ECO412A

International Economics and Finance

Course Instructor :

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Investigating PPP and its Deviations: Overshooting Effects and Productivity Differentials

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Abstract

This paper examines the validity of Purchasing Power Parity (PPP) in the long run, focusing on the factors causing deviations from the theory. Our analysis reveals that PPP does not hold for exchange rates between India and select ASEAN members—Singapore, Malaysia, and the Philippines—due to differences in levels of development, productivity, and the sticky nature of prices. We provide empirical validation of the Balassa-Samuelson hypothesis, showing that productivity differentials between the traded and non-traded goods sectors significantly contribute to PPP deviations. Additionally, our investigation into exchange rate overshooting postulates finds limited evidence of significant overshooting, with short-term shocks showing only minimal impact on exchange rates. Robust econometric techniques, including unit-root tests and regression models, substantiate these findings, offering insights into the long-term and short-term dynamics of exchange rates. The implications of these results emphasize the limitations of PPP in explaining exchange rate behavior across countries at different stages of economic development.

Contents

1 Introduction

Purchasing Power Parity, commonly termed as PPP, is a theory of exchange rate determination. However, as stated by Dornbusch [1] , at different times and by different authors, PPP has been assumed to be an identity, a truism, or a gross oversimplification. We begin this paper with a brief overview of PPP and its different postulates, followed by potential complications that arise due to the stringent assumptions of the theory. To better understand these deviations from PPP, we review the literature on this topic, including the paper by Froot & Rogoff [2] which details the various methodologies used to test PPP and the reasons for possible deviations. We then outline our objective in this paper, to test whether PPP holds for exchange rates between India and ASEAN bloc members, and if not, to test whether the Balassa-Sameulson hypothesis could explain the deviation. The later sections of this paper deal with the methodologies and data to test our hypothesis, signing off with our findings and conclusions.

1.1 Postulates of Purchasing Power Parity

The most basic formulation of PPP derives itself from the **Law of One Price** in an integrated, cooperative market. The Law of One Price states the following: *In the absence of trade frictions (such as transport costs and tariffs), and under conditions of free competition and price flexibility , identical goods sold in different locations must sell for the same price when prices are expressed in a common currency.* [3]

Purchasing power parity simply relates the law of one price to a basket of goods. This formulation, also called as **absolute PPP** states the following: *If the law of one price holds for each good in the basket, it will also hold for the price of the basket as a whole.*

In other words, purchasing power parity states that the exchange rate should adjust such that the same basket of goods and services costs the same in both countries, when priced in a common currency. It can be written as

$$e = \frac{p}{p^*} \tag{1}$$

where e is the nominal exchange rate, p is the domestic price level, and p^* is the foreign price level. Under absolute PPP, the **real exchange rate** between two countries **equalizes to one**. The second most common formulation of PPP, called **relative PPP** states the following: *The rate of depreciation of nominal exchange rate is equal to the inflation rate differential.* It can be written as

$$\hat{e} = \hat{p} - \hat{p^*} \tag{2}$$

where $\hat{e}$ is the rate of depreciation of exchange rate, $\hat{p}$ is the domestic inflation rate and $\hat{p^*}$ is the foreign inflation rate.

1.2 Possible reasons for Deviation

There has been vast empirical research done showing that PPP generally doesn't hold in the short run. With the rise of floating exchange rates, it has become self-evident that price levels do not explain the fluctuations in exchange rates on a monthly or even annual basis. For example, consider the data on price levels and exchange rates for the U.S and U.K. from 1975-2010. [3] We clearly see that although the relative price levels and exchange rates drift together in the long run, they

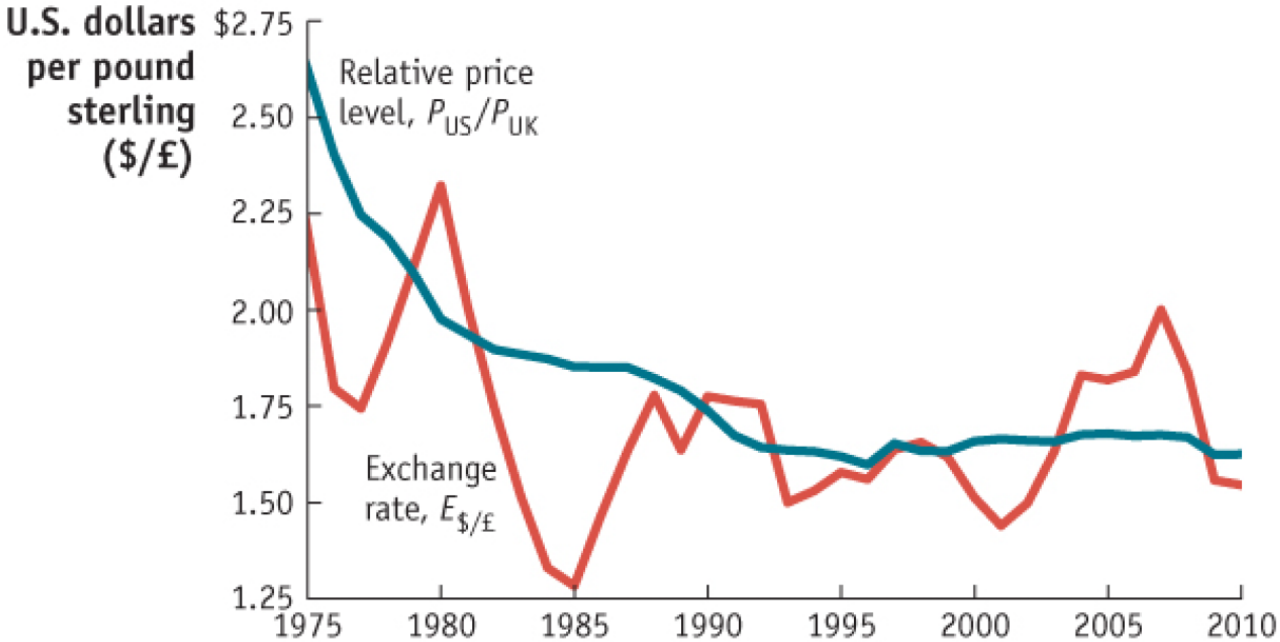

Figure 1: Data from Penn World Table, version 7.1

do not move together in the short run, as the exchange rate fluctuates wildly in the short run.

The reasons for these deviations stem from the assumptions of the law of one price and purchasing power parity. For purchasing power parity to hold, there must be **free flow of goods & services, no transaction costs, and the goods in consideration should be identical across countries**. Even if countries try to ensure the first through free-trade agreements, it is not practically possible for the other assumptions to hold in reality. Additionally, PPP doesn't account for the **sticky** nature of prices, which might lead to **exchange rate overshooting**, another possible reason for deviation from PPP in the short run.

1.3 Balassa-Samuelson Hypothesis

There are a lot of empirical tests that can be conducted to test the deviations from PPP in terms of price levels and exchange rates, but the Balassa-Samuelson hypothesis attempts to empirically explain this deviation in terms of more fundamental factors like **productivity**. The key result put forward by Balassa [4] and Samuelson [5] was the following: *Countries with higher productivity growth in the tradable goods sector experience real exchange rate appreciation due to higher wages and prices in the non-tradable goods sector.*

The reasoning for this was that a higher productivity in the tradable sector pushes up prices and wages. Since labor is mobile, this also pushes the wages in the non-tradable sector, also pushing up the prices. This leads to an overall appreciation of the real exchange rate. Another key point of this argument is that this productivity bias seems to be stronger in richer countries, meaning **richer countries have higher price levels.** For our purposes, the implication is that PPP might not hold in the short run between countries at different stages of development, as the currency of the developed country might be overvalued due to a higher productivity level in the tradable goods sector.

