The linkage between relative population growth and purchasing power parity: Empirical evidence from selected countries

Ruhul Salim* and AFM Hassan**

Relative population growth affects relative prices through the so-called Balassa-Samuelson (BS) effect and that in turn impacts PPP. This paper empirically investigates the relationship between PPP exchange rate and relative population growth in a panel of 80 selected countries in the world. Following the BS hypothesis this paper argues that relative population growth affects nominal wages that impact price levels and thereby impacts PPP. Using panel unit root and panel cointegration tests the empirical results show that there is stable relationship between PPP exchange rate and relative population growth in these selected countries in the long run. These empirical findings suggest that population growth have an important role in exchange rate determination through PPP.

Keywords: Balassa-Samuelson hypothesis; Purchasing power parity; population growth; panel cointegration

JEL Classification: F31, F29, C23

"Under the skin of any international economist lies a deep-seated belief in some variant of the PPP theory of the exchange rate"
-Dornbusch and Krugman (1976; p.540)

1. Introduction

Purchasing power parity is one of the most extensively researched topics yet it remains an 'empirical puzzle' in International Macroeconomics (Obstfeld and Rogoff, 2000). Most of the earlier studies either test whether purchasing power parity (PPP) holds in the long run or find explanations behind the 'failure' of PPP (Frenkel, 1978; Krugman, 1986; Dornbusch, 1987; Taylor, 1988; Mark, 1990; Betts and Devereux, 1996; Wu, 1996; Sarno and Taylor, 2002; Wu and Chen, 2008 and Kalyoncu and Kalyoncu, 2008 to cite a few).

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The Balassa-Samuelson (BS) mechanism has been considered as one of the leading explanations of real exchange rate departures from PPP and this has been well documented in the literature. The BS hypothesis rests on two components: first, the relative price of non-traded goods in each country should reflect the relative productivity of labor in the traded and non-traded goods sectors; second, purchasing power parity holds for traded goods. Numerous papers have examined the BS hypothesis empirically however, no uniform consensus emerged (Bahmani-Oskooee, 1992; Drine and Rault, 2003; Bahmani-Oskooee and Miteza, 2004; Genius and Tzouvelekas, 2008; and Lothian and Taylor, 2008 among others). The aim of this paper is not to test the BS hypothesis; rather it aims to explain the link between PPP exchange rate and the relative population growth through the BS mechanism.

This issue of population growth, particularly the growth of working age population is important and has received considerable attention in the popular press concerning its potential impacts on the economy. However, academic exercises combining relative population growth and PPP exchange rate are only a few. Aloy and Gente (2005) and Andersson and Österholm (2005) investigate that population structure affects real exchange rate through its impact on saving as postulated in the *life-cycle hypothesis*. Aloy and Gente use the *overlapping generation model* while Andersson and Österholm estimate the reduced form single equation in order to test their hypotheses empirically. However, this paper argues that relative population growth affects price levels through its effect on nominal wages and thereby impacts PPP. According to the BS mechanism labor is immobile across countries, so wage adjustments in response to increase (decrease) in working-age population in the traded relative to the non-traded good sector increase (decrease) the relative price of non-traded goods. This tends to appreciate (depreciate) real exchange rate. More closely related to the present paper, Salim and Hassan (2009) shows that relative population growth may affect long-run PPP through its effect on money demand and price levels. However, the theoretical model underlying this analysis is informal and untenable. Transaction demand for money model for demographic dynamics to affect the real economy is simply ad hoc. Therefore, the issue is formally analyzed in this paper by combining the BS ideas. This paper uses evidence from 80 countries over 55 years to examine the link between relative population growth and PPP exchange rate.

The rest of the paper is organized as follows. The next section develops an analytical framework followed by the econometric methodology in section 3. Section 4 checks the validity of the relationship between PPP exchange rate and relative population growth by investigating the time series properties of the data and establishing the cointegration relationship between these variables. Concluding remarks and policy implications are given in final section.

