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Is the Balassa-Samuelson Hypothesis still relevant? Cross-country evidence from 1950 -2017

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Abstract. We revisit the Balassa and Samuelson hypothesis based on the relationship between real exchange rate and total factor productivity relative to the United States and investigate with panel data set of 182 countries from 1950 to 2017. Results, suggest that there is an inverse relationship between the two, an increase in productivity results in an increase in real exchange rate and the findings supports the hypothesis. We use a range of tests including Arellano-Bond Dynamic Panel Data (both fixed and random effect) estimator and findings validates the hypothesis. All these additional tests confirm that the relationship between real exchange rate and relative factor producity are related in the long-run also.
Keywords. Balassa–Samuelson effect; Exchange rate, Fixed effect model, Random effect model, Trade and globalization.
JEL. C15, E31, F31, F41.

1. Introduction

Given the trend worldwide towards increased trade and globalization, improvement of transportation and infrastructure, and with the improvement in communication technology over the past decades, it is important that we revisit one of the most prominent hypothesis in international trade and economics, the Balassa and Samuelson (B-S) hypothesis and to understand and illustrate the current trends in international trade and the dynamics exchange rate movements as the overall relationship between different countries in large parts depend on economic relationship.

Our study is broad based than studies extant in the economic literature as thedata consist of both developed and developing countries for 182 countries[1], all across the globe, covering the period 1950 to 2017 with 6,006

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[1] List of 182 countries presented in the Appendix.

observations. In prelude to our study, we observe that the exchange rate of home country appreciates when its total factor productivity (TFP) increases, relative that of the U.S. We find support for the BS Hypothesis from both the linear (simple) and the non-linear (quadratic) models and in both fixed and random effect models, but the Hausman test results favor random effect model. Panel Unit root tests show that the variables are stationary. Johansen Panel Co-integration (Kao-approach) test also show that the series are co-integrated. The Arellano-Bond Dynamic Panel Data Estimators confirm the inverse relation between the exchange rate and the productivity variables.

This paper is structured as follows. Literature review presented in the section 2 of the paper followed by Data and Methodology in section 3. Then Estimation results are analyzed in section 4 and finally section 5 presents the conclusion of the study.

2. Literature review

Many studies in the past have investigated the B-S effect in groups of developing countries with United States as the reference point. Drine & Rault (2003), tested the B-S hypothesis using annual data from the period 1990-1999 for 20 Latin American countries, and found that the hypothesis holds not only for the whole area, but also for Central American and South American groups of countries when considered separately. Garcia-Solanes & Torrejon-Flores (2007) remarked that improvements in the tradable sector productivity are normally linked to economic growth, which implies a relationship between relative economic development and the real exchange rate. As a result, it is expected that countries growing faster will tend to experience real exchange rate appreciations with respect to others countries. Garcia-Solanes & Torrejon-Flores (2009) conducted an in depth literature review of BS hypothesis and found that the best results supporting the hypothesis occur in the context of economics that grow at very divergent speeds, such as, Japan and Germany, compared to the USA in the post-World War II period, which was studied by Hsieh (1982) and Marston (1987). Another example is the case of some South East Asian countries compared with Japan during the seventies and eighties, studied by Ito, Isard & Symansky (1997). The last example came from the comparison of Central and Eastern European countries compared with Germany since the early nineties. Halpern & Wyplosz (2001), Kovacs (2002), Egert (2002a, b), Mihaljek & Klau (2003), Egert *et. al.*, (2002). Calderon & Schmidt-Hebbel (2003) provides empirical evidence on macroeconomic policies and results in Latin America and the Caribbean (LAC), based on recent data for the region and the world at large. The authors argue that there is evidence that capital inflow affects growth positively, but that also there is evidence that growth gives feedback to capital inflows creating the possible bias of endogenous regressors. Choudhri & Khan (2005) study finds that the traded-nontraded productivity differential is a significant determinant of the relative price of nontraded goods, and the relative price in turn exerts a significant effect on the real exchange rate. The terms of trade also influence the real exchange rate. These results provide strong verification of Balassa-Samuelson effects for developing countries. Alberola & Tyrväinen (1998), Chinn & Johnston (1999) and MacDonald & Ricci (2001) obtained positive results for the whole general BS proposition, but Canzoneri, Cumby & Diba (1999) found favorable evidence only for that part of the hypothesis that links the productive differential with the relative price of the tradable and non-tradable sectors. Heston, Nuxoll & Summers (1994) found that the difference between tradable and non-tradable prices moved with the income levels of OECD countries, which is consistent with the results of Canzoneri, Cumby & Diba (1999). Recent studies like Gubler & Sax (2019) paper reconsiders the Balassa-Samuelson (BS) hypothesis. The authors analyzes an OECD country panel from 1970 to 2008 and compare three data sets on sectoral productivity, including newly constructed data on total factor productivity. Overall, their within- and between-dimension estimation results do not support the BS hypothesis. For the time since the mid-1980s, they find a robust negative relationship between productivity in the tradable sector and the real exchange rate, even after including the terms of trade to control for the effects of the home bias. Earlier, supportive findings may depend on the choice of the data set and the model specification. Couharde *et. al.,* (2020) article highlights the guidance note outlines the construction and contents of RPROD. RPROD is a global database that complements EQCHANGE, by providing additional measures of the Balassa-Samuelson effect. Josip (2020) paper surveys empirical evidence on the Harrod-Balassa-Samuelson effect. The survey encompasses the published empirical work on the phenomenon since its (re)discovery in 1964. Results of the survey indicate that growing body of evidence definitely points towards professional rethinking about the significance of the Harrod-Balassa-Samuelson effect. Costa *et al.,* (2019) paper states that the lack of Purchasing Power Parities (PPPs) at regional level, regional Gross Domestic Product (GDP) figures have been traditionally adjusted using national PPPs and their paper tries to overcome this problem by estimating PPPs at subnational level for OECD countries through a new method which uses publicly available data and is based on the Balassa-Samuelson hypothesis.

