this phenomenon, that has become a prominent feature of the relevant literature, has been based on the Balassa-Samuelson "productivity bias hypothesis" which relates sectoral productivity fluctuations to changes in the relative price of home goods (Balassa, 1964; Samuelson, 1984).

Recently, Bahmani-Oskooee and Nasir (2001) in reviewing the empirical studies aimed at examining the Balassa-Samuelson hypothesis divided them into three different groups according to the kind of data used: cross-section, time-series and panel data studies. They concluded that studies using cross-section data provided mixed evidence on the productivity bias hypothesis, while those built on time-series for the most part supported the hypothesis. Apparently, they found only one study that used panel data, a study which provided some support to the productivity bias hypothesis for OECD coun-

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tries (Asea and Mendoza, 1994). Indeed this is an important flaw in the relevant literature as the use of panel data enables a more detailed specification of the productivity bias equation and thus more reliable results can be obtained. Following the above argument, they used panel data from 69 developing and industrialized countries over the period 1960-1990 in order to enrich our understanding of the true relationship between a country's relative productivity and real exchange rates.

In spite of the important empirical results reported therein, they did not fully explore the potentials provided by the availability of panel data. Specifically, their empirical specification of the productivity bias equation has according to our knowledge two important shortcomings: first, it does not take into consideration time-specific factors that may significantly influence the relationship between productivity and real exchange rates and, second it is assumed that the unobservable country-specific factors neutrally affect the estimated productivity bias equation, that is the impact of labour productivity on real exchange rate is assumed to be common across countries and years.

The purpose of the present paper is to generalize the empirical specification of the productivity bias equation suggested by Bahmani-Oskooee and Nasir (2001). Specifically, using the notion of the random coefficient regression model proposed by Hildreth and Houck (1968) we model both country- and time-specific unobservable effects in a consistent way into the productivity bias equation. The resulting model is non-neutral in the sense that the unobservable country- and time-specific factors directly affect the way in which a country's productivity influences real exchange rates. Thus, it is possible to undertake the country-by-country empirical examination of the Balassa-Samuelson productivity bias hypothesis.

The rest of the paper is organized as follows. Section II presents the empirical model used to empirically examine the Balassa-Samuelson productivity hypothesis. The data used in this study and the empirical results are discussed in Section III. Finally, Section IV summarizes and concludes the paper.

The Empirical Model

Adopting the same analytical framework as Bahmani-Oskooee and Nasir (2001), we express both individual country's productivity and real exchange rates relative to the United States (US). That is, we set the US as the base country and the US dollar as the reserve currency. The deviation of PPP from the equilibrium exchange rate for country i at year t, denoted by ER_{it}, may thus be computed from:

$$ER_{it} = \left(P_{it} / P_{USt}\right) / R_{it}^{e} \qquad (1)$$

where, i=1, 2, …, N are the countries in the sample, t=1, 2, …, T are the time periods examined, P_{it} is the price level of country i, P_{USt} is the price level in the US and, R_{it}^{e} is the exchange rate relative to the US dollar of country i. According to the Balassa-Samuelson hypothesis, differences in individual countries' productivities affect the real value of national currencies (or the real exchange rate) defined above. In their empirical model, Bahmani-Oskooee and Nasir (2001) used the real GDP per worker relative to the US in order to approximate an individual country's relative productivity. Specifically, their model, expressed in logarithms, has the following form:

$$ln\, ER_{it} = \beta_0 + \beta_1\, ln\, LPR_{it} + v_{it} \tag{2a}$$

and

$$LPR_{it} = \frac{GDPW_{it}}{GDPW_{USt}} \tag{2b}$$

where, $GDPW_{it}$ and GDP_{USt} are the real GDP per worker in country *i* and in the US respectively, and v_{it} is the usual error term.

In order to provide empirical evidence for the productivity bias hypothesis, Bahmani-Oskooee and Nasir (2001) estimated four variants of the above model. In its simplest form, the productivity bias equation in (2) was estimated applying ordinary least squares (OLS) on the pooled data. The second variant accounts for the existence of first-order autocorrelation and heteroscedasticity applying the *Prais-Winston* transformation on both the dependent and independent variables in (2), which is essentially a feasible generalized least squares estimator (FGLS).