2. Analytical Framework

There are mainly two variants of PPP theory: absolute and relative PPP. In its absolute form PPP states that the exchange rate between two countries' currencies equalizes the relative price levels of these economies, provided that the effects of trade barriers and transaction costs are negligible, *i.e.* $E = \frac{P^h}{P^f}$ (where E, P^h and P^f stand for exchange rate between the two countries' currencies, home price and foreign price levels respectively). However, absolute PPP theory is not a useful operational hypothesis, because information on national price levels are available in the form of price indices, but not on absolute price levels. For this complexity most of the empirical literature on PPP has focused on the relative PPP hypothesis. The relative version of PPP theory states that the exchange rate should have constant proportionate relationship to the ratio of national price levels, *i.e.* $E = k\frac{P^h}{P^f}$ (where *k* is a constant). This implies that if home price level is higher relative to the foreign price level then PPP exchange rate will depreciate and vice-versa. In order to relate the relative population growth to PPP exchange rate, it is assumed that labor supply is directly proportional to population growth. It is also assumed that the home and foreign economy produce two types of composite goods: traded and non-traded and in each country aggregate price index, *P* is the sum of weighted average prices of these two types of goods as follows:

$$P = \eta P_T + (1-\eta)P_N \tag{1}$$

where η is the share of traded goods in the price index. Prices of traded and non-traded goods are determined by prices of labor and capital employed in those sectors. To examine how these prices relate to population growth we partially resort to Balassa-Samuelson hypothesis as discussed in Gregorio *et al.* (1994) and Sarno and Taylor (2000). Production functions for traded and non-traded sector are given by the following Equations:

$$Y_T = \theta_T L_T^{\alpha^T} K_T^{\left(1-\alpha^T\right)} \tag{2}$$

and

$$Y_N = \theta_N L_N^{\alpha^N} K_N^{\left(1-\alpha^N\right)} \tag{3}$$

where *T* and *N* denote traded and non-traded goods, and α and $(1-\alpha)$ denote contribution of labor (*L*) and capital (*K*) respectively in the production process. Finally, θ is a productivity parameter. The model assumes perfect factor mobility and perfect competition in both traded and non-traded sectors. World (and hence domestic) interest rate (R) and wages (W) in two sectors are equal to their marginal products as follows, $W_T = \frac{\delta Y_T}{\delta L_T}$, $R_T = \frac{\delta Y_T}{\delta K_T}$, $W_N = \frac{\delta Y_N}{\delta L_N}$, $R_N = \frac{\delta Y_N}{\delta K_N}$. Perfect competition and perfect capital mobility imply $W_T = W_N = W$ and $R_T = R_N = R$.

Under perfect competition prices in traded and non-traded sector are derived by duality as

$$P_T = \frac{1}{\theta_T} W^{\alpha^T} R^{\left(1-\alpha^T\right)} \alpha_T^{-\alpha^T} \left(1-\alpha_T\right)^{-\left(1-\alpha^T\right)} \tag{4}$$

and

$$P_N = \frac{1}{\theta_N} W^{\alpha^N} R^{\left(1-\alpha^N\right)} \alpha_N^{-\alpha^N} \left(1-\alpha_N\right)^{-\left(1-\alpha^N\right)} \tag{5}$$

Equations (4) and (5) indicate that any change in wage (*W*) or rate of return on capital (*R*) changes prices of traded and non-traded sectors. Assuming a given *R* the focus of this study is on *W*, which is determined in the labor market by demand and supply of labor.

Demand for labor comes from the firms involved in the production process. Supply of labor comes from the fraction of the total population that is at working age stage. Labor demand and supply functions can be expressed as follows:

$$\text{Demand function}: \quad L^D = L^D(w, \mathbf{x}) \tag{6}$$

$$\text{Supply function}: \quad L^S = L^S(w, \mathbf{y}) \tag{7}$$

where, *w* stands for real wage and **x** and **y** include exogenous factors. Labor demand is a decreasing function while the supply is an increasing function of real wage. Any changes in exogenous factors will shift demand or supply schedules and change equilibrium wage. Exogenous variables those affect supply schedule include real unemployment benefit, tax rate (fraction of wage) paid by employee, size of working age population (Minford, 1983), unearned income, population between the ages 16 and 64 (Sarantis, 1981) and so on. Thus one of the obvious exogenous factors that shift the supply schedule is the size of labor force. Assuming a positive proportionate relationship between total population and working age people, a higher population growth (since labor is not mobile internationally according to the BS hypothesis) will increase the supply of labor lower the equilibrium wage and thereby lower home price level relative to the world (Equation 1). Thus an increase in relative population growth results appreciated PPP exchange rate. In a similar fashion, Obstfeld and Rogoff (1996) also argue that a rise (fall) in the relative foreign labor supply results in a rise (fall) in relative real wage at home. If this is the case then higher (lower) relative population growth at home will cause appreciated (depreciated) PPP exchange rate.