Zayed, *et. al.,* (2018) paper's objective is to analyze the influence of real exchange rate changes on relative price, relative productivity, government share and terms of trade in Bangladesh during 1972-2016 by applying the Johansen long-run test for co integration. The results suggest that there exists a long-run relationship among the said variables. Berka, Devereux, & Engel, (2018) study investigate the link between real exchange rates and sectoral TFP for Eurozone countries. They show that real exchange rate variation, both cross-country and time-series, closely accords with an amended Balassa-Samuelson interpretation, incorporating sectoral productivity shocks and a labor market wedge. Their findings contrast with previous studies that have found little relationship between productivity and real exchange rates among high-income countries that have floating nominal exchange rates. Caputo (2018) looks in the aftermath of the 2008–2009 financial crisis, several emerging economies experienced substantial real exchange rate appreciations, the author conclude that appreciation episodes, in the aftermath of the 2009 financial crisis, can be explained by two elements: (i) an improvement in fundamentals and (ii) a correction of past misalignments. Hence, the real appreciation observed since 2010 was driven, mostly, by fundamental elements. Mariarosaria (2015) paper explores the role of economic fundamentals, included in the transfer effect theory, in explaining medium/long-run movements in the Real Effective Exchange Rates in the EU over the period 1994-2012. They find that the coefficients of the determinants are extremely different across groups in magnitude and sometimes in sign as well and the transfer theory does not hold for periphery and the Central and Eastern European countries (CEECs). Guo & Hall (2008) investigated the BS-effect on the annual measures of Chinese inflation and industry input on regional and sectoral basis for the period 1985-2000. Utilizing the Asea & Mendoza (1994) framework combined with non-stationary panel data techniques, the authors found empirical results that support the BS-effect and also found that the restrictions of the models are rejected. Fazio, McAdam & MacDonald (2007) examined the relationship between real exchange rate and three variables including trade balanced, productivity and markup. Using a cointegration-based framework that builds of a panel dynamic OLS technique, authors found mixed evidence between the real exchange rate and the fundamentals and the authors found that a productivity increase produces a currency depreciation. Bordo *et.al.*, (2017) using historical data for over hundred years and 14 countries estimates the long-run effect of productivity on the real exchange rate. They find large variations in the productivity effect across four distinct monetary regimes in the sample period. Choudhri, & Schembri (2010) study examines how the Balassa–Samuelson hypothesis is affected by a modern variation of the standard model that allows product differentiation (within the traded and nontraded goods sectors) with the number of firms determined exogenously or endogenously. Ricci, Milesi-Ferretti, & Lee, (2013) study employed the newly constructed measures for productivity differentials, external imbalances, and commodity terms of trade to estimate a panel cointegrating relationship between real exchange rates and a set of fundamentals for a sample of 48 industrial countries and emerging markets. They find evidence of a strong positive relation between the consumer price index-based real exchange rate and commodity terms of trade. Caselli (2018) study motivated by a Ricardian framework, the paper finds that countries with exports similar to those of China experience a loss in competitiveness compared with countries with a different trade structure. Mariarosaria (2017) article studies the impact of real effective exchange rate misalignments, based on determinants including different types of foreign capital inflows, on GDP growth in the EU using a panel of 27 EU countries for the period 1994–2012, with annual frequency. The author concludes that core countries have been only slightly undervalued from the crisis onwards, while the periphery was overvalued. Dumrongrittikul & Anderson (2016) study examines real exchange rate responses to shocks in exchange rate determinants for fourteen Asian developing countries. They find that trade liberalization generates permanent depreciation, and higher government consumption causes persistent appreciation. Natal *et al.*, (2015) conduct an empirical investigation of the determinants of the Swiss franc real exchange rate. Results stemming from a co-integration approach point to terms of trade and relative government spending as the most significant explanatory variables. Balassa-Samuelson effects do not play any significant role. Ito *et.al.*, (1997) suggests that applicability of the Balassa-Samuelson hypothesis to a particular economy depends on the development stage of the economy. It is especially applicable when a resource less open economy is growing fast by changing industrial structure and export composition.

