ECO412A

Investigating PPP and its Deviations:

Overshooting Effects and Productivity Differentials

Group 7

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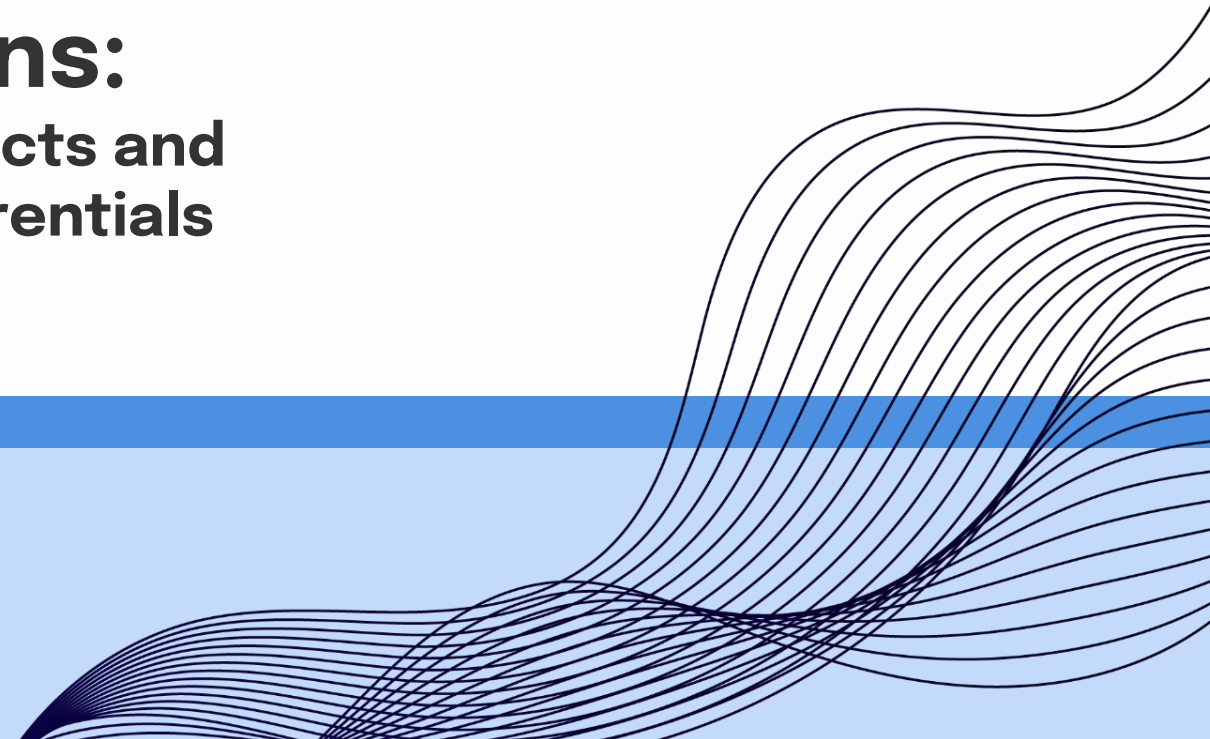


Table of contents

Introduction

PPP, or Purchasing Power Parity, states that the price of similar baskets of goods should be the same across different countries. This is called **absolute PPP.**

Another formulation, called **relative PPP,** states that the change in exchange rate is equal to the inflation rate differential.

Assumptions of PPP

- **No trade barriers**
- **No transaction costs**
- **Identical goods**

However, these assumptions often don't hold and lead to **deviations from PPP**.

1

Objective:

To analyse these deviations from PPP

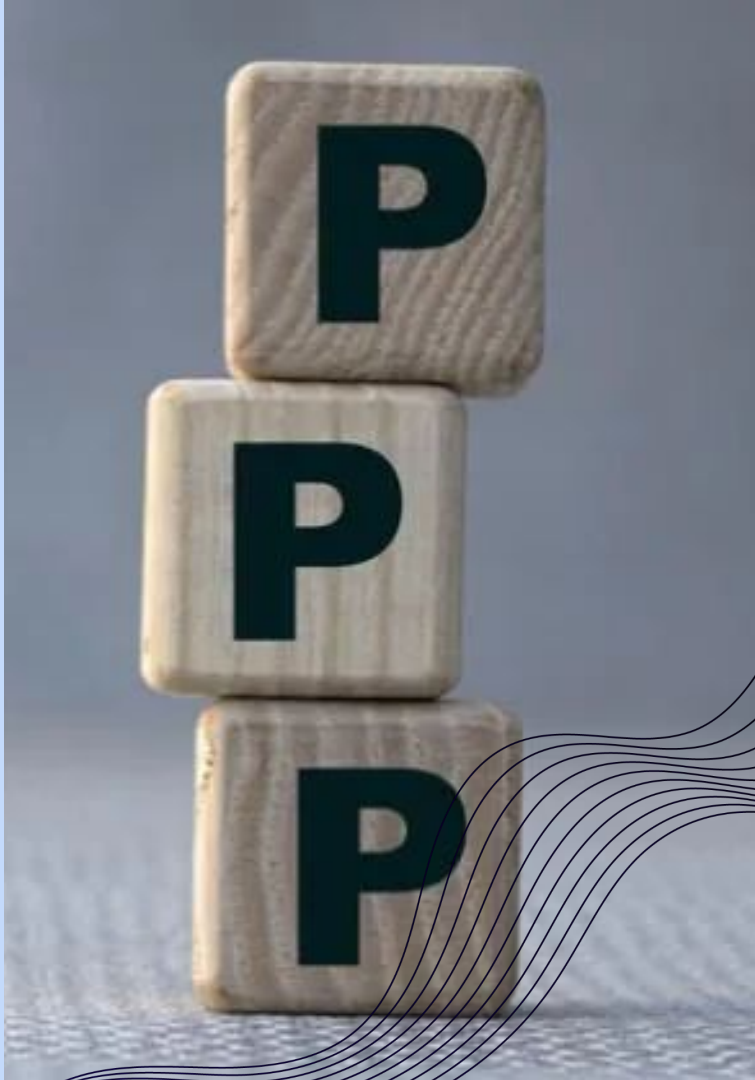
How to analyse these deviations?

Initially, we test relative PPP for exchange rate data between **India and 3 ASEAN members:**

- Singapore
- Malaysia
- Philippines

For possible deviations, we test for explanations:

- Exchange rate overshooting
- Balassa Samuelson effect



What is the Balassa-Samuelson Effect?

It states that countries with higher productivity levels in traded goods experience higher price levels, leading to an **appreciation** of the real exchange rate.

They further point that this productivity bias is stronger in rich countries. So, they argue that **richer countries have higher prices.**

Implications:
This effect is telling us that **PPP may not hold** in the short run for countries in **different stages of development**. Currencies of high-income nations may appear **overvalued** due to higher productivity in the traded goods sector.