1.4 Objective of this Study

We have picked the country set as India and ASEAN bloc members for two reasons: (1) since they are part of a free-trade agreement, we can expect a reasonably free movement of goods & services, and (2) the set includes countries at various stages of economic development, conducive to a Balassa-Sameulson effect in PPP deviations. Using time series data of exchange rates for these nations, we first test whether PPP holds in the short or long run for different exchange rate combinations. In case of deviations, we analyze possible macroeconomic phenomenon like exchange rate overshooting. Finally, we assess whether the Balassa-Sameulson hypothesis could explain the deviations from PPP for these nations.

2 Literature Review

The study by Froot & Rogoff [2] provides a thorough analysis of PPP and how it can be used to comprehend long-term real exchange rates. Although PPP had a lot of theoretical appeal, Froot & Rogoff's research over time examined the principle's actual applicability as well as its subtle theoretical aspects. The study emphasized the notable departures from PPP that were noted in empirical research, especially in the short term. Among the explanations given in the work are:

- **Price Stickiness:** Froot & Rogoff emphasized the role of sticky prices in explaining deviations from PPP. Prices of goods, especially ***non-traded goods*** (such as services), do not adjust instantly to changes in exchange rates. This causes real exchange rates to deviate from PPP predictions.

- **Market Frictions:** Transaction costs, tariffs, and other trade barriers prevent immediate price equalization.

- **Half-Life of Deviations:** Using econometric techniques such as autoregressive models, Froot & Rogoff estimated the speed at which exchange rates revert to their PPP values. The *"half-life"* of a deviation refers to the time it takes for half of the gap between the current real exchange rate and its long-run equilibrium to close. Empirical estimates by Frankel [6] & Engel [7] suggested that the half-life of PPP deviations can be anywhere from 3 to 5 years, indicating a slow adjustment process.

Froot & Rogoff also discussed the different types of economic shocks and their impact on real exchange rates:

- **Nominal shocks** (e.g., monetary policy changes or inflationary shocks) can cause real exchange rate deviations in the short run.

- **Real shocks** (e.g., productivity changes or terms of trade shocks) have more persistent effects on real exchange rates.

The key insight is that nominal shocks typically fade over time as prices adjust, but real shocks can lead to long-term changes in the equilibrium real exchange rate.

While actual exchange rates reflect mean reversion, the adjustment process is slow, as demonstrated by Froot & Rogoff's use of autoregressive and cointegration approaches. In this case, exchange rates do eventually converge toward PPP-implied values, even though PPP aberrations may last for a number of years. In the end, this proves the long-run PPP hypothesis to be correct, even though it is not a very accurate indicator of the short-term behavior of exchange rates.

Further variance decomposition approaches were used by Froot & Rogoff to differentiate between long-term trends and short-term exchange rate volatility. In particular, this examines how much of the volatility in exchange rates is attributable to short-term shocks like speculative bubbles as opposed to long-term fundamentals like inflation differentials. This showed that short-term factors unrelated to PPP account for a large part of exchange rate variability. On the other hand, exchange rate swings increasingly mirror the PPP-predicted fundamentals over longer time horizons. This emphasizes the difficulty of use PPP for short-term exchange rate predictions but validates its long-term applicability.

The study makes the case that sustained exchange rate misalignments can have a big impact on capital flows and trade competitiveness. An inflated currency could harm domestic sectors by making exports prohibitively expensive, whereas a nation with a consistently undervalued currency might benefit from a competitive advantage in exports. When drafting exchange rate policies and other measures to stabilize economies, officials must have a thorough understanding of the nature of deviations from PPP. Although PPP offers a valuable framework for comprehending exchange rates in the long run they found that it is less trustworthy for short-term forecasting. The empirical evidence shows that real exchange rates do not immediately adjust to parity levels. Instead, short-term deviations are common due to factors such as sticky prices, speculative market behavior and the presence of non-traded goods.

Ultimately, Froot & Rogoff drew attention to the further discrepancy that all exchange rates employed in the research are between pairs of high-income nations during the sample period relative to the global average. This made many question if PPP would hold up in two nations with very different development histories. They also show proof that, since the turn of the 20th century, the value of the Argentine peso has declined significantly in real terms relative to the dollar and the pound, and they conclude that, even after more than 70 years of data, it is still impossible to conclusively reject the random walk model.

Rogoff's further work [8] also showed persistent short-term deviations from PPP due to factors such as price stickiness and market frictions.

2.1 Research Gap

While much has been studied about PPP, key gaps remain, particularly regarding developing economies and specific sectoral impacts. Our research aims to address these overlooked areas, as described below.

- **Developing vs. Developed Economies:** While most literature primarily investigates Purchasing Power Parity (PPP) in developed nations, limited attention has been given to developing economies. The Balassa-Samuelson effect, for instance, has been well-explored in the context of richer countries. However, our research highlights the need for a comparative analysis that includes both developing countries (like Philippines) and developed ones (such as Singapore). This comparison allows us to uncover new patterns in PPP deviations that may be specific to economies at different stages of development.

- **Sector-Specific Productivity Impact:** Prior research on productivity's effect on PPP deviations often treats productivity in a broad, aggregate sense. Our study narrows this down to focus on the traded goods sector, which plays a more direct role in determining exchange rates and price levels. Understanding the dynamics between productivity in this sector and how it translates into non-traded goods sector and affects the overall price levels and real exchange rates presents a significant gap in the literature. This sector-specific focus is critical to better understand the nature and extent of PPP deviations.

3 Hypothesis Testing

We deal with four major problems in this research paper. The first two hypotheses pertain to the validity of PPP, while the other two hypotheses test for reasons of deviations from PPP.
The first hypothesis is **testing simple PPP**, using the conventional regression approach.

H_o	*PPP holds in the long run*
H_a	*PPP does not hold in the long run*

However, we might face stationarity issues for our time-series data using this simple approach. Therefore, our second hypothesis accounts for the non-stationary behaviour of real exchange rate and **treats it as a random walk**, with the following hypothesis:

H_o	*Real exchange rate follows a random walk*
H_a	*Real exchange rate is stationary*

If the null hypothesis is not rejected, then it means that deviations from PPP are permanent. If it gets rejected, it would mean that real exchange rate reverts to PPP in the long run.
The third hypothesis deals with the **Balassa-Samuelson** effect, with the following hypothesis for real exchange rate ν and productivity differentials:

H_o	ν *is positively affected by productivity differentials*
H_a	ν *is unaffected by productivity differentials*

Finally, we test for **exchange rate overshooting** due to **sticky-price effects** using the following hypothesis:

H_o	*Exchange rates overshoot due to short-term shocks*
H_a	*Exchange rates adjust immediately*

Testing for these four hypotheses provides us with a comprehensive and robust understanding of whether PPP holds in the long run, and what are the possible reasons for deviations from PPP. The next section provides the econometric specification of these problems.

4 Methodology

4.1 Testing Simple PPP

We assess the basic tenet of PPP, which postulates that the exchange rate between two countries should equalize the price of a similar basket of goods across these countries. To account for differences in baskets of goods in the CPI calculation for the two countries, we consider changes in prices and nominal exchange rates, instead of their absolute values directly. Our regression equation is:

$$\Delta e_t = \alpha + \beta(\Delta p_t - \Delta p_t^*) + \epsilon_t \tag{3}$$

where Δe_t represents the change in the nominal exchange rate, Δp_t and Δp_t^* are the changes in domestic and foreign price levels, respectively, α and β are parameters to be estimated and ϵ_t is the error term.