The last two variants which are more appealing in the context of panel data, allow for the existence of unobservable country-specific factors in order to examine their impact on the productivity bias equation. For this purpose country-specific dummy variables are introduced in (2) as follows:

$$ln\, ER_{it} = \sum_{i=1}^{N} \beta_{0i} D_i + \beta_1\, ln\, LPR_{it} + v_{it} \tag{3}$$

where D_i are the country-specific dummy variables. Then following the same analytical procedures as they did for cases 1 and 2, they estimated model (3) applying both OLS on the pooled data[2] and *Prais-Winston* FGLS.

The above analytical approach, while being quite informative regarding the relationship between labour productivity and real exchange rates, has two important shortcomings: on the one hand, only country-specific unobservable factors are incorporated explicitly in the productivity bias equation; and on the other hand, the effect of these country-specific factors is neutral in the sense that only the intercept terms vary across countries and not the slope coefficients that actually reflect the impact of labour productivity on real exchange rates. In other words, the impact of labour productivity on real exchange rates is assumed to be common across countries and years.

Regarding the first criticism, it is reasonable to assume that apart from the country-specific factors (*e.g.*, income level, development status, school enrollment, type of regime), time-specific factors (*e.g.*, economic crisis, war conflict) as well may affect the magnitude of the impact of a country's individual labour productivity on the real exchange rate. If one does not take into consideration these effects, then the empirical results may be biased in supporting or failing to support the Balassa-Samuelson hypothesis. As far as the second criticism is concerned, the assumption that country-specific factors neutrally affect the estimated relationship between labour productivity and real exchange rate is rather restrictive, especially when in the literature the Ballassa-Samuelson hypothesis has been supported by some groups of countries but not by others. The model in (3) above actually implies that the impact of labour productivity on real exchange rate is common across countries and thus the country-specific factors are only shifting neutrally the estimated productivity bias equation. We can, however, reasonably assume that these factors, regardless of whether they are country- or time-specific, may directly affect the estimated coefficient of labour productivity which in turn should be different across countries and years. This may be important in establishing the productivity bias hypothesis.

Moreover, in an attempt to explicitly incorporate country-specific characteristics into their model, Bahmani-Oskooee and Nasir examined the relevance of other variables like black market premium and resource abundance (measured as the population per square mile of territory in the country), while they split the sample into four groups according to the economic size and the level of development of each country (OECD, Latin America, Asia and Africa). In all cases their empirical results confirm the Balassa-Samuelson productivity bias hypothesis. However, as also noted by the authors, they were selective in their choice of exogenous variables as "data on other variables and for all countries over the entire period of the analysis were not available" (p. 398).

It would be desirable, therefore, to generalize the model in (3) to take into account all these country- and time-specific factors that are either not available or difficult to quantify empirically which may affect the impact of labour productivity on real exchange rate. If we assume that the impact of these factors is random, then following Hsiao (1986) we can write the model (3) as:

$$ln\, ER_{it} = \beta_0 + \beta_{1it}\, ln\, LPR_{it} + v_{it} \tag{4a}$$

and

$$\beta_{1it} = \overline{\beta} + u_i + \lambda_t \tag{4b}$$

where u_i and λ_t are random terms with zero mean capturing the effect of unobservable country- and time-specific factors on the productivity bias equation. If we make the following assumptions on (4):

$$E\left(u_i u_j\right) = \begin{cases} \sigma_u^2 & for\ i = j, \\ 0 & for\ i \neq j. \end{cases}, \quad E\left(\lambda_t \lambda_s\right) = \begin{cases} \sigma_\lambda^2 & for\ t = s, \\ 0 & for\ t \neq s. \end{cases}$$

$$E(u_i\lambda_t) = 0,\ E(u_i LPR_{it}) = 0,\ E(\lambda_t LPR_{it}) = 0 \quad \forall i,t$$

$$E(u_i u_j') = \begin{cases} \sigma_u^2 I_T & if\ i = j \\ 0 & if\ i \neq j \end{cases}$$

then the model can be estimated using the FGLS estimator as described in Hsiao (1986, pp. 140-43). It is obvious that the above specification of the productivity bias equation is more flexible than that suggested by Bahmani-Oskooee and Nasir (2001) in the sense that each country for every year is allowed to have a different estimate of the slope parameter, allowing thus, the country-by-country empirical examination of the Balassa-Samuelson productivity bias hypothesis. The present approach allows us therefore to determine for which countries and time periods the productivity bias hypothesis holds and, in this way, more realistic results can be obtained to support or not the hypothesis.