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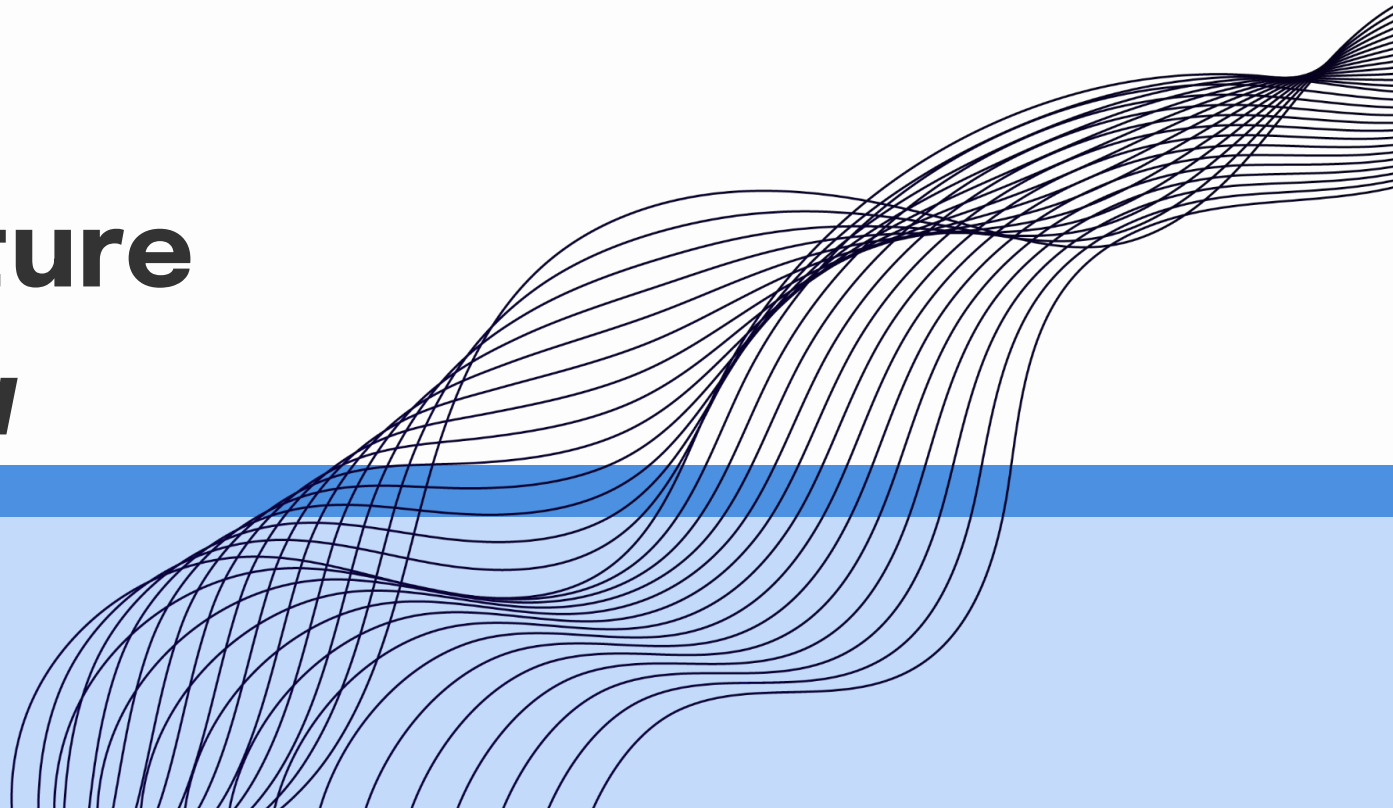
Literature Review



Work Through the Years

I. **Empirical Evidence of PPP Deviations**

- Froot's work (1993) highlighted that deviations from PPP ***can persist for several years***, with slow reversion to PPP. Where empirical studies (Frankel, 1986 & Engel, 1999) find the ***half-life of deviations from PPP can be around 3 to 5 years***.
- Rogoff's work (1996) showed ***persistent short-term deviations from PPP*** due to factors such as price stickiness and market frictions.

II. **Theoretical Explanations for Deviations**

- Balassa's & Samuelson's work (1964) established that productivity differences in the tradable and non-tradable goods sectors lead to deviations from PPP. Froot further discussed how high income economies see sustained deviations due to this effect.

- Dornbusch's overshooting model (1976) explained how ***sticky prices*** lead to temporary exchange rate deviations. Froot's work (1995) extended this idea, emphasizing that ***sticky prices cause persistent short-term deviations.***

Froot's Work

- While PPP works reasonably well over very long periods (established via cointegration) , it often breaks down in the short-to-medium run.

- While PPP suggests that real exchange rates should revert to a mean over time, ***empirical evidence*** shows that real exchange rates can deviate from their long-run values for extended periods due to various factors.

- Froot looked at the mechanisms that drive long-run adjustments in real exchange rates. Over time, exchange rates do tend to move toward PPP equilibrium, but the adjustment process is slow and complex. Factors influencing this adjustment include:
  - ➔Capital flows
  - ➔Monetary policy
  - ➔Productivity differentials

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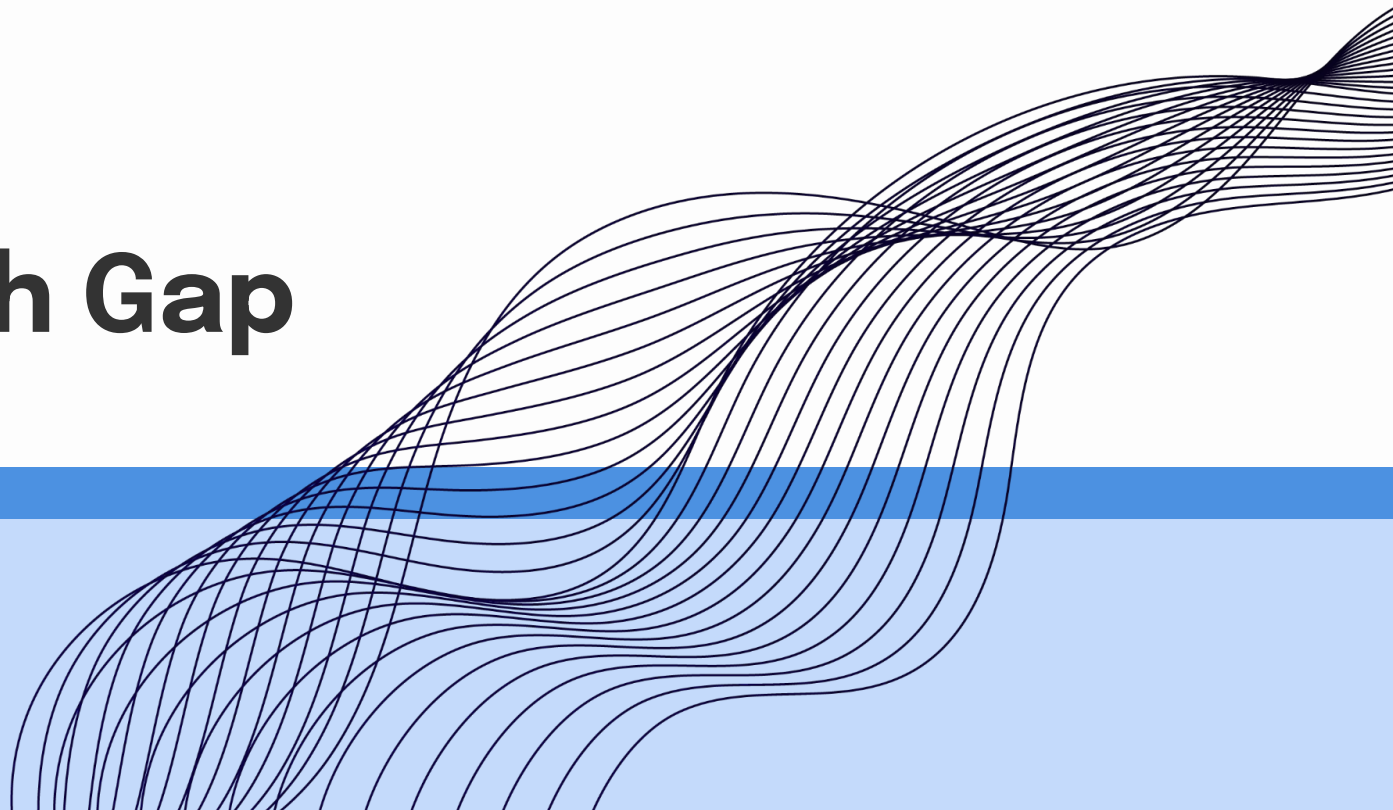
Research Gap



Research Gap

- **Comparative Analysis of Developing vs Developed Economies**: Most literature focuses on evaluating PPP and its deviations (such as the Balassa-Samuelson effect) in developed nations. By comparing developing (Philippines, Malaysia) and developed (Singapore) countries, our research uncovers **new patterns of PPP deviations** that vary with economic development stages.