The hypothesis to be tested here is:

H_o	*β = 1 (indicating PPP holds)*
H_a	*$\beta \neq$ 1 (indicating deviations from PPP)*

To ensure the robustness of our findings, we employ the **Augmented Dickey-Fuller (ADF)** test to examine the stationarity of the residuals from our regression. If the residuals are found to be non-stationary, it implies that there might be a spurious regression, and the results could be misleading. The testing involves regressing the first difference of the error term against its lagged values and the lagged first differences to account for autocorrelation.

The regression equation for this test is:

$$\Delta\epsilon_t = \alpha + \gamma\epsilon_{t-1} + \sum_{i=1}^{n} \beta_i \Delta\epsilon_{t-i} + v_t \tag{4}$$

where ϵ_{t-1} is the lagged error term from the PPP regression, β_i are coefficients on the lagged first differences to account for autocorrelation and v_t is the white noise error term.

The hypothesis tested using the Dickey-Fuller test statistic is:

H_o	*γ = 0 (error is non-stationary)*
H_a	*γ < 0 (error is stationary)*

4.2 Real Exchange Rate as a Random Walk

The first model assumes stationarity of the error terms, which may not hold statistically. So, now we model real exchange rate as a random walk, i.e., as a non-stationary series. Under the null hypothesis, real exchange rate follows a random walk as represented by the equation below, suggesting deviations from PPP do not necessarily correct themselves over time:

$$q_t = q_{t-1} + \epsilon_t \tag{5}$$

where q_t represents the real exchange rate defined as the logarithm of the nominal exchange rate adjusted for the price levels:

$$q_t = e_t - p_t + p_t^* \tag{6}$$

The following hypothesis can be tested using **Dickey-Fuller Test**.

H_o	*q_t has a unit root*
H_a	*q_t does not have a unit root*

4.3 Balassa-Samuelson Hypothesis

This model examines the impact of productivity differentials on the real exchange rates, based on the Balassa-Samuelson effect. We use the GDP of the traded goods sector divided by the labor force in the traded goods sector as a measure of the productivity of this sector. Thus, we estimate the following cross-sectional model for a certain year to examine deviations from PPP as a result of productivity differentials in the traded goods sector between the two countries:

$$\left(\frac{p}{ep^*}\right)_i = \alpha + \beta\left(\frac{GDP_T}{L_T}\right)_i + \epsilon_i \tag{7}$$

where $\left(\frac{p}{ep^*}\right)_i$ is the inverse of the real exchange rate for country i, $(GDP_T)_i$ and $(L_T)_i$ represent the GDP of the traded goods sector and the labor force in the traded goods sector for country i, respectively and α and β are parameters.
We test the following hypothesis for this model:

H_o	β > 0 *(richer countries have higher real exchg. rates)*
H_a	β = 0 *(no impact of productivity differentials)*

4.4 Overshooting of Exchange Rates

This model investigates whether exchange rates overshoot their equilibrium value in response to shocks, due to sticky prices and other short-term frictions. Additionally, we also include interest rate differentials in the regression equation as they impact capital inflows and hence exchange rates in the flexible regime. The regression equation for the model is similar to the first model, except an additional interest rate differential term in the RHS:

$$\Delta e_t = \alpha + \beta_1(\Delta p_t - \Delta p_t^*) + \beta_2(\Delta r_t - \Delta r_t^*) + \epsilon_t \tag{8}$$

where Δr_t and Δr_t^* are the changes in domestic and foreign interest rates, respectively. The hypothesis to be tested is:

H_o	$\|\beta_1\|$ > 1 *(exchange rates overshoot)*
H_a	β_1 = 1 *(exchange rates adjust immediately)*

The Augmented Dickey-Fuller test is also used here to assess the stationarity of the residuals, ensuring that the estimates are consistent and reliable.

Our methodology uses time series models, like the Augmented Dickey-Fuller test, to analyze exchange rate behavior over time. We also apply regression models to study productivity differences in the traded goods sector. By examining both short-run overshooting and long-run trends, we aim to capture how exchange rates behave across different economies, providing a well-rounded analysis.

5 Data Sources

For the empirical analysis, we will utilize data pertaining to India and 3 ASEAN member countries, Singapore, Malaysia and the Philippines. We will be leveraging the **World Development Indicators** dataset of the World Bank for the following indicators: **Traded Sector Labor, Interest Rates, Exchange Rates, Price Levels, Traded Sector GDP**

6 Observations

6.1 PPP does not hold

We tested the first hypothesis for Singapore, Malaysia, and Philippines with India as the reference country. We ran regressions between depreciation of exchange rate and inflation rate differential with data from 1960 to 2023. For all three country pairs, the null hypothesis was rejected. This means that PPP does not hold for these countries in the long run.