Data and Empirical Results

For the quantitative assessment of the effect of labour productivity on real exchange rates, we used a panel data set of 59 developing and industrialized countries[3] (in addition to the US which was used as the base country) covering the period from 1965 to 1992. The data on GDP per worker (variable 19) and real exchange rates (variable 13) were obtained from *Penn World Tables Mark 5.6* which is a revised and updated version of the preceding (*Mark 5*) version described in detail by R. Summers and A. Heston. The FGLS estimation results of the productivity bias equation in (4) are shown in table 1. The hypothesis of random coefficient variation either over countries $\left(\sigma_u^2\right)$ or over time $\left(\sigma_\lambda^2\right)$ cannot be rejected by the Breusch-Pagan Lagrange multiplier (LM) test, lending support to the stochastic varying coefficient productivity bias equation. Both test-statistics are well above the respective critical values of the chi-squared distribution at the 1 per cent significance level.

The mean response coefficient ($\bar{\beta}$) of real exchange rates to changes in labour productivity shown in table 1 is positive and statistically significant at the 1 per cent level. Since the model in (4) is expressed in logarithms, this value coincides with the elasticity of real exchange rate with respect to labour productivity. The value of this elasticity is 0.2547, very close to the relevant mean estimates reported by Bahmani-Oskooee and Nasir. However, for comparative purposes, it would be interesting at this point to see how individual country- and time-specific factors affect the relationship between real exchange rate and labour productivity. Table 2 presents the estimates of the total average effects by country computed as the sum of the country specific effect (u_i), the mean effect ($\bar{\beta}$) and the average of the time specific effects ($\bar{\lambda}_t$).

Table 1. Parameter Estimates of the Productivity Bias Equation

Parameter	Estimate	t-ratio
Constant	-0.1076	(13.024)
LPR ($\bar{\beta}$)	0.2547	(6.265)
Hypothesis:	LM-test:	
$\sigma_u^2 = 0$	39.15	
$\sigma_\lambda^2 = 0$	296.04	

At a first glance, the estimates exhibit great variability across countries, the highest positive values correspond to Japan (1.0217), Iceland (0.9775), Norway (0.7770) and Denmark (0.7721), and the estimates are negative but not significant for 12 countries, most of them being in the African continent. Overall, the Balassa-Samuelson hypothesis is supported, according to our results, for thirty-five (35) of the countries in the sample. A common feature of the results is that the estimates are not significant for most of the African countries with the exception of Egypt, Morocco and South Africa, and for some of the Latin American countries. The results by Bahmani-Oskooee and Nasir (2001) coincide with our findings as the estimated value of the elasticity of labour productivity for the sample of OECD countries is much higher than the relevant estimates for the sample of African or Latin American countries. In particular, for the sample of African countries they failed to establish the productivity bias hypothesis when the model was

Table 2. Average Total Effects For Each Country

Country	Estimate	t-Ratio	Country	Estimate	t-Ratio
OECD:					
Australia	0.4683	(2.5883)	Togo	-0.0613	(0.3358)
Canada	0.5109	(2.8197)	Tunisia	0.0401	(0.2584)
Denmark	0.7721	(4.2962)	Uganda	-0.3151	(1.0512)
Greece	0.5436	(3.1766)	Zambia	-0.1285	(0.7091)
Iceland	0.9775	(5.4556)	LATIN AMERICA:		
Israel	0.6309	(3.5288)	Bolivia	0.4979	(2.8739)
Japan	1.0217	(5.8478)	Brazil	0.2557	(1.8799)
New Zealand	0.2994	(1.9428)	Chile	0.3312	(2.3392)
Norway	0.7770	(4.3078)	Colombia	0.4307	(4.1397)
Switzerland	0.5889	(3.2504)	Costa Rica	0.3230	(3.0900)
Turkey	0.3962	(2.3773)	Dominican Rep.	0.2928	(1.8414)
Mexico	-0.1790	(1.0222)	Ecuador	0.6446	(4.5171)
AFRICA:			El Salvador	0.3850	(2.2534)
Burkina Faso	0.0698	(0.3818)	Guatemala	0.6278	(4.3833)
Burundi	0.1057	(0.5785)	Honduras	0.0747	(0.4208)
Cameroon	-0.1476	(0.8121)	Panama	-0.0541	(0.4461)
Central Afr. Rep.	0.0566	(0.3104)	Paraguay	0.0872	(0.5032)
Chad	0.1318	(0.7227)	Peru	-0.0373	(0.2857)
Congo	0.1278	(0.7153)	Uruguay	0.1135	(1.9592)
Ivory Coast	0.0191	(0.1058)	Venezuela	0.2133	(1.9545)
Egypt	0.3516	(2.0163)	Trinidad&Tobago	-0.0983	(0.5451)
Gabon	0.2164	(2.0644)	ASIA:		
Ghana	-0.2887	(1.0446)	Fiji	0.1363	(1.9465)
Kenya	0.1331	(0.7307)	India	0.4075	(2.2404)
Madagascar	0.1787	(0.9812)	Indonesia	0.3728	(2.0585)
Malawi	0.1638	(0.8967)	Malaysia	0.0198	(1.9271)
Mauritania	-0.0744	(0.4096)	Pakistan	0.6355	(3.5344)
Morocco	0.2571	(1.9422)	Philippines	0.4630	(2.6018)
Nigeria	-0.1154	(0.6352)	Singapore	0.5655	(3.2366)
Rwanda	0.2947	(1.7516)	Syria	-0.5689	(1.0700)
South Africa	0.5903	(5.8330)	Thailand	0.4933	(2.7506)