- **Sector-Specific Productivity Impact:** Many studies that address PPP deviations due to productivity do so in a broad context. Our research narrows this down to productivity in the traded goods sector. This sectoral focus is a significant gap in the literature, especially in understanding how productivity differential in the traded goods sector translates to the non-traded goods sector and then influences overall price levels and real exchange rates .

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Hypotheses

We intend to test the following hypothesis in our research work.

The first two hypotheses test **whether PPP holds in the long run**.

1) Hypothesis 1 is about testing of simple PPP using a conventional approach:

H_o: PPP holds in the long-run

H_a: PPP does not hold in the long run

2) Hypothesis 2 accounts for non-stationary behaviour of real exchange rate and treats it as a random walk:

H_o: Real exchange rate follows a random walk (i.e., deviations from PPP are permanent)

H_a: Real exchange rate is stationary (i.e., real exchange rates revert to PPP in long run)

The next two hypotheses test for reasons of **deviations from PPP**.

3) Hypothesis 3 is the **Balassa-Samuelson** hypothesis:

H_o: Real exchange rates are positively affected by productivity differentials between countries

H_a: No relationship between productivity differentials and real exchange rates

4) Hypothesis 4 tests for overshooting of exchange rates in the short run due to **sticky-price** effects:

H_o: Exchange rates overshoot their equilibrium in response to short-term shocks

H_a: Exchange rates adjust immediately without any overshooting.

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Methodology

Testing Simple PPP

We estimate the following regression model for testing simple PPP between two countries:

$$\Delta e_t = \alpha + \beta\,(\Delta p_t - \Delta p_t^*) + \epsilon_t$$

- Δe_t : Change in the nominal exchange rate
- Δp_t : Change in prices in home country
- Δp_t^* : Change in prices in foreign country
- ϵ_t : Error term

We use simple OLS to estimate the above model. The null and alternative hypothesis (hypothesis 1) in terms of model coefficients are:

H_o: $\beta = 1$ (PPP holds)

H_a: $\beta \neq 1$ (PPP does not hold)

Testing Consistency

The estimated coefficients α and β are consistent only if either Δe_t and $\Delta p_t - \Delta p_t^*$ are stationary series or the difference $\Delta e_t - \beta(\Delta p_t - \Delta p_t^*)$ is a stationary series. Equivalently, ϵ_t must be a stationary series, i.e., **ϵ_t must not have a unit root**. We use **Augmented Dickey–Fuller (ADF)** test for this and estimate the following equation.

$$\Delta\epsilon_t = \alpha + \gamma\epsilon_{t-1} + \Sigma\beta_i\Delta\epsilon_{t-i} + v_t$$

- $\Delta\epsilon_t$ is the first difference of the error term,
- 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,
- v_t is the white noise error term

H_o: $\gamma = 0$ (Error is non-stationary)
H_a: $\gamma < 0$ (Error is stationary)

Test Statistic: $\mathrm{DF}_\tau = \frac{\hat{\gamma}}{\mathrm{SE}(\hat{\gamma})}$

If DF_τ < critical value, reject null.

Model 2: Real Exchange Rate as Random Walk

The first model assumes stationarity of the error terms, which may not hold statistically. So, we model real exchange rate as a random walk, i.e., as a non-stationary series. Thus, the null hypothesis in this model is that the real exchange rate does not revert to any specific mean or equilibrium, including PPP.

$$q_t = e_t - p_t + p_t^*$$

- e_t *is the (log) nominal exchange rate,*
- p_t *is the (log) domestic price level,*
- p_t^* *is the (log) foreign price level*

Under the null hypothesis, real exchange rate follows a random walk.

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

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

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

Testing Balassa Samuelson Hypothesis

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 model to examine deviations from PPP as a result of productivity differentials in the traded goods sector between the two countries.

$$(p/ep^*)_i = \alpha + \beta\,(GDP_T / L_T)_i + \epsilon_i$$

For country i,

- $(p/ep^*)_i$ is the inverse of real exchange rate
- $(GDP_T)_i$ is the GDP of traded goods sector
- $(L_T)_i$ is the Labor force in traded goods sector
- $(GDP_T / L_T)_i$ should be taken as a ratio relative to the reference country

We test the following hypothesis:

H_o: $\beta > 0$ (richer countries have higher real exchange rates)
H_a: $\beta = 0$ (productivity differentials have no effect on real exchange rates)

Testing Overshooting of Exchange Rates

The model is similar to model 1, except that the null hypothesis is that overshooting of exchange rate happens in the short run. Additionally, we also include interest rate differentials in the regression equation as they impact capital inflows and hence exchange rates in the flexible regime.

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

- Δe_t : Change in the nominal exchange rate
- Δp_t : Change in home prices
- Δp_t^* : Change in foreign prices
- Δr_t : Change in home interest rates
- Δr_t^* : Change in foreign interest rates
- ϵ_t : Error term

We test the following hypothesis:

H_o: $|\beta_1| > 1$ (exchange rate overshoots in short-run)

H_a: $\beta_1 = 1$ (exchange rates adjust quickly to price differentials)

Also, we test the consistency of the estimates using **Augmented-Dickey Fuller (ADF)** Test.