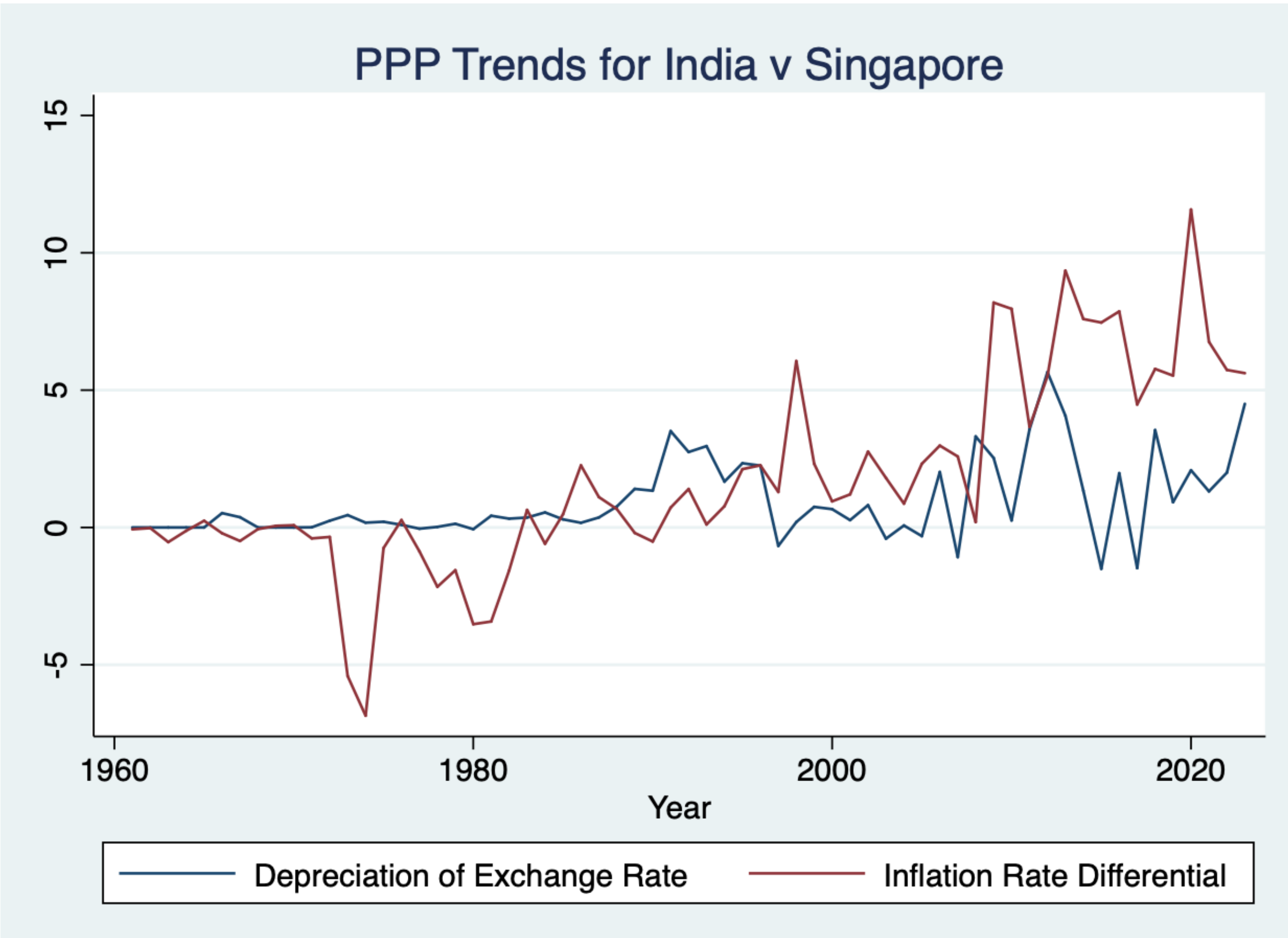

Figure 2: PPP Trends for India v Singapore

The regression results show that the coefficient values of the inflation differential for Singapore, Malaysia and Philippines came out to be 0.15, 0.09, 0.01 respectively. These coefficients were significant at 1%, 10% and 10% level respectively. The complete regression results can be found in the **Appendix**. Also, the fact that PPP did not hold for these countries can be seen from figures 2, 3 & 4. For each country it can be seen that exchange rate depreciation and inflation rate differential diverge at different points. Especially the post-Covid number indicate that inflation rate differentials have in fact overshot the exchange rate deprecations by significant margins. The results of the regression are **robust**, as the **Augmented Dickey-Fuller** tests confirmed the variables of interest were all **stationary** in nature. The results of the ADF tests are provided in **Appendix**.

The initial specification provided in Hypothesis 1 did not prove to be sufficient for significant results in case of Malaysia and Philippines. To counter this problem, the original specification was modified by adding **lagged terms of the inflation rate differential**. Therefore the model tested for these countries had the following specification:

$$\Delta e_t = \alpha + \beta_1(\Delta p_t - \Delta p_t^*) + \beta_2(\Delta p_{t-1} - \Delta p_{t-1}^*) + \beta_3(\Delta p_{t-2} - \Delta p_{t-2}^*) + \beta_4(\Delta p_{t-3} - \Delta p_{t-3}^*) + \epsilon_t \quad (9)$$

where $p_{t-1}, p_{t-2}, p_{t-3}$ are the first, second, and third-order lagged terms for the domestic price levels. The rationale behind adding these lagged variables was to capture the **delayed effects** of inflation rates on exchange rates. We found that adding these lagged variables did increase the explanatory effect of our regression models. Again the results for these regressions are provided in Appendix.

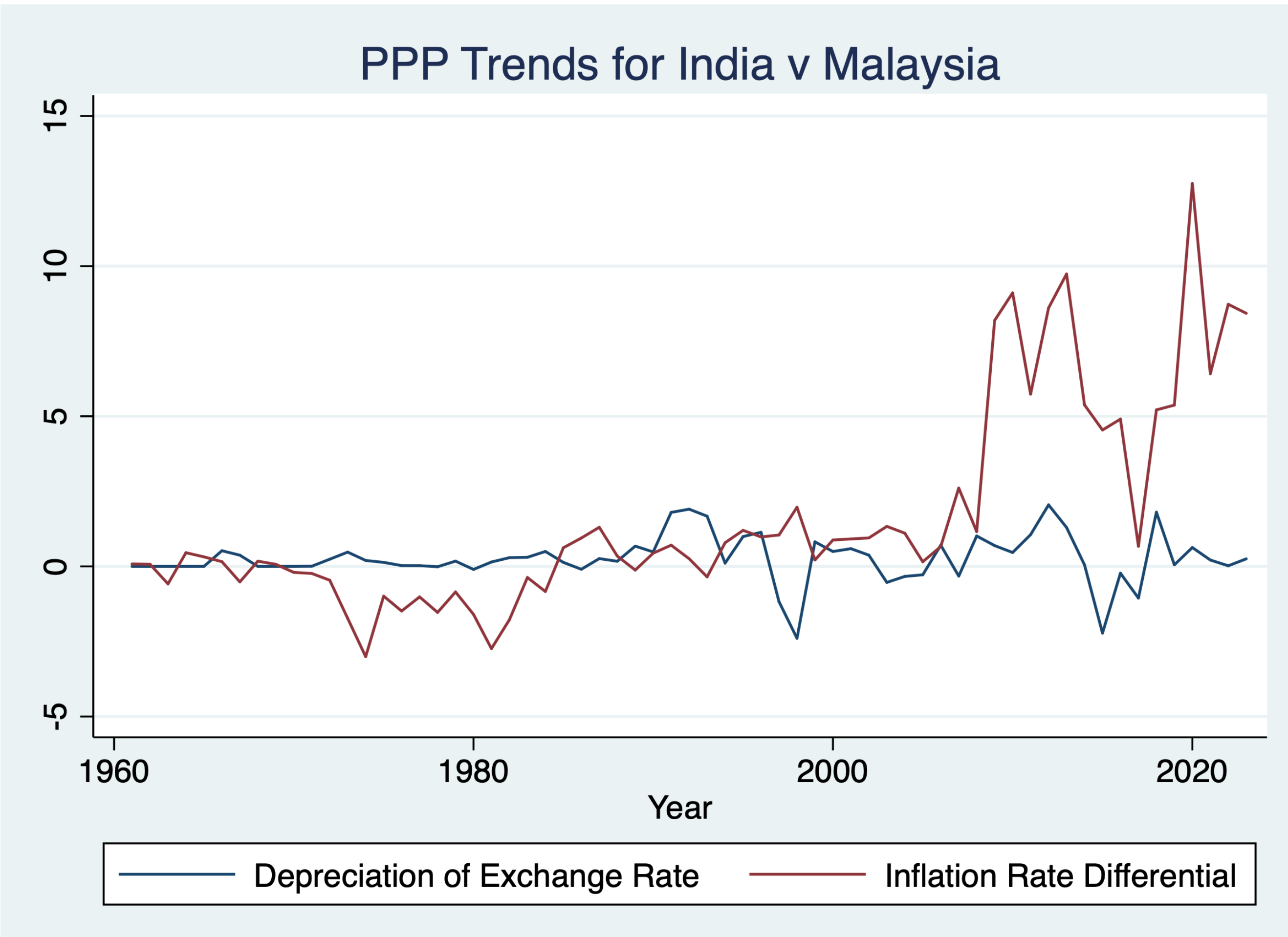

Figure 3: PPP trends for India v Singapore

The indication from these results is that since PPP does not hold in the long run for these countries, and the model is robust, there must be some other theoretical explanation that explain why PPP does not hold. We provide the results from our regression testing the Balassa-Sameulson effect in the next section.