Hence, a negative relationship is hypothesized between PPP exchange rate and relative population growth rate based on the above discussion. Empirical data on PPP exchange rate and relative population growth rate support this hypothesized relationship. Table 1 reports simple correlation coefficients between relative population growth and PPP exchange rate for 80 countries. Population growth rate is relative to the USA and PPP exchange rate is in terms of the USA dollar.

The following table clearly shows that there is significant negative correlation between relative population growth and PPP exchange rate in all countries except Denmark, Ecuador, Finland, Germany, Hungary, Israel, Japan, New Zealand, Singapore, Sweden and United Kingdom. However, the positive correlation coefficients of none of these countries are statistically significant except Japan.

Table 1: Correlation between PPP and Relative Population Growth

Country	Correlation	Country	Correlation	Country	Correlation
Algeria	-0.891 (0.000)	France	-0.294 (0.163)	Namibia	-0.589 (0.002)
Australia	-0.378 (0.068)	Gabon	-0.359 (0.085)	Nepal	-0.702 (0.000)
Austria	-0.106 (0.622)	Gambia, The	-0.323 (0.124)	Netherlands	-0.162 (0.449)
Bahamas	-0.828 (0.000)	***Germany***	***0.039*** *(0.855)*	***New Zealand***	***0.176*** *(0.410)*
Bangladesh	-0.776 (0.000)	Guatemala	-0.503 (0.012)	Nigeria	-0.488 (0.015)
Barbados	-0.646 (0.001)	Honduras	-0.762 (0.000)	Pakistan	-0.611 (0.002)
Belgium	-0.505 (0.012)	Hong Kong	-0.170 (0.427)	Papua New Guinea	-0.415 (0.044)
Bermuda	-0.440 (0.031)	***Hungary***	***0.092*** *(0.668)*	Philippines	-0.744 (0.000)
Botswana	-0.945 (0.000)	Iceland	-0.440 (0.031)	Portugal	-0.580 (0.003)
Burundi	-0.320 (0.127)	India	-0.839 (0.000)	Senegal	-0.405 (0.050)
Cambodia	-0.650 (0.001)	***Israel***	***0.126*** *(0.558)*	***Singapore***	***0.537*** *(0.007)*
Canada	-0.128 (0.552)	Jamaica	-0.514 (0.010)	Solomon Islands	-0.706 (0.000)
Central African Republic	-0.732 (0.000)	***Japan***	***0.892*** *(0.000)*	South Africa	-0.762 (0.000)

Chile	-0.847 (0.000)	Jordan	-0.537 (0.007)	Spain	-0.813 (0.000)
China	-0.862 (0.000)	Kenya	-0.727 (0.000)	Sri Lanka	-0.405 (0.050)
Colombia	-0.754 (0.000)	Korea, Republic of	-0.783 (0.000)	St. Lucia	-0.587 (0.003)
Congo, Republic of	-0.312 (0.137)	Lesotho	-0.771 (0.000)	Swaziland	-0.800 (0.000)
Costa Rica	-0.70 (0.000)	Luxembourg	-0.235 (0.270)	***Sweden***	***0.229*** *(0.281)*
Cote d`Ivoire	-0.384 (0.064)	Macao	-0.716 (0.000)	Switzerland	-0.258 (0.224)
Cuba	-0.446 (0.029)	Malawi	-0.229 (0.282)	Syria	-0.880 (0.000)
Denmark	***0.264*** (0.212)	Malaysia	-0.604 (0.002)	Tanzania	-0.825 (0.000)
Dominican Republic	-0.077 (0.721)	Maldives	-0.887 (0.000)	Thailand	-0.810 (0.000)
Ecuador	***0.083*** *(0.700)*	Malta	-0.274 (0.196)	Trinidad &Tobago	-0.801 (0.000)
Egypt	-0.814 (0.000)	Mauritius	-0.205 (0.335)	Tunisia	-0.879 (0.000)
Equatorial Guinea	-0.492 (0.015)	Mexico	-0.887 (0.000)	***UK***	***0.095*** *(0.658)*
Fiji	-0.508 (0.011)	Mongolia	-0.732 (0.000)	Vanuatu	-0.456 (0.025)
Finland	***0.397*** *(0.055)*	Morocco	-0.893 (0.000)		

Note: Figures in parentheses are *p* values.