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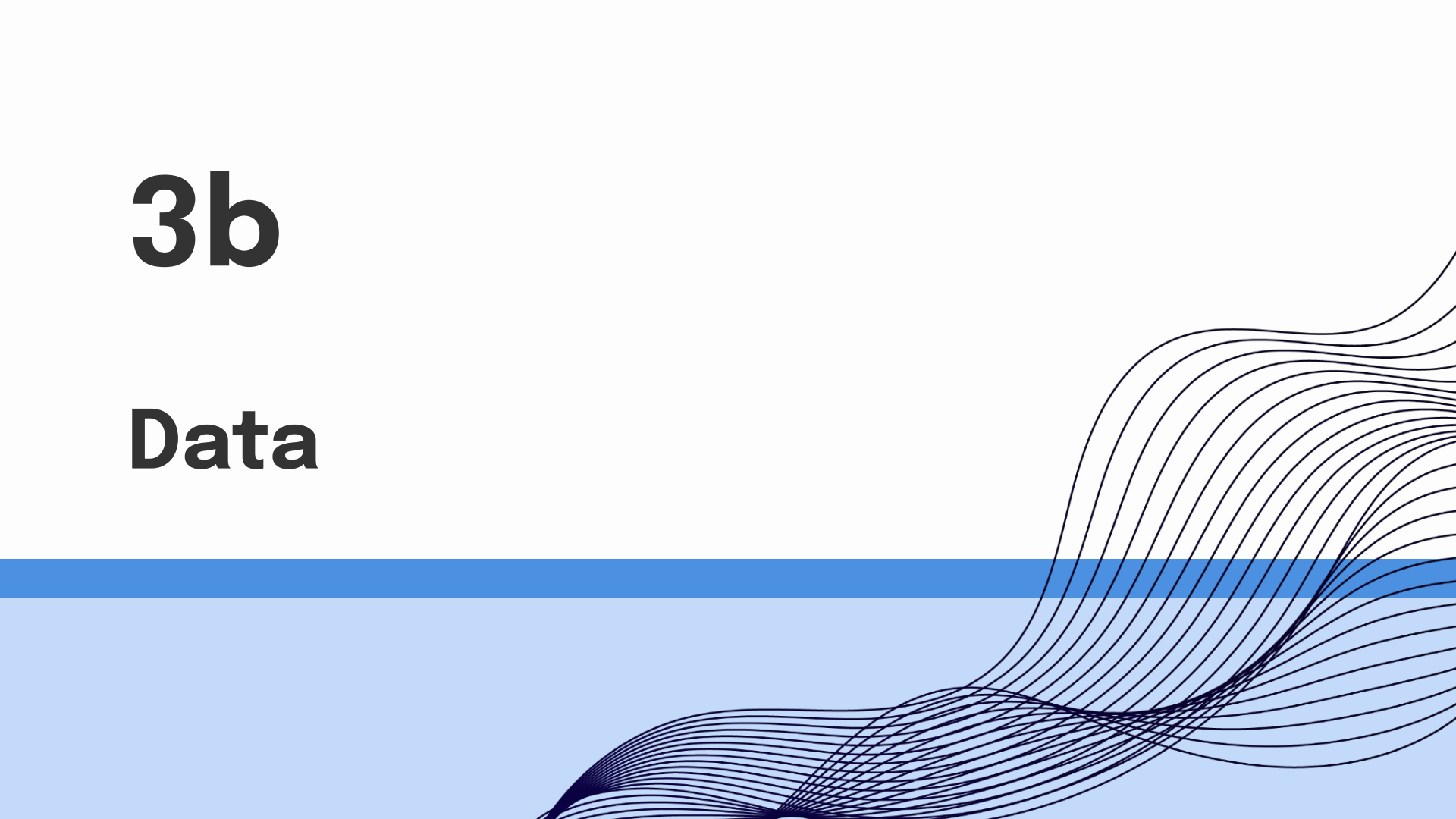
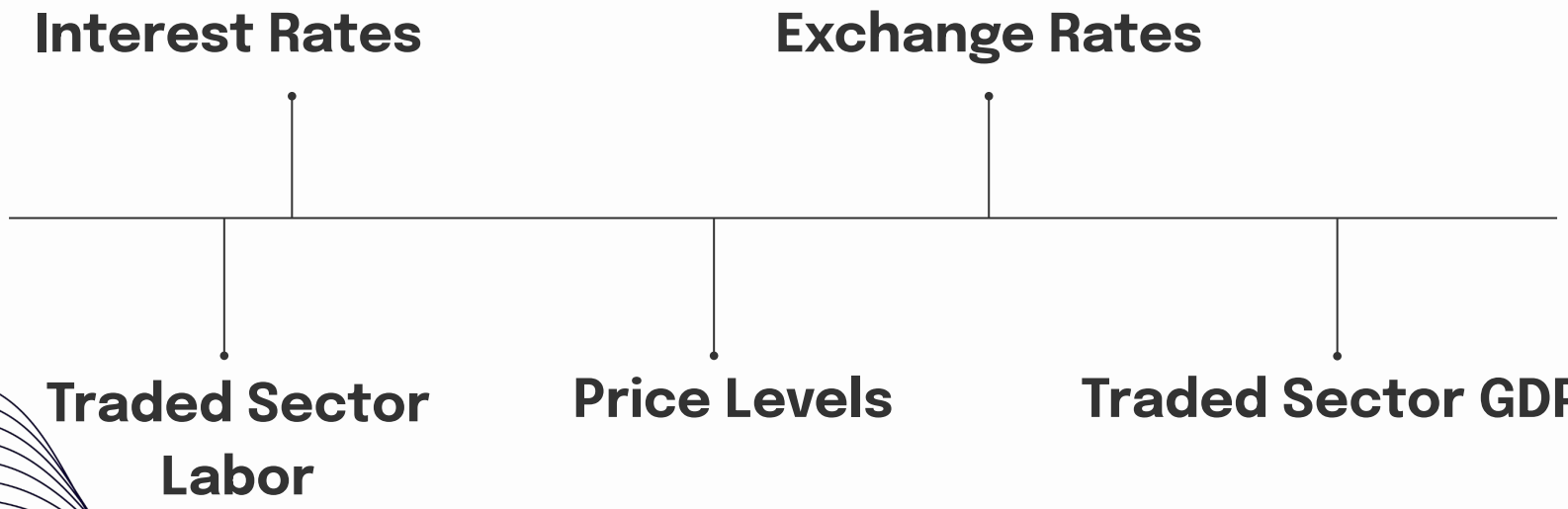
Data



World Development Indicators

Data Bank provided by World Bank



Snapshot of PPP Data (1960-2023)