6.2 Evidence for Balassa-Sameulson Effect

We tested the Balassa-Sameulson effect by regressing the inverse of the real exchange rate against relative productivity in the traded good sector. For this experiment, we collected the GDP and

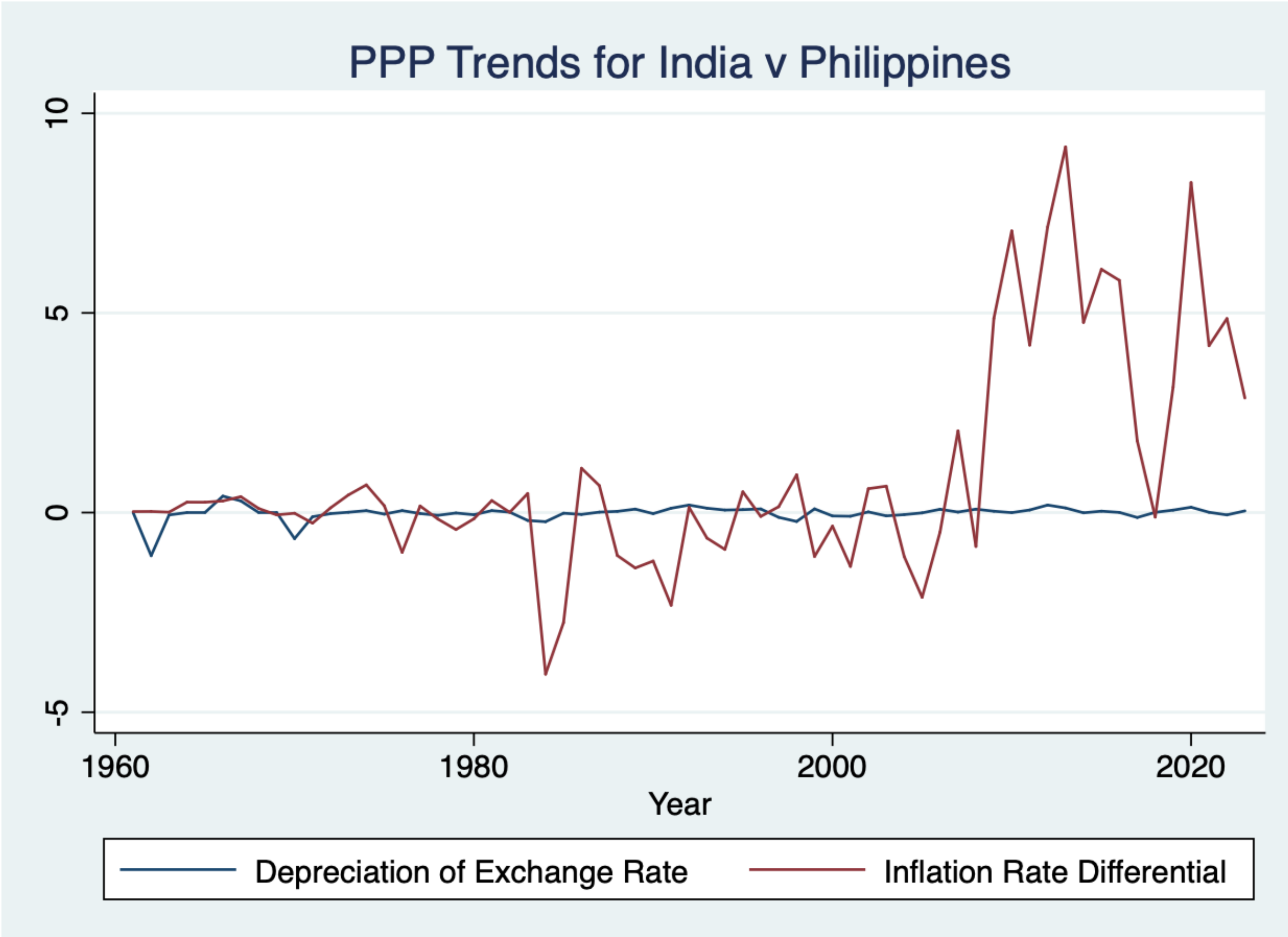

Figure 4: PPP trends for India v Philippines

labor data for the **manufacturing and agricultural sectors** as part of the traded sector. Due to limitations of traded sector data, we were only able to collect data from 2004 to 2023. However, with 20 years of data too we had some interesting results.

6.2.1 Singapore has higher productivity in traded goods sector

In our regression between Singapore and India, the coefficient for productivity difference came out be **positive** and **significant** at the 1% level. The results are provided in Appendix. These results show that the null hypothesis holds and PPP may not be holding between these countries because of Singapore's higher trade productivity and subsequently higher real wage rates.

As can be seen from Figure 5, Singapore's traded sector productivity has outstripped India's since 2004 and increasingly so in the last decade. These results are **in line** with our initial expectations according to the Balassa Sameulson hypothesis.

6.2.2 Malaysia and Philippines show the opposite trend

In case of Malaysia and Phillipines we saw that coefficients of the productivity difference were **negative** and **significant**, meaning that the Balassa-Sameulson effect was holding in reverse.

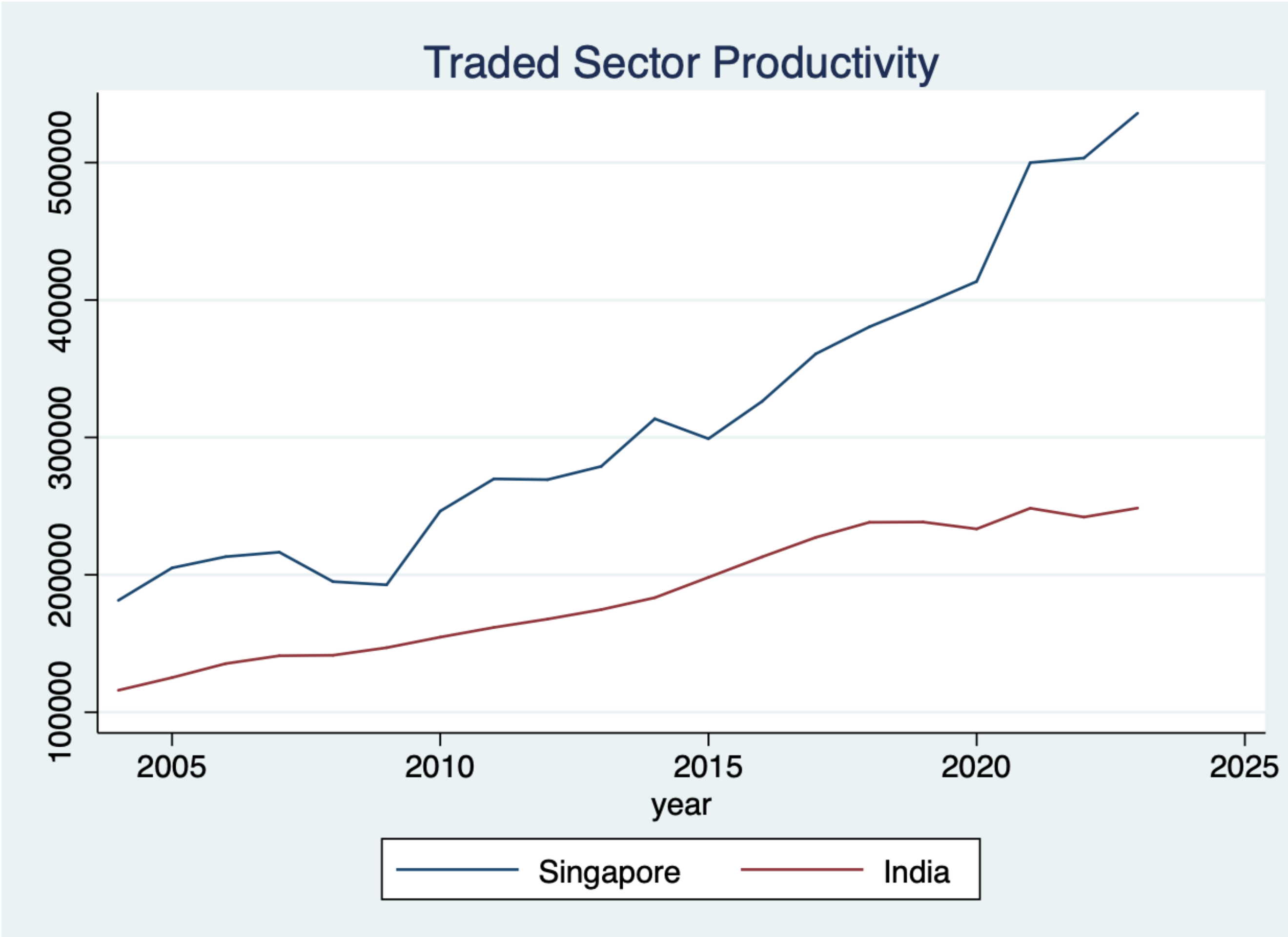

Figure 5: Traded Sector Productivity for India and Singapore

This further implies that India's traded sector productivity was **higher** compared to Malaysia and Philippines. This can be seen from figures 6 and 7. The results for the regression are provided in Appendix.