NOTE: In parentheses are the absolute values of t-ratios.

estimated under the *Prais-Winston* transformation as the parameter of labour productivity turned out to be non-significant.

Therefore, the level of economic development plays an important role when determining the effects of productivity differentials on real exchange rates. Figure 1 shows the relation between the total average country effects and the level of real GDP, pointing out that the productivity bias hypothesis is more in evidence for developed countries. On the other hand, since our analysis allows us to examine, on a case-by-case basis, the validity of the Balassa-Samuelson hypothesis, we can observe that there exists a lack of homogeneity among the different countries as far as the applicability of equation (3) is concerned. For instance, we should note that some of the Latin American countries exhibit high estimated values (Bolivia, Colombia, Guatemala), while for many others the estimates are not significant.

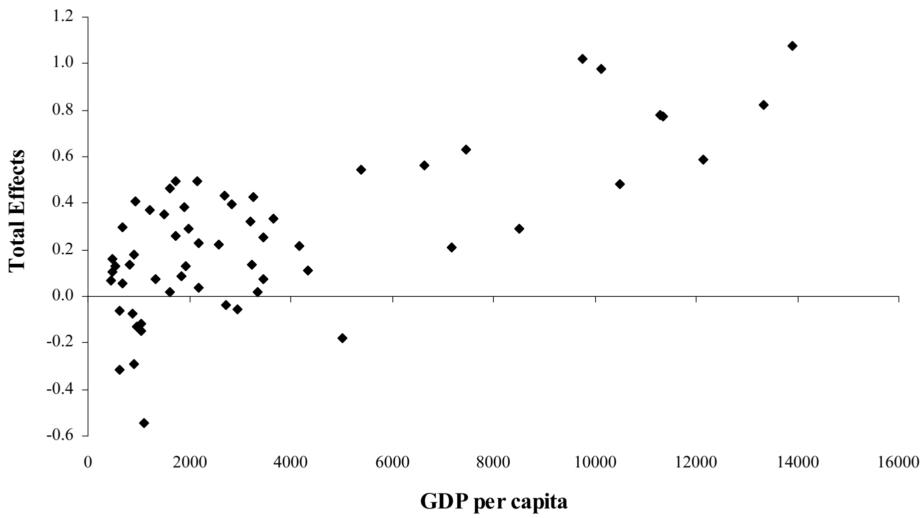

Figure 1. Relationship Between Real GDP Per Capita and Average Total Country Effects

In order to check for time effects, we have grouped the data by geo-economic areas in the following way: some OECD countries plus Israel, Latin American countries, Asia (without Israel) and Africa, and have considered 4 sub periods (1965-69, 1970-79, 1980-89, 1990-92). Table 3 shows the total average effects for each of the 4 sub periods for all countries and by geographical region. The results emphasize the fact that the productivity bias effect is stronger in OECD countries, followed by Asia, Latin America and then Africa. As a matter of fact, the productivity hypothesis does not seem to hold for the “African group” during the first two sub periods while after 1980 it does. In their recent panel data study for Asia, Latin America and Africa and for the period 1980-1996, Drine and Rault (2003) find evidence that the Balassa-Samuelson effect holds for the three groups of countries while, similarly to our findings, the strength of the effect is much lower for Africa.