3. Data and methodology

We collected a panel dataset data for 182 countries from all across the world including developed and developing countriescovering the period 1950 to 2017 for 6,006 observations from Penn Online database. In order to account for countrywide heterogeneity, we used panel data models, the fixed effect and the random effect models. Use of such panel data allowed us to generalize the result for many countries. We approximated a simple version of the model and a quadratic version. We alternately use CTFP (TFP level at current PPP's relative to USA and CWTFP (Welfare-relevant TFP levels at current PPPs relative to USAas independent variables. The dependent variable, XR_e is defined as real exchange rate, which is the nominal exchange rate (currency/USD (market-estimated) adjusted by GDP deflator.

Thus the simple model is specified as

$$Exchange\ rate = \beta_1 + \beta_2\ Productivity\ Index \tag{1}$$

We do not show the time and country level effects in equation (i) for simplicity sake. Exchange rate variable is measured as home currency per US dollar and TFP-productivity of given country is relative to the US-productivity. Therefore, the beta-2 coefficient(slope) should be negative and significant if B-S Hypothesis is true, which implies that an increase in relative productivity of given country compared to the US productivity will cause appreciation of home country currency.

The quadratic model – extended model is

$$Exchange\ rate = \beta_1 + \beta_2\ Productivity\ Index + \beta_3 + \ Productivity\ Index\hat{}2 \tag{2}$$

In order to test, if the impact of productivity changes on the real exchange rate is linear or non-linear (quadratic) we test the quadratic model in equation (ii). We include the non-linear (quadratic model) to check if our findings from the simple model change drastically or not. If beta-3 coefficient is statistical significant, then we know that the relationship is non-linear. Sign of this variable will tell us if we have a U-shape or Inverse-U shape curve. We conduct the Hausman-test to choose between the random effect model and the fixed effect model.

In the next step, we conduct panel unit-root tests(panel data version) on each series to see if they are stationary or not. Several versions of the Dicky-Fuller tests are conducted. Then we apply the Kao-test to check for co-integration between variables. In the last step, we run the Arellano-Bond Dynamic Panel Data model to confirm the long-run relationship between the XR_e and CTFP or XR_e and CWTFP.

4. Empirical analysis

In Table 1, we present the summary statistics of the variables included in this study. This is a large data set with approximately 6,006 rows of observations.

Table 1. *Summary statistics*

Variable	Obs	Mean	Std. Dev.	Min	Max
xr	9,985	243.1362	1342.97	0.00	33412.96
ctfp					
cwtfp	6,006	0.702	0.273	0.108	2.255
ctfp_sq	6,006	0.592	0.543	0.00	13.048
cwtfp_sq	6,006	0.567	0.46	0.012	5.085

In Table 2, we present the correlation coefficients. The correlation between real exchange rate (XR_e) and the productivity index (CTFP) is-0.1285. The correlation between exchange rate and square of total factor productivity (CTFP_SQ) index is -0.1013. On the other hand, the correlation between exchange rate (XR_e) and the alternative measure of productivity (CWTFP) and square of productivity (CWTFP_SQ) is -0.1468 and -0.1231, respectively.