This means that PPP does not hold between these countries because of the higher trade sector productivity in India leading to higher real wage rates. Combining the results of hypothesis 1 and 3, we can formulate the following observation: **Purchasing Power Parity does not hold between India-Singapore, India-Malaysia, and India-Philippines due to differences in their Traded Goods' sector productivity as argued by Balassa & Sameulson**.

6.3 No Evidence for Exchange Rate Overshooting

Initially, we had also provided a possible model for testing PPP in case the time series tested in Hypothesis I were not stationary. This would imply that the exchange rate might be following a random walk. However, since the results of Hypothesis I were robust and the variables were stationary as checked using ADF tests, we did not proceed further with Hypothesis II.

For Hypothesis IV, which investigates exchange rate overshooting, we analyzed the regression results for three countries:

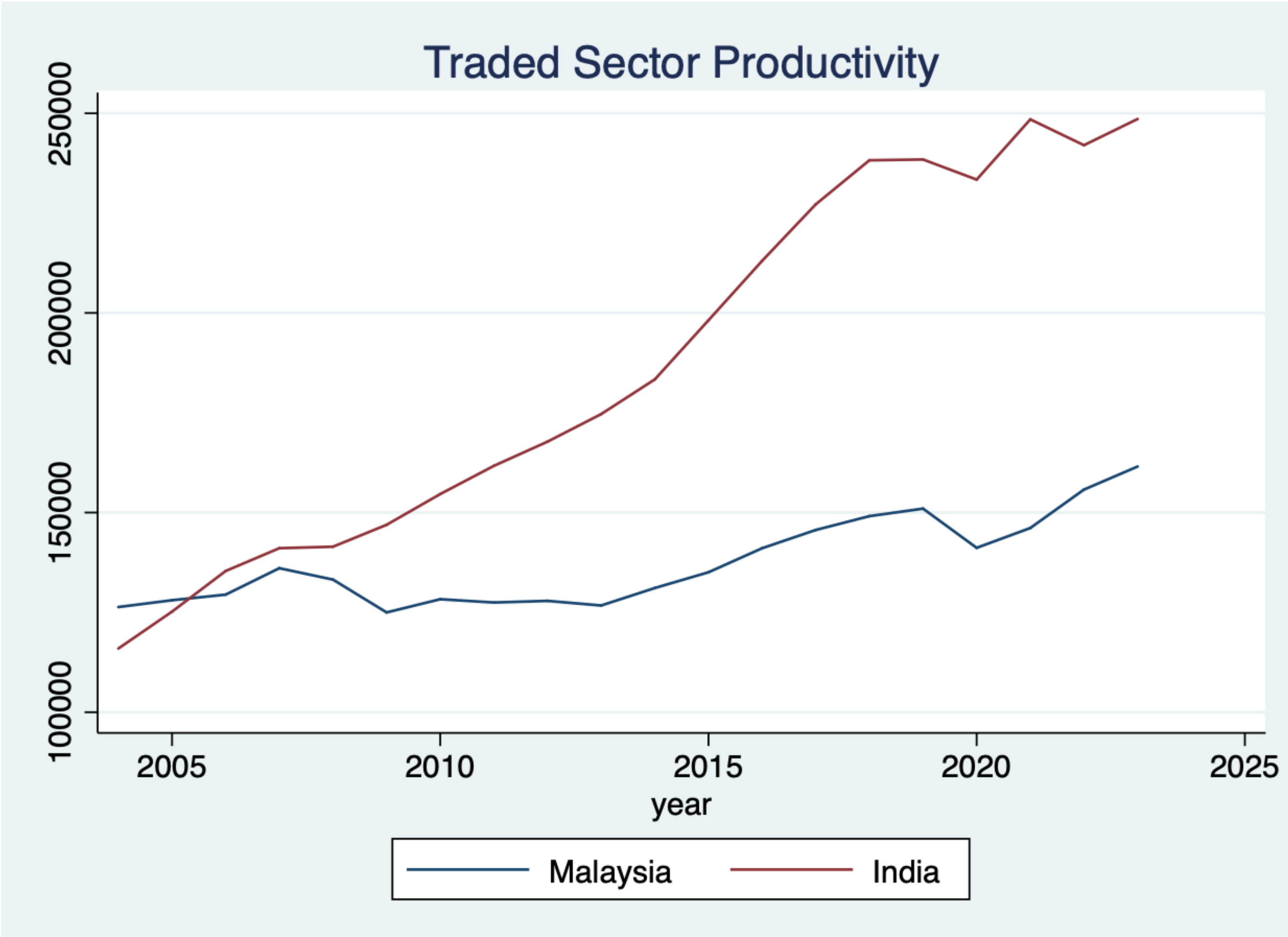

Figure 6: Traded Sector Productivity for India and Malaysia

- For **Singapore**, the coefficient $\beta_{Singapore} = 0.09$, which is different from the null hypothesis. The p-value $= 0.047$ indicates that the results are statistically significant at the 5% level. Thus, we reject the null hypothesis.

- For **Malaysia**, the coefficient $\beta_{Malaysia} = -0.81$, which is different from the null hypothesis. The p-value $= 0.00$ indicates that the results are statistically significant at the 1% level. Thus, we reject the null hypothesis.

- For **Philippines**, the coefficient $\beta_{Philippines} = 0.019$, which is different from the null hypothesis. The p-value $= 0.00$ indicates that the results are statistically significant at the 1% level. Thus, we reject the null hypothesis.

The regression results for these three countries are provided in the **Appendix** for reference.

Despite rejecting the null hypothesis in these cases, the magnitudes of the coefficients do not provide strong evidence for substantial exchange rate overshooting. This suggests that short-term shocks do not lead to significant overshooting of exchange rates in the context of our study.