Year	p_ind	p_sgp	p_mal	p_phi	e_ind_sgp	e_ind_mal	e_ind_phi	infl_ind	infl_sgp	infl_mal	infl_phi	dep_ind_sgp	dep_ind_mal	dep_ind_phi	infl_D_ind_sgp	infl_D_ind_mal	infl_D_ind_phi	r_ind	r_
1978	8.22876409	50.8726011	37.4497517	5.37185584	3.60279256	3.53743219	1.11228742	0.2025064	2.36362129	1.73572478	0.36707682	0.020527997	-0.012982364	-0.06815061	-2.161114899	-1.533218382	-0.164570421	10.7746313	3
1979	8.74517527	52.9464051	38.8183409	6.31372123	3.73675464	3.71304891	1.10142133	0.51641118	2.07380397	1.36858919	0.94186539	0.133962083	0.175616719	-0.01086609	-1.557392789	-0.852178013	-0.425454211	-1.0611457	3
1980	9.73740928	57.4611149	41.409434	7.46285072	3.67219975	3.61201934	1.04679684	0.99223401	4.51470988	2.59109302	1.14912949	-0.064554895	-0.10102957	-0.054624489	-3.52247587	-1.59885901	-0.156895483	4.47650826	0.53502484
1981	11.0142316	62.162596	45.4261491	8.43918552	4.09833719	3.75783554	1.09606411	1.27682236	4.70148105	4.01671509	0.9763348	0.426137437	0.145816201	0.049267263	-3.424658688	-2.739892735	0.30048756	5.11823674	7.33834686
1982	11.8833363	64.5970615	48.0694513	9.30181604	4.41823434	4.04862793	1.10715831	0.86910469	2.43446553	2.6433022	0.86263052	0.319897151	0.29079239	0.0110942	-1.565360839	-1.774197511	0.006474173	7.77470724	5
1983	13.2936604	65.3699077	49.8500569	10.2347283	4.77929924	4.35062929	0.90876952	1.41032402	0.7728462	1.78060566	0.9329123	0.361064898	0.30200136	-0.198388781	0.637477817	-0.370281643	0.47741172	7.32098669	5
1984	14.3995476	67.0701694	51.7928495	15.3867857	5.32683518	4.84825965	0.68044684	1.10588726	1.70026164	1.94279261	5.1520574	0.547535941	0.49763036	-0.228322684	-0.594374382	-0.836905353	-4.046170147	7.94709992	8
1985	15.1996476	67.3921886	51.9722904	18.9416113	5.62177579	4.98128975	0.66472418	0.80009995	0.32201925	0.17944088	3.5548256	0.294940612	0.133030095	-0.015722657	0.478080703	0.620659072	-2.754725649	8.68167358	9
1986	16.5265343	66.4583328	52.3553277	19.1590871	5.79164913	4.88519012	0.61861225	1.32688678	-0.9338558	0.38303726	0.2174758	0.169873337	-0.096099626	-0.046111939	2.260742608	0.943849519	1.109410988	9.09322415	8
1987	17.9810554	66.8061136	52.5071623	19.9388174	6.15460711	5.14419067	0.6301879	1.45452108	0.34778079	0.15183459	0.77973029	0.362957986	0.259000545	0.011575659	1.10674029	1.302686489	0.67479079	6.56018009	5
1988	19.6683027	67.8236944	53.8495181	22.7023513	6.91557863	5.31433172	0.65974391	1.68724728	1.01758083	1.34235582	2.76353389	0.760971523	0.170141051	0.029556004	0.669666447	0.344891459	-1.07628661	7.638633	0
1989	21.0596935	69.4144695	55.3644132	25.4817981	8.31966705	5.9898296	0.74645703	1.39139081	1.59077509	1.51489513	2.77944675	1.404088418	0.675497882	0.086713118	-0.199384284	-0.123504316	-1.38805594	7.43584325	1
1990	22.9490076	71.8167331	56.8137434	28.5848064	9.65692585	6.47109386	0.71999753	1.88931407	2.4022636	1.44933019	3.1030083	1.337258797	0.481264257	-0.026459494	-0.512949534	0.439983881	-1.21369423	5.269527	2
1991	26.1320914	74.2769602	59.2898757	34.090657	13.1645587	8.26977528	0.82764063	3.18308385	2.46022707	2.47613232	5.50585062	3.507632822	1.79868142	0.107643096	0.722856778	0.70695153	-2.3227667 76	3.6247166	3.01429375
1992	29.2124946	75.9579006	62.1163594	37.0398409	15.9107512	10.1743946	1.01589777	3.08040313	1.68094048	2.82648373	2.94918396	2.74619252	1.904619362	0.18825714	1.399462642	0.253919393	0.131219171	9.13274941	4.50231813
1993	31.0607371	77.6968046	64.3131575	39.5275519	18.8720539	11.8462184	1.12439048	1.84824254	1.73890395	2.19679808	2.48771093	2.961302689	1.671823804	0.108492708	0.10933859	-0.348555539	-0.639468388	5.81477651	1.86759885
1994	34.2438214	80.1055086	66.7088037	43.6330705	20.5400257	11.9552873	1.18762708	3.18308432	2.40870399	2.39564618	4.10551867	1.667971859	0.109068894	0.063236604	0.774380332	0.78743814	-0.922434352	4.33710974	2.33434734
1995	37.7452132	81.483751	69.0106411	46.6140802	22.878262	12.9480206	1.26104411	3.50139176	1.37824239	2.30183737	2.98100968	2.338236305	0.992733232	0.073417028	2.123149368	1.19955439	0.520382076	5.86417811	
1996	41.1336585	82.6108183	71.4181183	50.0989972	25.1291824	14.0834591	1.35158064	3.38844529	1.12706737	2.40747725	3.48491701	2.250920384	1.135438544	0.090536537	2.261377912	0.98096804	-0.096471726	7.7929943	
1997	44.0805775	84.2659973	73.3196361	52.8996611	24.4565889	12.9082161	1.23218441	2.946919	1.65517894	1.90151783	2.8006639	-0.672593549	-1.175243061	-0.119396232	1.291740052	1.045401171	0.146255095	6.909579	5
1998	49.9128077	84.0405838	77.1838317	57.7849101	24.6530377	10.5136143	1.00895788	5.83223022	-0.2254135	3.86419558	4.88524896	0.196448829	-2.394601784	-0.223226534	6.057643698	1.968034642	0.94698126	5.12127633	8
1999	52.2436461	84.0546269	79.3021893	61.2167842	25.4020821	11.3303759	1.1014722	2.33083847	0.01404304	2.11835758	3.43187414	0.749044349	0.816761607	0.092514317	2.316795423	0.212480888	-1.10103567	9.19124732	9
2000	54.3383216	85.1991348	80.5192719	63.6514523	26.0687708	11.8267382	1.01695671	2.09467551	1.14450791	1.21708261	2.43466805	0.666688738	0.496362281	-0.08451549	0.9501676	0.877592901	-0.339992541	8.34261083	
2001	56.3919261	86.0487388	81.6600567	67.0539419	26.3357826	12.4174774	0.92535717	2.05360445	0.84960403	1.14078475	3.40248963	0.267011762	0.590739254	-0.091599539	1.204000422	0.912819702	-1.348885174	8.5914493	7
2002	58.8151729	85.7117058	83.1363663	68.879668	27.14768	12.7921893	0.94199534	2.4232468	-0.337033	1.47630968	1.82572614	0.811897486	0.374711842	0.016638169	2.760279806	0.946937125	0.597520661	7.90717719	
2003	61.0535955	86.1470401	84.0422836	70.4564315	26.7384513	12.258759	0.85941733	2.23842255	0.4353343	0.9059173	1.57676349	-0.409228773	-0.533430263	-0.082578004	1.803088252	1.332505246	0.661659063	7.30788116	7
2004	63.3536381	87.5794304	85.2367524	73.8589212	26.8108549	11.925386	0.80864622	2.30004263	1.43239027	1.19446874	3.40248963	0.072403671	-0.333373026	-0.050771115	0.867652367	1.105573895	-1.102446993	4.9101283	1.28941695
2005	66.0438513	87.951736	87.7726062	78.6721992	26.4960594	11.6448132	0.80057332	2.69021317	0.37230566	2.53585384	4.81327801	-0.314795559	-0.280572773	-0.008072897	2.317907514	0.15435933	-2.123064839	4.85514517	3.33607855
2006	69.8720985	88.7986248	90.9405264	82.9875519	28.5141028	12.3513693	0.8829319	3.82824728	0.84688883	3.16792019	4.3153527	2.018043368	0.706556125	0.082358583	2.981358446	0.660327089	-0.487105421	2.5706067	3.40551305
2007	74.3249645	90.6677294	92.7842121	85.3941909	27.4357956	12.0284215	0.89599079	4.45286594	1.86910453	1.84368565	2.406639	-1.078307114	-0.322947856	0.013058883	2.583761413	2.609180288	2.046226936	5.68184406	
2008	80.5305542	96.6769886	97.832399	92.4481328	30.7487368	13.0417737	0.98154234	6.20558977	6.00925924	5.0481869	7.05394191	3.312941133	1.013352208	0.085551551	0.196330526	1.157402864	-0.848352141	3.77175625	6
2009	89.2941734	97.2538798	98.4030636	96.3485477	33.2793242	13.7339273	1.01521776	8.76361914	0.57689118	0.57066461	3.90041494	2.530587403	0.692153608	0.033675426	8.186727963	8.192954531	4.8632042	4.80859211	2
2010	100	100	100	100	33.5354108	14.195771	1.01365889	10.7058266	2.74612021	1.59693644	3.65145228	0.256086649	0.461843694	-0.001558873	7.959706409	9.108890187	7.05437434	-1.9838592	4
2011	108.911793	105.247793	103.174471	104.718417	37.1055508	15.2517715	1.07751297	8.91179336	5.2477934	3.17447092	4.71841705	3.570139944	1.056000516	0.063854077	3.663999966	5.737322443	4.193376318	1.31798086	4
2012	119.235539	110.063514	104.890852	107.888206	42.7608633	17.3003167	1.2654217	10.3237455	4.81572088	1.7163806	3.16978869	5.655312545	2.048545251	0.187908736	5.508024652	8.607364929	7.15395684	2.47352049	4
2013	131.18041	112.659477	107.098817	110.674621	46.8295736	18.5971267	1.3805209	11.9448714	2.59596262	2.20796534	2.78641538	4.068710263	1.296809927	0.1150992	9.348908765	9.736906046	9.158456007	3.86599286	5
2014	139.924446	113.814403	110.464923	114.656499	48.1666189	18.6471524	1.37468864	8.74403583	1.15492641	3.36610565	3.98187746	1.33704531	0.05002573	-0.005832259	7.589109423	5.377930183	4.762158372	6.69517609	5
2015	146.790502	113.219589	112.789535	115.429504	46.6618984	16.4260505	1.40984485	6.86605541	-0.5948147	2.32461256	0.77300556	-1.50472049	-2.221101917	0.035156204	7.460870157	4.541442844	6.093049852	7.55648841	2
2016	154.054013	112.616956	115.147475	116.876642	48.6377545	16.1982745	1.41486264	7.26351158	-0.6026325	2.35794034	1.44713831	1.975856062	-0.227775988	0.005017792	7.86614406	4.90557124	5.816373274	6.23271141	4
2017	159.181198	113.265923	119.605066	120.211352	47.157933	15.1429982	1.29199926	5.12718465	0.64896682	4.4575904	3.33471002	-1.479821446	-1.05527625	-0.122863381	4.478217826	0.669594245	1.79247463	5.32760886	2.31884961
2018	165.451069	113.76273	120.663223	126.59379	50.7023684	16.9485159	1.29866331	6.26987115	0.49680713	1.05815697	6.38243737	3.544435385	1.805517611	0.006664054	5.773064022	5.211714174	-0.112566227	5.36166639	1.66586025
2019	171.621576	114.405786	121.463089	129.621996	51.6218234	16.9996029	1.35957672	6.1705071	0.64305585	0.79986669	3.02820617	0.919454975	0.051087049	0.060913412	5.527451249	5.370640415	3.142300929	6.89487543	5.46558717