Table 2. *Correlation coefficients*

	xr	ctfp	cwtfp	ctfp_sq	cwtfp_sq
xr	1				
ctfp	-0.1285	1			
cwtfp	-0.1468	0.895	1		
ctfp_sq	-0.1013	0.9325	0.7658	1	
cwtfp_sq	-0.1231	0.8368	0.9558	0.7743	1

In Table 3, we present the estimation results of simple (linear) models described in equation (i). The coefficients of the productivity index (CTFP and alternate welfare based measure CWTFP) is negative and statistically significant (level of significance 1 percent) across all the models (both fixed and random effect). This supports the B-S Hypothesis, that is, there is an inverse relationship between labor productivity and exchange rate. Hausman test reveals that the random effect model is preferred[2].

Table 3. *Simple model*

	Fixed Effect			
	Coefficient	Std. Err.	t-stat	p-value
CTFP	-202.378	73.347	-2.760	0.006
Constant	375.000	53.852	6.960	0.000
	Random Effect			
	Coefficient	Std. Err.	t-stat	p-value
CTFP	-233.138	71.173	-3.280	0.001
Constant	406.810	85.876	4.740	0.000
	Fixed Effect			
	Coefficient	Std. Err.	t-stat	p-value
CWTFP	-270.735	79.455	-3.410	0.001
Constant	420.919	57.291	7.350	0.000
	Random Effect			
	Coefficient	Std. Err.	t-stat	p-value
CWTFP	-307.290	77.036	-3.990	0.000
Constant	454.312	87.315	5.200	0.000

In Table 4, we present the estimation results of extended (quadratic) models presented in equation (ii). We include the extended version to check if the results of the simple model change when we change the model. We do not find different results for any pair of simple and corresponding extended model (compare Table 3 and 4 – corresponding panels). The coefficients of the productivity index are similar (negative and statistically) to those of the linear model as described in Table 3. However, the coefficients of the square of productivity index (CTFP_SQ and CWTFP_SQ) are positive and significant in all models. This implies that there is a U-shape relationship between the XR_e and CTFP and it square term (alternately CWTFP and its square term). These results remain the same in both fixed and random effect models, that is, the relation between the exchange rate and the total factor productivity is not sensitive across models[3].

[2]We have estimated all the models with nominal exchange rates also and get similar signs and significance for the relevant coefficients.

[3]We re-run the linear and the extended model for a sample of 13 developed countries and 164 developing countries, to compare results. For sake of brevity, we placed the results of the linear (Table 3-B and 3-C) and non-linear (Table 4-B and 4-C) countries separately in the statistical appendix section at the end of the article. List of countries are presented in appendix separately. We find that in tables Table 3-B and Table 4-B, the coefficients of CTFP and CWTFP are positive and significant. This is different from Table 3-C and 4-C, where the coefficient's of CTFP and CWTFP are negative and significant (the same as the overall sample Table 3 and Table 4). Thus we find that for developed countries, the local currency depreciates when productivity increases relative to the US. But for the rest of the developing countries, local currency appreciates for the same change in productivity. Findings for developing countries support the BS hypothesis, but those for developed countries do not. Choudhri & Khan (2005) study presented evidence on this issue based on a panel data sample of 16 developing countries. Their study finds trade influences the real

Table 4. *Extended model*

Fixed Effect				
CTFP	-539.882	189.879	-2.840	0.004
CTFP_SQ	164.665	85.453	1.930	0.054
Constant	517.846	91.619	5.650	0.000
Random Effect				
CTFP	-603.931	183.978	-3.280	0.001
CTFP_SQ	183.620	83.967	2.190	0.029
Constant	558.669	110.631	5.050	0.000
Fixed Effect				
CWTFP	-991.584	267.213	-3.710	0.000
CWTFP_SQ	400.390	141.717	2.830	0.005
Constant	699.719	114.089	6.130	0.000
Random Effect				
CWTFP	-1067.576	257.664	-4.140	0.000
CWTFP_SQ	427.059	138.069	3.090	0.002
Constant	740.770	127.440	5.810	0.000