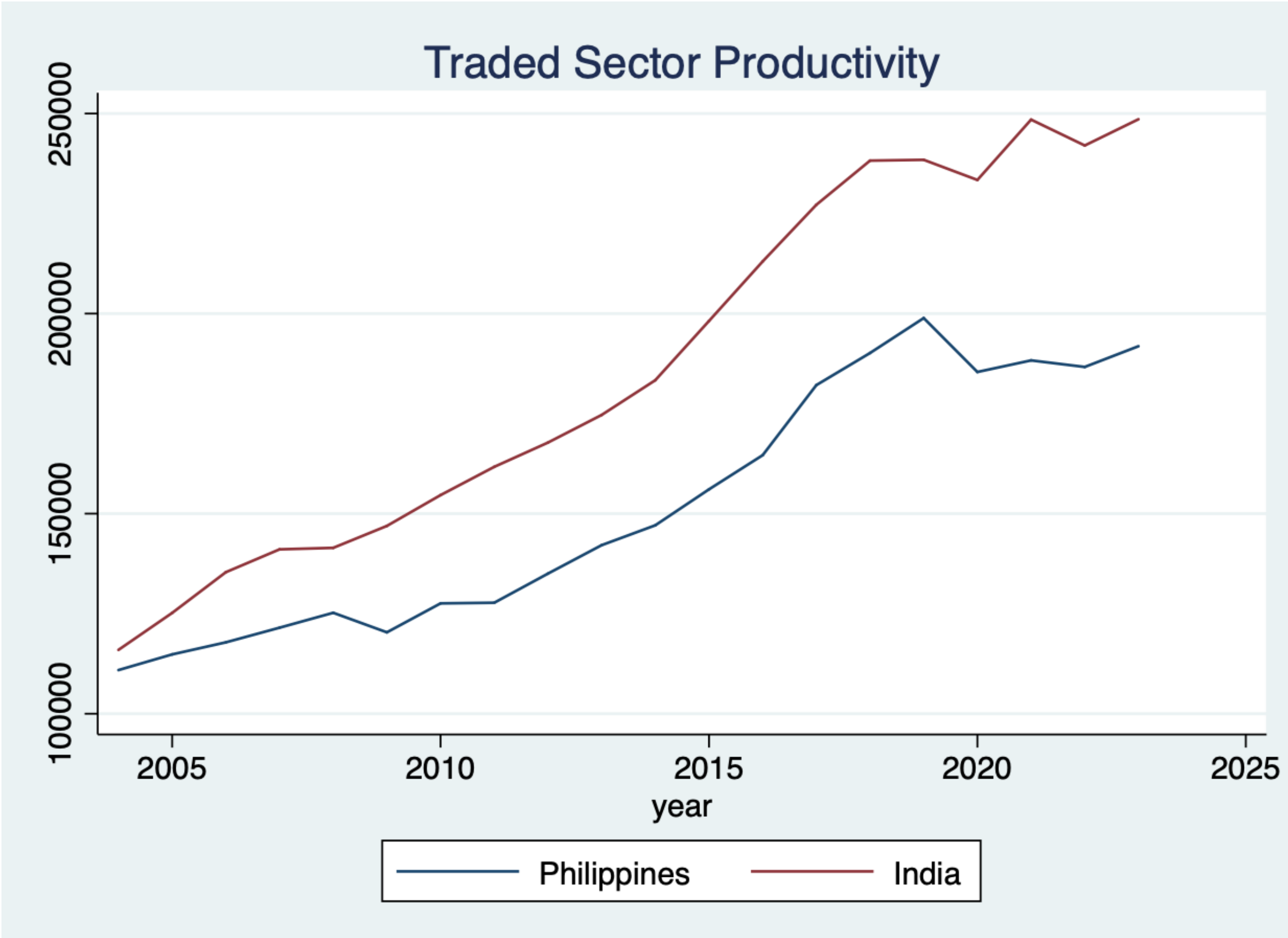

Figure 7: Traded Sector Productivity for India and Philippines

7 Conclusions

The findings of our study are summarized as follows:

PPP Does Not Hold in the Medium to Long Run Due to variations in the level of development and productivity, coupled with the presence of sticky prices, Purchasing Power Parity (PPP) does not hold in the medium to long run. The evidence from our analysis, particularly in the context of India and ASEAN member countries, supports the notion that PPP deviations are persistent and not easily corrected over time.

Reinforcement of the Balassa-Samuelson Effect Given that the countries we have chosen vary significantly in levels of productivity, our empirical results validate the Balassa-Samuelson effect. Specifically, the coefficient $\beta > 0$ or $\beta \neq 0$ in our regressions provides strong evidence that differences in productivity between the traded and non-traded goods sectors are a significant driver of real exchange rate deviations. This underscores the role of productivity differentials in influencing PPP deviations, particularly between developing and developed economies.

Not Much Evidence for Exchange Rate Overshooting Our analysis found a lack of robust evidence for exchange rate overshooting, particularly in the post-global financial crisis period.

The regression results indicate that $|\beta_1| < 1$, suggesting that short-term shocks do not lead to significant overshooting of exchange rates. This is consistent with the observed slow adjustment of prices and the limited impact of short-term shocks on exchange rate behavior during the analyzed timeframe.

Overall, our study highlights the limitations of PPP as a framework for understanding exchange rate dynamics, particularly in the presence of productivity differentials and other real-world frictions. While the Balassa-Samuelson effect provides valuable insights into long-run exchange rate behavior, further research is needed to fully understand the mechanisms driving short-run deviations.

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A Appendix

```
. regress dep_ind_sgp infl_d_ind_sgp
```

Source	SS	df	MS			
				Number of obs	=	63
				F(1, 61)	=	10.35
Model	19.043016	1	19.043016	Prob > F	=	0.0021
Residual	112.214124	61	1.8395758	R-squared	=	0.1451
				Adj R-squared	=	0.1311
Total	131.25714	62	2.11705064	Root MSE	=	1.3563

dep_ind_sgp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
infl_d_ind_sgp	.1564768	.0486341	3.22	0.002	.0592269	.2537267
_cons	.6738049	.1914708	3.52	0.001	.2909355	1.056674

Figure 8: PPP results for India v Singapore

```
. regress dep_ind_mal infl_d_ind_mal infl_d_ind_mal_l1 infl_d_ind_mal_l2 infl_d_ind_mal_l3
```

Source	SS	df	MS			
				Number of obs	=	60
				F(4, 55)	=	0.94
Model	2.40871815	4	.602179537	Prob > F	=	0.4472
Residual	35.1922661	55	.639859384	R-squared	=	0.0641
				Adj R-squared	=	-0.0040
Total	37.6009843	59	.637304819	Root MSE	=	.79991

dep_ind_mal	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
infl_d_ind_mal	.0945312	.0546974	1.73	0.090	-.0150847	.2041472
infl_d_ind_mal_l1	-.0171344	.0620508	-0.28	0.783	-.141487	.1072181
infl_d_ind_mal_l2	-.0221707	.0628192	-0.35	0.725	-.1480632	.1037217
infl_d_ind_mal_l3	-.0517423	.0568757	-0.91	0.367	-.1657237	.062239
_cons	.2399878	.1168817	2.05	0.045	.0057516	.4742241

Figure 9: PPP results for India v Malaysia

```
. regress dep_ind_phi infl_d_ind_phi infl_d_ind_phi_l1 infl_d_ind_phi_l2 infl_d_ind_phi_l3
```

Source	SS	df	MS			
				Number of obs	=	60
				F(4, 55)	=	0.75
Model	.056522056	4	.014130514	Prob > F	=	0.5648
Residual	1.04158353	55	.018937882	R-squared	=	0.0515
				Adj R-squared	=	-0.0175
Total	1.09810558	59	.018611959	Root MSE	=	.13761

dep_ind_phi	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
infl_d_ind_phi	.0166198	.0100614	1.65	0.104	-.0035436	.0367832
infl_d_ind_phi_l1	-.0067684	.0114509	-0.59	0.557	-.0297166	.0161798
infl_d_ind_phi_l2	.0014845	.0115405	0.13	0.898	-.0216431	.0246121
infl_d_ind_phi_l3	-.005627	.0102635	-0.55	0.586	-.0261956	.0149416
_cons	-.0025688	.0191657	-0.13	0.894	-.0409777	.0358402

Figure 10: PPP results for India v Philippines

```
. regress inv_r_ind_sgp prod_D_ind_sgp
```

Source	SS	df	MS
Model	.001060703	1	.001060703
Residual	.002804659	18	.000155814
Total	.003865362	19	.00020344

Number of obs	=	20
F(1, 18)	=	6.81
Prob > F	=	0.0178
R-squared	=	0.2744
Adj R-squared	=	0.2341
Root MSE	=	.01248

inv_r_ind_sgp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
prod_D_ind_sgp	.061005	.0233815	2.61	0.018	.0118823	.1101277
_cons	.0548289	.0119282	4.60	0.000	.0297686	.0798892