Moreover, simple correlation coefficients cannot be used to draw meaningful conclusions about the long run relationship between these two variables. Thus, this article starts with the examination of time series properties of these variables followed by cointegration relationship between them.

3. Econometric issues

The econometric issues involve the examination of the underlying data for stationarity and cointegrating relationship between variables. This section covers the issues related to unit root test and cointegration in panel data set.

Panel unit root test: The motivation to employ panel unit root test comes from the low power of univariate unit root tests like ADF or PP tests. Panel unit root tests are more powerful because of increased sample size. The alternative way to get large sample is to use long time series data, but this may cause the problem of structural break (Maddala and Kim, 1998). By using panel data set one can exploit the extra information contained in pooled cross-section time series data. Besides, the asymptotic distribution of panel unit root test is standard normal which is in contrast to univariate time series unit root tests that have non-standard asymptotic distribution (Baltagi *at el.*, 2007). Several methods have been proposed to test stationarity in panel data among which three methods are widely used: Im, Pesaran and Shin (2003) [hereafter IPS], Levin, Lin and Chu (2002) [hereafter LLC] and Maddala and Wu (1999) [hereafter MW]. All these tests have their own limitations, such as LLC is applicable for homogeneous panel, where the autoregressive (AR) coefficients for unit roots are assumed to be the same across cross-sections. Although IPS allows heterogeneous panels, a major criticism of both LLC and IPS tests is that they both require cross-sectional independence. To see whether LLC and IPS can be used for the data under consideration Pesaran's (2004) CD test is done and it is found that the test statistic is 28.592 with p value 0.000, which implies that the null hypothesis of no cross-sectional dependence is strongly rejected.

Therefore, these two tests are not applicable for the data set in hand. Although MW test also requires cross-sectional independence, Maddala and Wu (1999) find that MW test is more robust than LLC and IPS tests to the violation of this assumption. Moreover, they find that in a variety of situations the MW test is more powerful than IPS test, which, in turn, is more powerful than the LLC test. From these points of view, it appears that MW test, also called Fisher's test, is suitable for the panel data under consideration.

Although not identical, panel unit root tests are similar to unit root tests conducted on a univariate time series. Consider an AR(1) process for panel data as follows:

$$y_{i,t} = \rho_i y_{i,t-1} + X_{i,t}\delta_i + \varepsilon_{i,t}$$

where, $i = 1,2,...,N$ represents cross-section units that are observed over periods $t = 1,2,....,T$. $X_{i,t}$ represents the exogenous variables including any fixed or individual trend, ρ_i is the autoregressive coefficient and $\varepsilon_{i,t}$ is idiosyncratic disturbance. If $|\rho_i| < 1$, y_i is said to be weakly stationary and if $|\rho_i| = 1$, then y_i is said to contain a unit root. There are two assumptions that are made in different tests about ρ_i. LLC test assumes that the persistence parameter ρ_i is common across cross-sections so that $\rho_i = \rho$ for all i. However, in IPS and MW test ρ_i is allowed to vary freely across cross-section, which seems more reasonable. Moreover, as IPS is designed for balance panel this study concentrates on MW test only. Consider the ADF regression for each cross-section unit as follows:

$$\Delta y_{i,t} = \rho_i y_{i,t-1} + \sum \beta_{i,t} \Delta y_{i,t-j} + X_{i,t}\delta + \varepsilon_{i,t}$$

The null hypothesis is $H_0 : \rho_i = 0$ for all *i* and the alternative is

$$H_1 : \begin{cases} \rho_i = 0 & \text{for } i = 1,2,...,N \\ \rho_i < 0 & \text{for } i = N+1, N+2,.....,N \end{cases}$$

MW uses Fisher's (1932) result to derive tests that combine the *p*-values from the individual unit root in each cross-sectional unit. If the *p*-value from individual unit root test for cross-section *i* is defined as π_i, then under the null hypothesis of unit root for all N cross-sections, the test statistic is given by $-2\sum_{i=1}^{N} \log(\pi_i) \rightarrow \chi^2_{2N}$. Banerjee (199) notes that MW test is a non-parametric, and may be computed for any arbitrary choice of a test for the unit root.