Variables like *p_sgp, e_ind_sgp* taken **directly** from external sources.

Variables like *infl_sgp, dep_ind_sgp* (Δe_t) calculated by **taking difference across time**

Variables like *infl_D_ind_sgp* ($\Delta p_t - \Delta p_t^*$) calculated by **taking difference across country**

STATA regression using the command: **regress dep_ind_sgp infl_d_ind_sgp**

Snapshot of Balassa-Samuelson Data (2004-2023)

year	r_ind_sgp	r_ind_mal	r_ind_vnm	r_ind_phi	GT_ind	GT_sgp	GT_mal	GT_vnm	GT_phi	L_ind	L_sgp	L_mal	L_vnm	L_phi	prod_ind	prod_sgp	prod_mal	prod_vnm	prod_phi
2004	19.3945955	8.8637422	0.00329694	0.69362846	3.4994E+13	1.0361E+11	5.9291E+11	1.4483E+15	5.6445E+12	301801192	571149.719	4692895.08	31793396.4	16965254.8	115950.332	181402.891	126341		
2005	19.8962132	8.7620511	0.00306701	0.67206667	3.7777E+13	1.1274E+11	6.1466E+11	1.5722E+15	5.9354E+12	301753484	549914.322	4800564.77	32175714.5	17229234.5	125191.693	205019.111	128039.5		
2006	22.4366155	9.48992205	0.0030772	0.74339284	4.1929E+13	1.258E+11	6.4798E+11	1.6994E+15	6.1507E+12	309740253	590052.335	5005551.77	32480907.7	17399043.9	135367.232	213197.918	129451.5		
2007	22.4905433	9.6353779	0.00273753	0.77984841	4.4873E+13	1.341E+11	6.7557E+11	1.8354E+15	6.4197E+12	318079641	619566.98	4965025.88	32529417.8	17612191.3	141075.585	216443.666	136066.2		
2008	25.6132406	10.735339	0.00250493	0.85501126	4.6184E+13	1.31E+11	6.678E+11	1.9435E+15	6.7351E+12	326507002	671666.759	5013268.62	33451900.4	17928305.8	141447.573	195030.481	133206.942	58098900	375671.062
2009	30.5555712	12.4625913	0.00276653	0.94088914	4.9238E+13	1.29E+11	6.1676E+11	2.0242E+15	6.5965E+12	335093905	669399.134	4934443.61	34259633	18271336.3	146938.542	192715.077	124990.0		
2010	33.5354	14.1958	0.002457	1.01366	5.3217E+13	1.6313E+11	6.5732E+11	1.7954E+15	7.0723E+12	344145535	662173.379	5123304.85	35481348.4	18478471.5	154635.203	246348.433	128299.8		
2011	38.3973577	16.1000256	0.00208871	1.12066473	5.547E+13	1.749E+11	6.8347E+11	1.9388E+15	7.2596E+12	343036617	648194.201	5361517.88	35653359.8	18943591.8	161701.583	269826.977	127476.8		
2012	46.3243083	19.6663066	0.00236315	1.39852087	5.7323E+13	1.7727E+11	7.1242E+11	2.0653E+15	7.7E+12	341691916	658380.428	5571078.14	35567443.5	19009835.7	167763.074	269250.335	127877.9		
2013	54.5283282	22.7786214	0.00266054	1.63629197	5.9941E+13	1.804E+11	7.3633E+11	2.1673E+15	8.1085E+12	343179232	646838.107	5810516.64	36113456.3	19017910.3	174663.688	278888.018	126723.449	60014691.5	426359.717
2014	59.2164702	23.620068	0.00281126	1.67763088	6.3116E+13	1.8637E+11	7.7652E+11	2.2901E+15	8.6277E+12	344246565	594414.396	5922992.47	36440687.4	19552471.3	183343.918	313542.786	131102.1		
2015	60.4972646	21.3776684	0.00300282	1.79286506	6.8313E+13	1.7958E+11	8.1245E+11	2.4686E+15	9.056E+12	344743674	600508.853	6016203.82	36387952.5	19341569.7	198156.264	299050.545	135043.2		
2016	66.5338949	21.6715408	0.00317955	1.86490792	7.3477E+13	1.8512E+11	8.4006E+11	2.6551E+15	9.6044E+12	344903978	567445.016	5955202.27	36430400.9	19449413.8	213036.727	326230.727	141063.7		
2017	66.2744485	20.1536548	0.00301614	1.71084054	7.8254E+13	2.0055E+11	8.8419E+11	2.8798E+15	1.0263E+13	344443180	555870.635	6071215.98	36262140.9	18785256.3	227191.206	360789.587	145636.8		
2018	73.7389378	23.2394874	0.00314739	1.69727314	8.1843E+13	2.1306E+11	9.1518E+11	3.1357E+15	1.0833E+13	343547650	559965.734	6138073.1	35594430.8	18990771.3	238229.938	380478.714	149099.3		
2019	77.4385658	24.0197044	0.00320643	1.80010985	8.1751E+13	2.1046E+11	9.4181E+11	3.3771E+15	1.1292E+13	342875527	530568.39	6237654.76	35552414.5	18926994	238427.592	396659.907	150987.196	94988426.6	596617.707
2020	86.0566511	26.8633277	0.00346173	2.05872965	8.3072E+13	2.1719E+11	8.9877E+11	3.5242E+15	1.0162E+13	355928377	525264.829	6366664.75	34867279.2	18269846.4	233395.034	413484.193	141167.6		
2021	90.5986037	27.891156	0.00357269	2.09306444	9.1129E+13	2.4871E+11	9.5631E+11	3.6646E+15	1.0883E+13	366758732	497435.761	6543886.65	34220108.4	19265302.5	248472.531	499986.231	146137.6		
2022	94.395274	28.8189191	0.00391069	2.02904891	9.2511E+13	2.5568E+11	1.0173E+12	3.931E+15	1.1427E+13	382256278	507983.581	6531435.51	35764131.7	20404663.5	242012.054	503319.089	155756.2		
2023	102.648469	30.1252851	0.00411281	2.08152024	9.8823E+13	2.4665E+11	1.0285E+12	4.077E+15	1.171E+13	397571384	460234.442	6367701.62	34792147	20347277.2	248567.894	535915.584	161525		