A striking feature of the average estimates presented in table 3 is the fact that the productivity bias effect went down in the decade 1970-79 overall and for each one of the regions (checking each country separately reveals the same pattern). Possible explanations for this phenomenon could lie in the two major events of the early seventies: the

Table 3. Average Total Effects Between Sub-Periods

Sub-Period	Estimate	t-Ratio
ALL COUNTRIES:		
1965-1969	0.2203	(3.173)
1970-1979	0.2066	(4.570)
1980-1989	0.2770	(6.126)
1990-1992	0.3978	(4.307)
Average	0.2547	(15.846)
OECD COUNTRIES:		
1965-1969	0.6008	(7.178)
1970-1979	0.5871	(9.016)
1980-1989	0.6574	(10.089)
1990-1992	0.7783	(7.514)
Average	0.6351	(12.821)
LATIN AMERICAN COUNTRIES:		
1965-1969	0.1956	(2.518)
1970-1979	0.1819	(3.189)
1980-1989	0.2522	(4.423)
1990-1992	0.3731	(3.779)
Average	0.2299	(6.004)
AFRICAN COUNTRIES:		
1965-1969	0.0386	(0.517)
1970-1979	0.0249	(0.470)
1980-1989	0.0953	(1.799)
1990-1992	0.2162	(2.242)
Average	0.0730	(2.284)
ASIAN COUNTRIES:		
1965-1969	0.2462	(2.837)
1970-1979	0.2325	(3.366)
1980-1989	0.3028	(4.386)
1990-1992	0.4237	(3.994)
Average	0.2805	(5.138)

end of Bretton Woods and the first oil crisis. The switch to floating rates has been reported to have produced an increase in the volatility of exchange rates not matched by changes in the distribution of fundamental macroeconomic variables (e.g., Baxter and Stockman, 1989). However, while systematic differences in the behavior of real exchange rates under different regimes have been reported in the literature, all countries did not switch to more flexible regimes at the same time, and as a matter of fact for many developing countries the shift to floating exchange rates has been more recent.

As far as the second explanation is concerned, Rogoff (1992) has argued that real oil prices could play the role of supply shocks. We argue that it could very well be the case that the seventies' oil shock led to a real currency appreciation for exporters of oil -not matched by an increase in the productivity differential- while it led to a currency depreciation for oil importers -not accompanied by a decrease in the productivity differential. As a matter of fact, DeLoach (2001), while finding evidence in favor of the Balassa-Samuelson hypothesis for nine (9) OECD countries also uncovers the role of oil prices in determining real exchange rates. Finally it is evident from table 3 that after the 1970s the estimates go up and seem to support, on an aggregated basis, the Balassa-Samuelson hypothesis in the long-run. Apparently this is true also for the group of African countries, for which productivity bias hypothesis failed to be established in the first two subperiods.

Conclusions

For the empirical assessment of the Balassa-Samuelson productivity bias hypothesis, panel data can be more robust than simple cross-section or time series based studies. Taking advantage of the use of panel data, we suggest a more flexible specification of the productivity bias hypothesis model. In particular, we propose a non-neutral productivity bias equation using the same analytical framework as Bahmani-Oskooee and A. Nasir (2001). In essence our model is based on the random coefficient regression models of Hildreth and Houck (1968), which allow for unobservable country- and time-specific factors to be accounted for in the productivity bias equation. This flexible specification permits a more realistic country-by country evaluation of the Balassa-Samuelson productivity bias hypothesis by using a single equation estimation framework. Our model is applied to a sample of fifty-five (59) industrialized and developing countries.

Our empirical results suggest that the Balassa-Samuelson productivity bias hypothesis holds for all countries in the sample except for those in the African continent and some Latin American countries when the entire period is considered. The strongest evidence comes from Japan, Iceland and Norway, whereas for most African countries the corresponding average elasticity values turned to statistically non-significant estimates. Further, our results indicate that the effect of labour productivity on real exchange rates is not uniform across countries. The level of economic development, as also acknowledged by other authors in the past, plays an important role in identifying the productivity bias hypothesis. Finally, there are also significant time effects that need to be taken into account. Our results indicate that during the 1970s the effect of labour productivity on real exchange rates was weakened, due mainly to the first oil crisis and the end of the Bretton-Woods agreement.

Notes

[1] The most notable examples of these studies include Frenkel (1981a), Frenkel, (1981b), Bahmani-Oskooee (1993), Karfakis and Moschos (1989), Hoque (1995), and Engel (1999).

[2] The polled OLS estimation of (3) with the inclusion of country-specific dummy variables, is essentially a fixed effects model explicitly discussed in panel data literature.

[3] The list of countries is shown in Table 2.

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