Panel cointegration: Estimation of long run equilibrium relationship occupies a significant share in empirical time series econometrics. Long run relation among multiple time series of a single cross-section unit is investigated using cointegration technique developed by Engle and Granger (1987), Johansen and Juselius (1990), Johansen (1991, 1995) and Phillips (1991). The counterpart of this type of cointegration test is panel cointegration. In the literature residual-based approach and system approach have been suggested for testing cointegration in panel data set. Two widely used residual-based panel cointegration tests are those of suggested by Pedroni (1999, 2004) and Kao (1999) and the system approach is suggested by Larsson *et al.* (2001). However, Monte Carlo comparison by Gutierrez (2003) shows that in homogeneous panels Kao's (1999) test have higher (lower) power than Pedroni's (1999) test when a small-*T* (high-*T*) are included in the panel. Gutierrez also shows that both these tests

outperform Larsson *et al.*'s (2001) test. Based on this finding this study follows residual based cointegration tests suggested by Pedroni.
Pedroni's (1999, 2004) test is the extension of Engle and Granger's (1987) cointegration test for a single cross-section unit. The Engle and Granger cointegration test is based on the examination of the residual of a spurious regression performed using $I(1)$ variables. If the variables are cointegrated then the residual will be $I(0)$ and if the variables are not cointegrated then residual will be $I(1)$. Pedroni proposes tests for cointegration that allows for heterogeneous intercepts and trend across cross-section units. For two $I(1)$ variables x and y consider the following regression

$$y_{i,t} = \alpha_i + \delta_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \beta_{Mi} x_{Mi,t} + e_{i,t}$$

for $t = 1,2,.....,T;\ i = 1,2,......,N;\ m = 1,2,.......,M$.

The parameters α_i and δ_i represent individual and trend effects respectively. Null hypothesis of the test is that $e_{i,t}$ is $I(1)$ against the alternative that $e_{i,t}$ is $I(0)$. To test whether the residuals are stationary following auxiliary regressions are estimated for each cross-section unit:

$$e_{i,t} = \rho_i e_{i,t-1} + u_{i,t}$$

$$e_{i,t} = \rho_i e_{i,t-1} + \sum_{j=1}^{p_i} \psi_{i,j} \Delta e_{i,t-j} + v_{i,t}$$

Against the null hypothesis of no cointegration ($H_0 : \rho_i = 0$), there are two alternative hypotheses, (1) the homogeneous alternative $[H_1 : (\rho_i = \rho) < 1, \text{for all } i]$, also called *within-dimension test* or *panel statistic test* and, (2) the heterogeneous alternative $(H_1 : \rho_i < 1, \text{for all } i)$, also called *between-dimension* or *group statistic test.* The panel cointegration test statistic $\aleph_{N,T}$ is constructed from the residuals from the either auxiliary regression mentioned above. Total eleven statistics are generated with varying degree of size and power for different *N* and *T.* Pedroni shows that the standardized statistic is asymptotically normally distributed, $\frac{\aleph_{N,T} - \mu\sqrt{N}}{\sqrt{\upsilon}} \Rightarrow N(0,1)$, where μ and υ are Monte Carlo generated adjustment terms.

Data sources: A panel of 80 countries is used in this study[1]. While selecting the countries attention has been given so that countries from all stages of economic development are included in the sample. This is done to ensure that the phenomenon under study is not biased to any specific group of countries. Annual data series have been obtained from the Penn World Table (PWT)-2006 over the period 1951-2005. PWT calculates PPP exchange rate over GDP, that is, the PPP exchange rate is the national currency value of GDP divided by the real value of GDP in USA dollars. Data on population growth have been collected from World Development Indicator-2008.

4. Analysis of empirical results

This section reports and analyses panel unit root and cointegration test results. There are several panel unit root tests in the literature. However, there is no uniformly powerful test for the unit root hypothesis. This paper uses two most popular panel unit root tests, namely, MW and PP tests for testing unit roots in PPP exchange rates (PPP) and

[1] Please see the Annex –A Table for the country list.

relative population growth rates (RPOPGR). MW test results based on both ADF and PP are presented in Table 2. In case of ADF, optimum lag length is chosen on the basis of Schwartz Information Criteria (SIC) and in case of PP Newey-West bandwidth is selected using Bartlett kernel.

Table 2: Panel Unit Root Test for all countries

	Level		First difference	
Variables	Intercept	Intercept & trend	Intercept	Intercept & trend
RPOPGR	91.423 (0.180)	80.923 (0.450)	371.961* (0.000)	292.859* (0.000)
PPP	103.309 (0.040)	56.337 (0.979)	251.678* (0.000)	201.452* (0.000)

Note: *, **, *** indicate significant at 1%, 5% and 10% respectively. Figures without parenthesis are test statistics and those inside parentheses are respective probabilities, which are computed using an asymptotic Chi-square distribution.