Note: Hausman Test prefers Random Effect model

In Table 5 Part (a), the result of Panel Unit-root test for XR_e-seriesare presented. The null hypothesis states that all panels contains unit roots. The alternative hypothesis states that at least one panel is stationary. Findings are mixed, where Inverse and Modified Chi-square both reject null hypothesis, and all panels contain unit root. But Iverse normal and Inverse logit tests show that we fail to reject null. In Part (b), we test the same two hypothesis for the CTFP-variable and find that all the four Chi-square tests reject the null hypothesis at 10 percent level of significance. In Part (c), the tests for CWTFP shows that we reject null at 1 percent level of significant. Therefore, we conclude that some of these variables are stationary in different panels.

exchange rate providing strong verification of Balassa-Samuelson effects for developing countries. Our findings for 164 developing countries bears similar conclusion.

Table 5. *Panel unit-root tests*

Panel Unit-root Tests		
Part a: Fisher-type unit-root test for xr_e Based on augmented Dickey-Fuller tests		
Ho: All panels contain unit roots		
Number of panels	182	
Ha: At least one panel is stationary		
Avg. number of periods	54.86	
AR parameter: Panel-specific Asymptotics: T -> Infinity		
Panel means: Included		
Time trend: Not included		
Drift term: Not included		
ADF regressions: 3 lags		
	Statistic	p-value
Inverse chi-square	631.757	0.000
Inverse normal	4.782	1.000
Inverse logit	1.981	0.976
Modified inv. chi-square	9.924	0.000
Part b: Fisher-type unit-root test for ctfp Based on augmented Dickey-Fuller tests		
Ho: All panels contain unit roots Number of panels	116	
Ha: At least one panel is stationary Avg. number of periods	51.32	
AR parameter: Panel-specific Asymptotics: T -> Infinity		
Panel means: Included		
Time trend: Not included		
Drift term: Not included		
ADF regressions: 3 lags		
	Statistic	p-value
Inverse chi-squared(232) P	264.474	0.070
Inverse normal Z	-1.518	0.065
Inverse logit t(579) L*	-1.475	0.070
Modified inv. chi-squared Pm	1.508	0.066
Part c: Fisher-type unit-root test for cwtfp		
Based on augmented Dickey-Fuller tests		
Ho: All panels contain unit roots Number of panels	116	
Ha: At least one panel is stationary Avg. number of periods	51.32	
AR parameter: Panel-specific Asymptotics: T -> Infinity		
Panel means: Included		
Time trend: Not included		
Drift term: Not included		
ADF regressions: 3 lags		

In Table 6, the Johansen Panel Co-integration (Kao-tests) tests results presented for four models separately. The null hypothesis states that no cointegration and alternative hypothesis states that all panels are cointegrated. In Table 6-Part (a) the Kao test for the simple model with XR_e and CTFP shows that we reject null even at 1 percent level of significance. Table 6- Part-(b) presents the Kao test results for the model with XR_e and CWTFP. Again we reject the null in all criteria's. Part (c) presents result for the quadratic model between XR_e, CTFP and CTFP_SQ. Again we reject null for all criteria's. Finally, Part (d) presents the result for XR_e, CWTFP and CWTFP_SQ. We get similar result. As a result, we conclude that in the long-run these variables are co-integrated in the long run. The long run relationship between these two variables supports the B-S Hypothesis, there is an impact of changes in relative productivity on the exchange rate in the long-run. This also supports the statistically significant coefficients that we have seen in Table 3 and 4.