Figure 11: Balassa-Samuelson results for India v Singapore

```
. regress inv_r_ind_mal prod_D_ind_mal
```

Source	SS	df	MS
Model	.014262998	1	.014262998
Residual	.001158132	18	.000064341
Total	.015421129	19	.000811638

Number of obs	=	20
F(1, 18)	=	221.68
Prob > F	=	0.0000
R-squared	=	0.9249
Adj R-squared	=	0.9207
Root MSE	=	.00802

inv_r_ind_mal	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
prod_D_ind_mal	-.1426267	.0095794	-14.89	0.000	-.1627522	-.1225011
_cons	.1024279	.0032337	31.67	0.000	.095634	.1092217

Figure 12: Balassa-Samuelson results for India v Malaysia

```
. regress inv_r_ind_phi prod_D_ind_phi
```

Source	SS	df	MS
Model	1.9141945	1	1.9141945
Residual	.505972908	18	.028109606
Total	2.42016741	19	.127377232

Number of obs	=	20
F(1, 18)	=	68.10
Prob > F	=	0.0000
R-squared	=	0.7909
Adj R-squared	=	0.7793
Root MSE	=	.16766

inv_r_ind_phi	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
prod_D_ind_phi	-5.164849	.6258813	-8.25	0.000	-6.479777	-3.849921
_cons	-3.833219	.5648276	-6.79	0.000	-5.019877	-2.64656

Figure 13: Balassa-Samuelson results for India v Philippines

```
. dfuller resid

Dickey-Fuller test for unit root                    Number of obs   =        62

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -5.766            -3.563            -2.920            -2.595
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

Figure 14: Augmented Dickey-Fuller results for India v Singapore

```
. dfuller resid

Dickey-Fuller test for unit root                    Number of obs   =        59

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -5.890            -3.567            -2.923            -2.596
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

Figure 15: Augmented Dickey-Fuller results for India v Malaysia

```
. dfuller resid

Dickey-Fuller test for unit root                    Number of obs   =        59

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -5.508            -3.567            -2.923            -2.596
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

Figure 16: Augmented Dickey-Fuller results for India v Philippines

Source	SS	df	MS			
Model	111.600908	2	55.8004539	Number of obs	=	47
Residual	12.4391524	44	.28270801	F(2, 44)	=	197.38
Total	124.04006	46	2.69652305	Prob > F	=	0.0000
				R-squared	=	0.8997
				Adj R-squared	=	0.8952
				Root MSE	=	.5317

dep_ind_sgp	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
infl_d_ind_sgp	.0960112	.047038	2.04	0.047	.0012123	.1908102
r_diff_ind_sgp	1.434428	.0730021	19.65	0.000	1.287302	1.581553
_cons	7.880115	.3588401	21.96	0.000	7.156921	8.60331

Figure 17: Exchange Rate Overshooting Between India and Singapore

Source	SS	df	MS			
Model	16.1160791	2	8.05803956	Number of obs	=	47
Residual	.435910866	44	.009907065	F(2, 44)	=	813.36
Total	16.55199	46	.359825869	Prob > F	=	0.0000
				R-squared	=	0.9737
				Adj R-squared	=	0.9725
				Root MSE	=	.09953

dep_ind_mal	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
infl_d_ind_mal	-.8199339	.0363516	-22.56	0.000	-.8931958	-.746672
r_diff_ind_mal	-1.153298	.0381106	-30.26	0.000	-1.230104	-1.076491
_cons	7.897019	.286321	27.58	0.000	7.319977	8.474061

Figure 18: Exchange Rate Overshooting Between India and Malaysia

Source	SS	df	MS			
Model	.212095534	2	.106047767	Number of obs	=	47
Residual	.044762195	44	.001017323	F(2, 44)	=	104.24
Total	.256857729	46	.005583864	Prob > F	=	0.0000
				R-squared	=	0.8257
				Adj R-squared	=	0.8178
				Root MSE	=	.0319

dep_ind_phi	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
infl_d_ind_phi	.0197568	.0028616	6.90	0.000	.0139897	.0255239
r_diff_ind_phi	.0394047	.0045266	8.71	0.000	.030282	.0485274
_cons	.0504926	.0224465	2.25	0.030	.0052546	.0957306

Figure 19: Exchange Rate Overshooting Between India and Philippines

```
* set data as time series
tsset year

* generate lagged variables for inflation differential
gen infl_d_ind_sgp_l1 = L.infl_d_ind_sgp
gen infl_d_ind_mal_l1 = L.infl_d_ind_mal
gen infl_d_ind_phi_l1 = L.infl_d_ind_phi
gen infl_d_ind_sgp_l2 = L2.infl_d_ind_sgp
gen infl_d_ind_mal_l2 = L2.infl_d_ind_mal
gen infl_d_ind_phi_l2 = L2.infl_d_ind_phi
gen infl_d_ind_sgp_l3 = L3.infl_d_ind_sgp
gen infl_d_ind_mal_l3 = L3.infl_d_ind_mal
gen infl_d_ind_phi_l3 = L3.infl_d_ind_phi

* regression for india v singapore
regress dep_ind_sgp infl_d_ind_sgp

* ADF test for india v singapore
predict resid, residuals
dfuller resid
drop resid

* regression for india v malaysia
regress dep_ind_mal infl_d_ind_mal infl_d_ind_mal_l1 infl_d_ind_mal_l2 infl_d_ind_mal_l3

* ADF test for india v malaysia
predict resid, residuals
dfuller resid
drop resid

* regression for india v philippines
regress dep_ind_phi infl_d_ind_phi infl_d_ind_phi_l1 infl_d_ind_phi_l2 infl_d_ind_phi_l3

* ADF test for india v philippines
predict resid, residuals
dfuller resid
```

Figure 20: STATA code for testing PPP

```
* set data as time series
tsset year

* create variables for inverse of real exchange rates
gen inv_r_ind_sgp = 1/r_ind_sgp
gen inv_r_ind_mal = 1/r_ind_mal
gen inv_r_ind_phi = 1/r_ind_phi

* create variables for differential trade sector productivity
gen prod_D_ind_sgp = log(prod_sgp/prod_ind)
gen prod_D_ind_mal = log(prod_mal/prod_ind)
gen prod_D_ind_phi = log(prod_phi/prod_ind)

* regression for india v singapore
regress inv_r_ind_sgp prod_D_ind_sgp

* regression for india v malaysia
regress inv_r_ind_mal prod_D_ind_mal

* regression for india v philippines
regress inv_r_ind_phi prod_D_ind_phi
```

Figure 21: STATA code for testing Balassa-Sameulson Hypothesis

```
* set data as time series
tsset time

* generate variables for difference in interest rates
gen r_ind_lag = D.r_ind
gen r_sgp_lag = D.r_sgp
gen r_mal_lag = D.r_mal
gen r_phi_lag = D.r_phi

* generate variables for difference in interest rates across countries
gen r_diff_ind_sgp = r_ind_lag - r_sgp_lag
gen r_diff_ind_mal = r_ind_lag - r_mal_lag
gen r_diff_ind_phi = r_ind_lag - r_phi_lag

* regression between india v singapore
regress dep_ind_sgp infl_d_ind_sgp r_diff_ind_sgp

* regression between india v malaysia
regress dep_ind_mal infl_d_ind_mal r_diff_ind_mal

* regression between india v philippines
regress dep_ind_phi infl_d_ind_phi r_diff_ind_phi
```

Figure 22: STATA code for testing exchange rate overshooting