Test results show that all series under consideration contain unit root at their level. However, their first difference are stationary, that is, the variables are I(1). When variables are integrated to order one, the next issue of interest in empirical research is to search for long run relationship between them. Therefore, the cointegration analysis proposed by Pedroni (1999, 2004) is used next and all eleven Pedroni's tests based on the null of no cointegration are considered. Also various sources of heterogeneity under the alternative also introduced in order to allow the cointegration relation to be country-specific. The results are reported in Table 3.

Table 3: Panel Cointegration Test

Null Hypothesis: No cointegration				
Alternative hypothesis: common AR coefficients (within-dimension)				
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-0.837303	0.2810	-1.893460	0.0664***
Panel rho-Statistic	-2.615808	0.0130*	-2.641389	0.0122**
Panel PP-Statistic	-5.916220	0.0000*	-6.995788	0.0000*
Panel ADF-Statistic	-7.757581	0.0000*	-8.889260	0.0000*
Alternative hypothesis: individual AR coefficients (between-dimension)				
	Statistic	Prob.		
Group rho-Statistic	1.356103	0.1591		
Group PP-Statistic	-3.469555	0.0010*		
Group ADF-Statistic	-8.189316	0.0000*		

Note: *, **, *** indicate significant at 1%, 5% and 10% respectively. Trend assumption: Deterministic intercept and trend. Lag selection: Automatic SIC with a max lag of 4.

Cointegration results are encouraging and show that the variables are cointegrated under both homogeneous and heterogeneous alternatives. Out of eleven test statistics, nine are highly significant indicating a long run equilibrium relationship between purchasing power parity exchange rate and relative population growth. This result suggests that there is a common stochastic trend among PPP exchange rate and relative population growth that makes it likely that these two variables move together in the selected countries.

Next the sample countries are divided into high income and low income economies in order to see whether the economic condition (stage of development) has any effect on the hypothesized relationship between PPP exchange rate and relative population growth. Countries are classified into high income and low income countries based on the World Bank classification as reported in World Development Indicator (WDI)-2008. In WDI-2008 countries are divided into four groups: low income, middle income, upper middle income and high income. For the sake of simplicity countries in the sample that fall in low income and middle income group are included in low income economies and countries that fall in upper middle income and high income groups are included in high income economies. Table 4 reports unit root test results for high and low income countries respectively.

Table 4 Fisher unit root test for high and low income countries

	Level		First difference	
High income countries				
Variables	Intercept	Intercept & trend	Intercept	Intercept & trend
RPOPGR	91.423 (0.180)	80.923 (0.450)	371.961* (0.000)	292.859* (0.000)
PPP	103.309 (0.040)	56.337 (0.979)	251.678* (0.000)	201.452* (0.000)
Low income countries				
POP	46.256 (0.999)	80.355 (0.467)	189.447* (0.000)	120.694* (0.002)
PPP	17.605 (1.000)	44.338 (0.999)	166.597* (0.000)	155.808* (0.000)

Note 1: *, **, *** indicate significant at 1%, 5% and 10% respectively. Figures without parenthesis are test statistics and those inside parentheses are respective probabilities, which are computed using an asymptotic Chi-square distribution.

Table-5: Pedroni Residual Cointegration Test (High income countries)

Null Hypothesis: No cointegration

Alternative hypothesis: common AR coefs. (within-dimension)	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-0.837303	0.2810	-1.893460	0.0664***
Panel rho-Statistic	-2.615808	0.0130*	-2.641389	0.0122**
Panel PP-Statistic	-5.916220	0.0000*	-6.995788	0.0000*
Panel ADF-Statistic	-7.757581	0.0000*	-8.889260	0.0000*

Alternative hypothesis: individual AR coefs. (between-dimension)	Statistic	Prob.
Group rho-Statistic	1.356103	0.1591
Group PP-Statistic	-3.469555	0.0010*
Group ADF-Statistic	-8.189316	0.0000*

Note: *, **, *** indicate significant at 1%, 5% and 10% respectively. Trend assumption: Deterministic intercept and trend Lag selection: Automatic SIC with a max lag of 4.