Variables like *r_ind_sgp* **calculated using PPP data**

Variables like *GT_sgp, L_sgp* **taken directly** from external sources

Variables like *prod_sgp* calculated by **taking ratio of *GT_sgp, L_sgp***

Variables in STATA:
gen inv_r_ind_sgp = 1/r_ind_sgp
gen prod_D_ind_sgp = log(prod_sgp/prod_ind)

STATA regression using the command:
regress *inv_r_ind_sgp prod_D_ind_sgp*

4

Results & Observations

Testing Simple PPP

$$\Delta e_t = \alpha + \beta\,(\Delta p_t - \Delta p_t^*) + \epsilon_t$$

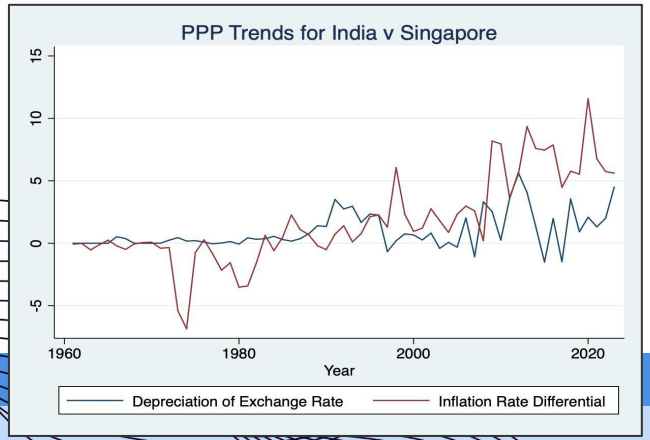
$H_o: \beta = 1$
$H_a: \beta \neq 1$

- $\beta_{Singapore} = 0.156$, is different from the null hypothesis that PPP holds.
- ***p-value = 0.002,*** indicates results are **statistically significant** at *1%* level.
- Thus, we **reject** the Null Hypothesis.

Testing PPP Between India and Singapore

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



PPP DOES NOT HOLD BETWEEN INDIA AND SINGAPORE

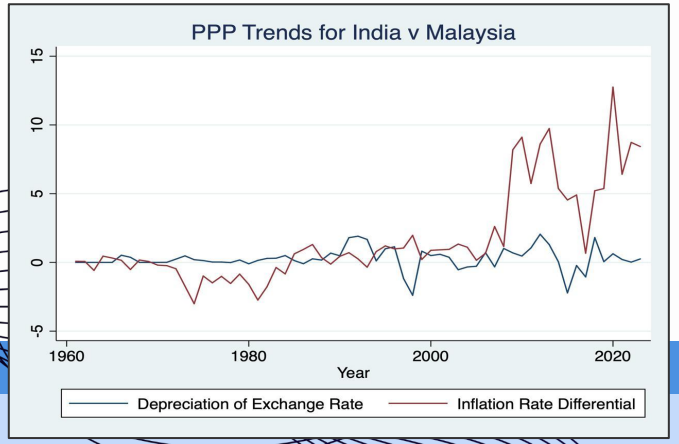
- $\beta_{Malaysia} = 0.095$, is different from the null hypothesis that PPP holds.
- ***p-value = 0.090,*** indicates results are **statistically significant** at *10%* level.
- We consider lagged values of price differentials, to account for **delayed impact** of prices on exchange rates.
- Thus, we **reject** the Null Hypothesis.

$$\Delta e_t = \alpha + \beta (\Delta p_t - \Delta p_t^*) + \epsilon_t$$

$H_o: \beta = 1$
$H_a: \beta \neq 1$

Testing PPP Between India and Malaysia

```
. 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
------------------------------------------------------------------------------
```



PPP DOES NOT HOLD BETWEEN INDIA AND MALAYSIA

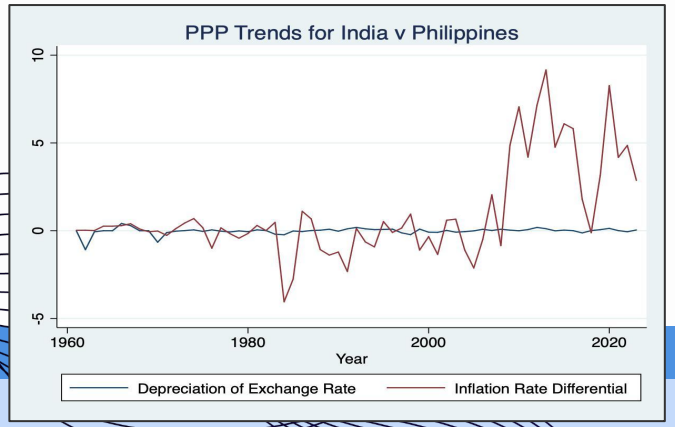
- $\beta_{Philippines} = 0.017$, is different from the null hypothesis that PPP holds.
- ***p-value = 0.104,*** indicates results are **close** to *10%* significance level.
- We consider lagged values of price differentials, to account for **delayed impact** of prices on exchange rates.
- Thus, we **reject** the Null Hypothesis.

$$\Delta e_t = \alpha + \beta (\Delta p_t - \Delta p_t^*) + \epsilon_t$$

$H_o: \beta = 1$
$H_a: \beta \neq 1$

Testing PPP Between India and Philippines

```
. 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
------------------------------------------------------------------------------
```



PPP DOES NOT HOLD BETWEEN INDIA AND PHILIPPINES

Augmented Dickey-Fuller Test

$$\Delta\epsilon_t = \alpha + \gamma\epsilon_{t-1} + \Sigma\beta_i\Delta\epsilon_{t-i} + v_t$$

$H_o: \gamma = 0$
$H_a: \gamma < 0$

India-Singapore Regression

```
. 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
```

India-Malaysia Regression

```
. predict resid, residuals
(4 missing values generated)

. 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
```

India-Philippines Regression

```
. 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
```

For all three ADF tests,

- Test statistic (***Z(t)***) is lower than critical values at *1%*, *5%* and *10%* values.
- ***p-value=0.000***
- **Reject** the null hypothesis of a unit root.

RESIDUALS ARE STATIONARY

REGRESSIONS ARE NOT SPURIOUS

NOT NEEDED TO MODEL EXCHANGE RATE AS A NON-STATIONARY SERIES!!