Table 6. *Cointegration tests*

Part (a): Linear Model with CTFP		
Kao test for cointegration		
Ho: No cointegration Number of panels	117	
Ha: All panels are cointegrated. Avg. Number of periods	49.33	
Cointegrating vector: Same		
Panel means: Included Kernel: Bartlett		
Time trend: Not included Lags: 2.28 (Newey-West)		
AR parameter: Same Augmented lags: 3		
	Statistic	p-value
Modified Dickey-Fuller t	22.384	0.000
Dickey-Fuller t	34.966	0.000
Unadjusted modified Dickey-Fuller t	20.838	0.000
Unadjusted Dickey-Fuller t	40.825	0.000
Part (b): Linear Model with CWTFP		
Kao test for cointegration		
Ho: No cointegration		
Number of panels	117	
Ha: All panels are cointegrated		
Avg. number of periods	49.32	
Cointegrating vector: Same		
Panel means: Included Kernel: Bartlett		
Time trend: Not included Lags: 2.34 (Newey-West)		
AR parameter: Same Augmented lags: 3	Statistic	p-value
	22.385	0.000
Modified Dickey-Fuller t	34.983	0.000
Dickey-Fuller t	20.841	0.000
Unadjusted modified Dickey-Fuller t	40.829	0.000
Unadjusted Dickey-Fuller t		
Part (c): Quadratic Model with CTFP and CTFP_SQ		
Kao test for cointegration		
Ho: No cointegration	117	
Number of panels	49.33	
Ha: All panels are cointegrated		
Avg. number of periods		
Cointegrating vector: Same		
Panel means: Included Kernel: Bartlett		
Time trend: Not included Lags: 2.32 (Newey-West)	Statistic	p-value
AR parameter: Same Augmented lags: 3	22.403	0.000
	35.001	0.000
Modified Dickey-Fuller t	20.854	0.000
Dickey-Fuller t	40.851	0.000
Unadjusted modified Dickey-Fuller t		
Unadjusted Dickey-Fuller t		

In Table 7-Part (a), we run the Arellano-Bond Dynamic Panel Data Estimator to examine the relationship between XR_e and CTFP. The coefficients of CTFP and one period lag of CTFP arenot statistically significant. In Table 7-Part (b), we rerun the same model on XR_e and CWTFP. We findsimilar results as in Part (a).

Table 7. *Arellano-Bond dynamic panel data estimator part*

(a): XR_eand CTFP				
	Coef.	Std. Dev.	z-stat	p-value
L1.ctfp	20.613	249.708	0.080	0.934
ctfp	-237.262	239.702	-0.990	0.322
Constant	389.634	56.842	6.850	0.000
Part (b): XR_e and CWTFP				
	Coef.	Std. Dev.	z-stat	p-value
L1.cwtfp	-9.210	265.148	-0.030	0.972
cwtfp	-276.064	262.352	-1.050	0.293
Constant	435.729	59.292	7.350	0.000

Although the literature on BS-hypothesis are quite broad, we feel, our paper stands out in many ways. First, we have worked with a large panel-data set including both the developed and the developing countries. Thus, we focused on how the BS-hypothesis relates to countries that are on a different levels of development. Second, we have employed a host of estimation techniques for panel data-set including fixed and random effect panel data estimation, cointegration and unit-root test for panel data, and Arellano-Bond panel data analysis in a dynamic setting. Third, our use of such panel data techniques implies that the results we get can be applied to different countries. Fourth, we believe that the trading relationship between countries are different and evolve over time as countries develop. Also, structure of economics of countries change with time and countries attain economic development with technological improvement, regulatory changes, trade policy changes etc. Consequently, our study on the BS-hypothesis was in a dynamic settings, in addition to the more conventional fixed and random effect models. Fifth, in the conclusion section of the paper we clearly show how our results relate to the findings of Gubler & Sax (2019). Sixth, policy recommendations are made based the findings of the paper so that countries that are achieving rapid economic development compared to its trading partners can maintain competitiveness in their export market. Given the availability of larger data-sets now, the need to examine the relationship between real exchange rate and relative factor productivity can hardly be overemphasized.

Given the changes that have taken place in international trade, financial liberalization and opening up of national economies to foreign investment and with the collapse of the Berlin Wall in 1989 and demise of Soviet Union in 1991 and left in its place 15 independent states in Eastern Europe and Central Asia, we felt the need to check the BS hypothesis (a long-standing idea), if the results are relevant in today's world and the existing relations still hold. International trade, investment, and economic-relations between countries are fluid and they change over time. Every decade is different from the previous one and as a result old ideas need to be revisted, appraised and evaluated. If there is a change, countries should take steps to reposition themselves to take advantage of it or take steps to safeguard their economic interests.