Table 4 reveals that the unit-root null hypothesis cannot be rejected at the 5% level for the variables under consideration and for both groups of high income and low income countries. Next, those tests are also applied on the variables taken in first differences and the results find evidence in favor of the rejection of the non-stationary hypothesis for all series, which justifies the possibility of cointegration. Therefore, Pedroni's cointegration tests are used for both groups of countries and the results are reported in Tables 5 and 6.

Table-6: Pedroni Panel cointegration test (Low income countries)

Null Hypothesis: No cointegration				
Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	3.982307	0.0001*	0.636837	0.3257
Panel rho-Statistic	-5.500899	0.0000*	2.409225	0.0219**
Panel PP-Statistic	-12.09419	0.0000*	2.123744	0.0418**
Panel ADF-Statistic	-19.48331	0.0000*	-3.748827	0.0004*
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	Prob.		
Group rho-Statistic	4.348786	0.0000*		
Group PP-Statistic	3.548211	0.0007*		
Group ADF-Statistic	-3.873064	0.0002*		

Note: *, **, *** indicate significant at 1%, 5% and 10% respectively. Trend assumption: Deterministic intercept and trend. Lag selection: Automatic SIC with a max lag of 4.

Cointegration test results for high income countries reported in Table-5 show that nine, out of eleven, test statistics are significant at 1%, 5% or 10% levels, which implies that there is long run equilibrium relationship between PPP exchange rate and relative population growth. The results for low income countries reported in Table 6 show that ten out of eleven test statistics are significant at 1% or 5% levels. Recall that nine out of eleven statistics are statistically significant when cointegration tests involve all countries in the sample. Thus there is no significant changes in empirical findings when countries are splitted based on their income group. Thus, it may be inferred from empirical results that PPP exchange rate and relative population growth both in high and low income countries are cointegrated. That is there is long run stable relationship between PPP exchange rate and relative population growth in these countries. These results give additional insight in the International Macroeconomics literature.

5. Conclusion and policy implications

This paper empirically examines the link between the relative population growth and PPP exchange rate through the so-called Balassa-Samuelson effect. It argues that relative population growth have significant role in explaining movement in national price levels through its impact on wages and that in turn affect PPP exchange rate. Since labor is immobile in the BS mechanism, so wage adjustment in response to increase (decrease) in working age population in the traded relative to non-traded good sector increase (decrease) the relative price of non-traded goods. This tends to appreciate (depreciate) real exchange rate. This paper relies on panel data and recent advances in panel unit-root and panel cointegration in testing the long run equilibrium relationship between relative population growth rates and PPP exchange rates for 80 countries and provides strong results supporting the hypothesis. This result has various major implications in the International Economics in general and policy decisions in particular. Among others, the relative population growth rates have important role in explaining real exchange rate behavior (Aloy and Gente, 2005). Moreover, it could also affect the international competitiveness of a country's goods and services. Relative population growth could invalidate the PPP hypothesis in the long run due to the BS effect. Since PPP is main edifice of most of the monetary exchange rate models, failure of PPP doctrine help collapse these models and thus, policy suggestions based on these models would then be inapplicable. Hence, the role of relative population growth should be taken into account in dealing with issues in International Economics.

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Annex-A: Country List

High income countries	Low income countries
Australia	Algeria
Austria	Bangladesh
Bahamas	Burundi
Barbados	Cambodia
Belgium	Central African Republic
Bermuda	China
Botswana	Colombia
Canada	Congo, Republic of
Chile	Cote d`Ivoire
Costa Rica	Cuba
Denmark	Dominican Republic
Equatorial Guinea	Ecuador
Finland	Egypt
France	Fiji
Gabon	Gambia, The
Germany	Guatemala
Hong Kong	Honduras
Hungary	India
Iceland	Jamaica
Israel	Jordan
Japan	Kenya
Korea, Republic of	Lesotho
Luxembourg	Malawi
Macao	Maldives
Malaysia	Mongolia
Malta	Namibia
Mauritius	Nepal
Mexico	Nigeria
Morocco	Pakistan
Netherlands	Papua New Guinea
New Zealand	Philippines
Portugal	Senegal
Singapore	Solomon Islands
South Africa	Sri Lanka
Spain	Swaziland
St. Lucia	Syria
Sweden	Tanzania
Switzerland	Thailand
Trinidad &Tobago	Tunisia
United Kingdom	Vanuatu