Balassa Samuelson Model

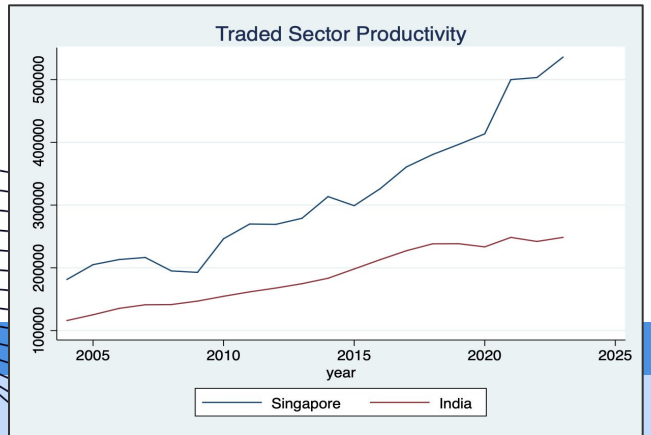
$$(p/ep^*)_i = \alpha + \beta\,(GDP_T / L_T)_i + \epsilon_i$$

$H_o: \beta > 0$
$H_a: \beta = 0$

- $\beta_{Singapore} = 0.061 > 0$
- ***p-value = 0.018,*** indicates results are **statistically significant** at *5%* level.
- Thus, a **positive** β indicates that the country having higher traded sector productivity (here, Singapore) has larger value of real exchange rate.

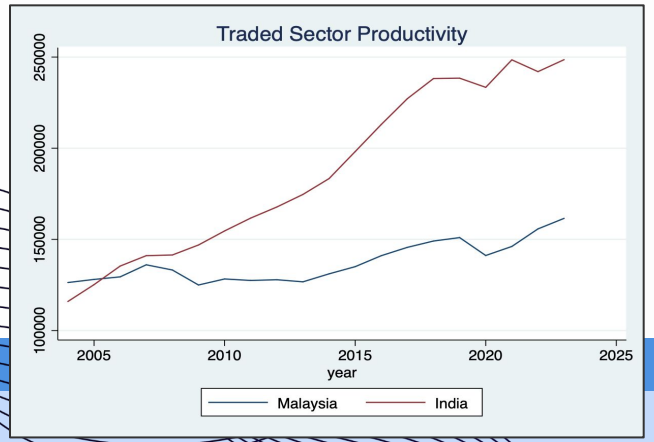
Testing Between India and Singapore

```
. regress inv_r_ind_sgp prod_D_ind_sgp

      Source |       SS           df       MS      Number of obs   =        20
-------------+----------------------------------   F(1, 18)        =      6.81
       Model |  .001060703         1  .001060703   Prob > F        =    0.0178
    Residual |  .002804659        18  .000155814   R-squared       =    0.2744
-------------+----------------------------------   Adj R-squared   =    0.2341
       Total |  .003865362        19  .00020344    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
------------------------------------------------------------------------------
```



BALASSA-SAMUELSON HYPOTHESIS IS NOT REJECTED

- $\beta_{Malaysia} = -1.426 < 0$
- ***p-value = 0.000,*** indicates results are **statistically significant** at 1% level.
- Thus, a **negative** β indicates that the country having higher traded sector productivity (here, India) has larger value of real exchange rate.



$$(p/ep^*)_i = \alpha + \beta\,(GDP_T / L_T)_i + \epsilon_i$$

H_o: $\beta > 0$
H_a: $\beta = 0$

Testing Between India and Malaysia

```
. regress inv_r_ind_mal prod_D_ind_mal

      Source |       SS           df       MS      Number of obs   =        20
-------------+----------------------------------   F(1, 18)        =    221.68
       Model |  .014262998         1  .014262998   Prob > F        =    0.0000
    Residual |  .001158132        18  .000064341   R-squared       =    0.9249
-------------+----------------------------------   Adj R-squared   =    0.9207
       Total |  .015421129        19  .000811638   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
------------------------------------------------------------------------------
```

BALASSA-SAMUELSON HYPOTHESIS IS NOT REJECTED

- $\beta_{Malaysia} = -5.165 < 0$ thus the null hypothesis does not hold.
- ***p-value = 0.000,*** indicates results are **statistically significant** at 1% level.
- Thus, a **negative** β indicates that the country having higher traded sector productivity (here, India) has larger value of real exchange rate.

$$(p/ep^*)_i = \alpha + \beta\,(GDP_T / L_T)_i + \epsilon_i$$

$H_o: \beta > 0$
$H_a: \beta = 0$

Testing Between India and Philippines

```
. regress inv_r_ind_phi prod_D_ind_phi

      Source |       SS           df       MS      Number of obs   =        20
-------------+----------------------------------   F(1, 18)        =     68.10
       Model |  1.9141945         1  1.9141945     Prob > F        =    0.0000
    Residual |  .505972908       18  .028109606    R-squared       =    0.7909
-------------+----------------------------------   Adj R-squared   =    0.7793
       Total |  2.42016741       19  .127377232    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
------------------------------------------------------------------------------
```

BALASSA-SAMUELSON HYPOTHESIS IS NOT REJECTED

Testing Exchange Rate Overshooting

$$\Delta e_t = \alpha + \beta_1 (\Delta p_t - \Delta p_t^*) + \beta_2 (\Delta r_t - \Delta r_t^*) + \epsilon$$

$H_o: |\beta_1| > 1$
$H_a: \beta_1 = 1$

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

Exchange Rate Overshooting Between India and Singapore

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

EXCHANGE RATE DOESN'T OVERSHOOT BETWEEN INDIA AND SINGAPORE

$$\Delta e_t = \alpha + \beta_1 (\Delta p_t - \Delta p_t^*) + \beta_2 (\Delta r_t - \Delta r_t^*) + \epsilon$$

$H_o: |\beta_1| > 1$
$H_a: \beta_1 = 1$

- $\beta_{malaysia} = -0.81$, is different from the null hypothesis.
- ***p-value = 0.00,*** indicates results are **statistically significant** at *1%* level.
- Thus, we **reject** the Null Hypothesis.

Exchange Rate Overshooting Between India and Malaysia

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

EXCHANGE RATE DOESN'T OVERSHOOT BETWEEN INDIA AND MALAYSIA

$$\Delta e_t = \alpha + \beta_1 (\Delta p_t - \Delta p_t^*) + \beta_2 (\Delta r_t - \Delta r_t^*) + \epsilon$$

$H_o: |\beta_1| > 1$
$H_a: \beta_1 = 1$

- $\beta_{philippines}$ ***= 0.019,*** is different from the null hypothesis.
- ***p-value = 0.00,*** indicates results are **statistically significant** at *1%* level.
- Thus, we **reject** the Null Hypothesis.

Exchange Rate Overshooting Between India and Philippines

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

EXCHANGE RATE DOESN'T OVERSHOOT BETWEEN INDIA AND PHILIPPINES

6

Conclusions

Conclusions

PPP does not hold in the medium to long run

Due to variation in the level of development and productivity and sticky prices, PPP does not not hold.

Reinforcement of the Balassa-Samuelson effect

Given that the countries we have chosen vary in levels of productivity, we find empirical validation for the Balassa–Samuelson effect, i.e. $\beta > 0$ *or* $\beta \neq 0$.

Not much evidence for Exchange Rate Overshooting

Lack of robust evidence for exchange rate overshooting post the global financial crisis , i.e. $|\beta_1| < 1$.

Group Members

Name	Contribution
Akshat Gupta	Balassa Samuelson Model
Bhavya Sikarwar	Tested PPP & ADF Test
Rishabh Yadav	Tested Exchange Rate Overshooting
Sampada Kalavakunta	Data Collection & Literature Review
Sarthak Motwani	Tested PPP & ADF Test

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Thanks!

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