5. Conclusion

Here in this study, we investigated the relationship between real exchange rate and total factor productivity relative to the U.S. with the help of a panel data set of 182 countries for the period 1950-2017. Use of such a large data set including both developed, developing countries, and the use of panel data methodology, makes our findings generally applicable and not just confined to a particular country or region of the world. Our findings supports the B-S Hypothesis. Policy ought to be formulated carefully to diminish the adverse effect of home currency appreciation on export. Countries experiencing such phenomena may look how countries in the past have managed to walk a fine line between achieving high economic growth as well as increasing factor productivity and maintain export-competitiveness simultaneously, especially in countries where export earning plays a significant role in their annual budgets. We suggest to the policy makers in the developing countries experiencing rapid growth with increased productivity of factors have to be careful on the appreciation of value of their country's currency and the potential adverse effect on export and loss of export-competitiveness. Our views and findings are in line with Ito *et. al.*, (1997), Edwards & Levy-Yeyati (2005), Calderón & Schmidt-Hebbel (2003), and García-Solanes & Torrejón (2007) in their studies. Gubler & Sax (2019) study did not find support for the BS-hypothesis. However our study, find that there is support for BS-hypothesis. The mechanism behind BS-hypothesis play stronger role with such wider dispersion of the level of development between countries. One of the limitation, we feel in this study was data availability, we could not report the tradable and non-tradable sectors separately.

Appendix

Variables	Variable Definitions
Ctfp	TFP level at current PPPs (USA=1)
Cwtfp	Welfare-relevant TFP levels at current PPPs (USA=1)
Xr_e	Real Exchange Rate (Nominal Exchange Rate adjusted by GDP deflator)
ctfp_sq	ctfp square
cwtfp_sq	cwtfp square

Source: Penn World Tables, 2019 online.

Additional Statistical Tables

Table 3B. *Simple model developed country*

	Fixed Effect			
	Coefficient	Std. Err.	t-stat	p-value
CTFP	195.532	21.194	9.230	0.000
Constant	-127.175	18.650	-6.820	0.000
	Random Effect			
	Coefficient	Std. Err.	t-stat	p-value
CTFP	183.930	21.420	8.590	0.000
Constant	-115.449	31.973	-3.610	0.000
	Fixed Effect			
	Coefficient	Std. Err.	t-stat	p-value
CWTFP	263.425	27.535	9.570	0.000
Constant	-181.316	23.613	-7.680	0.000
	Random Effect			
	Coefficient	Std. Err.	t-stat	p-value
CWTFP	245.634	27.720	8.860	0.000
Constant	-164.302	36.418	-4.510	0.000

Table 3C. *Simple model developing country*

	Fixed Effect			
	Coefficient	Std. Err.	t-stat	p-value
CTFP	-239.9893	85.20339	-2.82	0.005
Constant	436.7295	59.72429	7.31	0
	Random Effect			
	Coefficient	Std. Err.	t-stat	p-value
CTFP	-264.492	82.698	-3.200	0.001
Constant	456.719	99.319	4.600	0.000
	Fixed Effect			
	Coefficient	Std. Err.	t-stat	p-value
CWTFP	-304.686	90.983	-3.350	0.001
Constant	477.919	62.775	7.610	0.000
	Random Effect			
	Coefficient	Std. Err.	t-stat	p-value
CWTFP	-334.658	88.353	-3.790	0.000
Constant	499.306	100.438	4.970	0.000

Table 4B. *Developed country extended model*

Fixed Effect				
CTFP	2771.875	82.970	33.410	0.000
CTFP_SQ	-1461.891	46.260	-31.600	0.000
Constant	-1222.830	37.229	-32.850	0.000
Random Effect				
CTFP	2624.869	89.669	29.270	0.000
CTFP_SQ	-1390.379	50.071	-27.770	0.000
Constant	-1149.031	43.425	-26.460	0.000
Fixed Effect				
CWTFP	3592.835	104.862	34.260	0.000
CWTFP_SQ	-1998.549	61.812	-32.330	0.000
Constant	-1524.073	44.869	-33.970	0.000
Random Effect				
CWTFP	3020.589	128.518	23.500	0.000
CWTFP_SQ	-1711.085	76.136	-22.470	0.000
Constant	-1249.300	55.800	-22.390	0.000

Note: Hausman Test prefers Random Effect model

Table 4C. *Developing country extended model*

Fixed Effect				
CTFP	-661.929	216.824	-3.050	0.002
CTFP_SQ	203.168	96.011	2.120	0.034
Constant	610.405	101.491	6.010	0.000
Random Effect				
CTFP	-703.164	210.460	-3.340	0.001
CTFP_SQ	214.217	94.460	2.270	0.023
Constant	632.129	126.181	5.010	0.000
Fixed Effect				
CWTFP	-1145.424	301.956	-3.790	0.000
CWTFP_SQ	464.776	159.181	2.920	0.004
Constant	794.393	125.231	6.340	0.000
Random Effect				
CWTFP	-1190.534	292.101	-4.080	0.000
CWTFP_SQ	477.819	155.390	3.070	0.002
Constant	814.553	143.768	5.670	0.000

Note: Hausman Test prefers Random Effect model

List of Developed Countries	
#	Country
1	Australia
2	Austria
3	Belgium
4	Canada
5	China
6	Denmark
7	Finland
8	France
9	Germany
10	Iceland
11	Ireland
12	Luxembourg
13	Netherlands
14	New Zealand
15	Norway
16	Republic of Korea
17	United Kingdom
18	United States

List of Developing Countries		List of Developing Countries	
#	Country	#	Country
1	Aruba	42	Djibouti
2	Angola	43	Dominica
3	Anguilla	44	Dominican Republic
4	Albania	45	Algeria
5	United Arab Emirates	46	Ecuador
6	Argentina	47	Egypt
7	Armenia	48	Spain
8	Antigua and Barbuda	49	Estonia
9	Azerbaijan	50	Ethiopia
10	Burundi	51	Fiji
11	Benin	52	Gabon
12	Burkina Faso	53	Georgia
13	Bangladesh	54	Ghana
14	Bulgaria	55	Guinea
15	Bahrain	56	Gambia
16	Bahamas	57	Guinea-Bissau
17	Bosnia and Herzegovina	58	Equatorial Guinea
18	Belarus	59	Greece
19	Belize	60	Grenada
20	Bermuda	61	Guatemala
21	Bolivia (Plurinational State of)	62	China, Hong Kong SAR
22	Brazil	63	Honduras
23	Barbados	64	Croatia
24	Brunei Darussalam	65	Haiti
25	Bhutan	66	Hungary
26	Botswana	67	Indonesia
27	Central African Republic	68	India
28	Switzerland	69	Iran (Islamic Republic of)
29	Chile	70	Iraq
30	Côte d'Ivoire	71	Israel
31	Cameroon	72	Italy
32	D.R. of the Congo	73	Jamaica
33	Congo	74	Jordan
34	Colombia	75	Japan
35	Comoros	76	Kazakhstan
36	Cabo Verde	77	Kenya
37	Costa Rica	78	Kyrgyzstan
38	Curaçao	79	Cambodia
39	Cayman Islands	80	Saint Kitts and Nevis
40	Cyprus	81	Kuwait
41	Czech Republic	82	Lao People's DR

	List of Developing Countries		List of Developing Countries
83	Lebanon	124	Russian Federation
84	Liberia	125	Rwanda
85	Saint Lucia	126	Saudi Arabia
86	Sri Lanka	127	Sudan
87	Lesotho	128	Senegal
88	Lithuania	129	Singapore
89	Latvia	130	Sierra Leone
90	China, Macao SAR	131	El Salvador
91	Morocco	132	Serbia
92	Republic of Moldova	133	Sao Tome and Principe
93	Madagascar	134	Suriname
94	Maldives	135	Slovakia
95	Mexico	136	Slovenia
96	North Macedonia	137	Sweden
97	Mali	138	Eswatini
98	Malta	139	Sint Maarten (Dutch part)
99	Myanmar	140	Seychelles
100	Montenegro	141	Syrian Arab Republic
101	Mongolia	142	Turks and Caicos Islands
102	Mozambique	143	Chad
103	Mauritania	144	Togo
104	Montserrat	145	Thailand
105	Mauritius	146	Tajikistan
106	Malawi	147	Turkmenistan
107	Malaysia	148	Trinidad and Tobago
108	Namibia	149	Tunisia
109	Niger	150	Turkey
110	Nigeria	151	Taiwan
111	Nicaragua	152	U.R. of Tanzania: Mainland
112	Nepal	153	Uganda
113	Oman	154	Ukraine
114	Pakistan	155	Uruguay
115	Panama	156	Uzbekistan
116	Peru	157	St. Vincent and the Grenadines
117	Philippines	158	Venezuela (Bolivarian Republic of)
118	Poland	159	British Virgin Islands
119	Portugal	160	Viet Nam
120	Paraguay	161	Yemen
121	State of Palestine	162	South Africa
122	Qatar	163	Zambia
123	Romania	164	Zimbabwe

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