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Purchasing Power Parity theory in exchange rate determination: evidences from the G-20 nations

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Abstract. *This research work is focused on evaluating the Purchasing Power Parity (PPP) theory using a sample of the top 20 economies of the world (G-20 countries) for the time period 1960-2022. The primary objective of the research is to understand the implications and utility of PPP theory in the context of time. Additionally, the research aims to test the effectiveness of the PPP theory in the exchange rate determination process. The study relies on derived and actual measures of exchange rates for analysis. It also tries to develop a model for exchange rate determination based on the PPP theory and do a comparative analysis of the results. The study highlights the inefficiencies and efficiencies of the system to suggest for areas of improvement with effective policy implications. The research has found more conclusive evidence supporting the PPP theory in short to medium term rather than long term. Also, it highlights that the actual exchange rates are not caused by price and inflation dynamics, contrary to the common rationale.*

Keywords: PPP, Foreign exchange, G-20 nations, Macroeconomics.

JEL Classification: F31, F45, F63.

1. Introduction

Foreign exchange rates are a type of commodity which has a usage in almost all sectors of an economy [Kilian & Zhou; Adler & Tovar (2014)]. Foreign exchange market includes traders, investors, speculators and arbitrageurs operating at individual and institutional level. The Purchasing Power Parity (PPP) theory is an economic theory that asserts that exchange rates between the currencies of two countries are in equilibrium when their purchasing power is the same for a given basket of goods and services [see Rogoff (1996); O'Connell (1998)]. In other words, PPP suggests that the exchange rate between two currencies should equalize the prices of identical goods and services in different countries, once converted into a common currency [Frankel & Rose (1996); Vo & Vo (2023)]. The 'absolute PPP' theory suggests that the exchange rate between two currencies should be such that a basket of goods and services costs the same in both countries when measured in a common currency. The 'relative PPP' theory relaxes the assumption of identical baskets of goods and services. It suggests that the rate of change in exchange rates should be equal to the rate of change in relative price levels between countries [see Taylor (2002); Rogoff (1996); O'Connell (1998)].

A central bank adopts a monetary strategy to affect various macroeconomic parameters such as inflation, exchange rate and economic growth (Ahmad & Premaratne, 2020). Kasem & Al-Gasaymeh (2022) studied the relationship between exchange rate, domestic and foreign price levels for the selected countries. Exchange rate determination is an integral and imperative process of international macroeconomics [Stockman (1980); Rossi (2013); Altavilla & De Grauwe (2010)]. Taylor (1995) observes that the exchange rate economics has been the most dynamic and challenging area of the last 20 years. Bilson (1984) and Hau & Rey (2006) comment that the early exchange rate theories faltered because they relied primarily on trade balance and price levels, as well as their lack of addressing the speed of transmission of information in the study variables. Sbeiti et al., (2025) studied the interaction of foreign exchange rates with other macroeconomic variables for the BRICS countries.

The local foreign exchange rate is a derived price and should move in consonance with the local inflation rate and with the local demand/supply dynamics in free market system. Oh (1996) reports the results of unit root tests for real exchange rates using a panel framework and found evidence supporting PPP over the recent flexible exchange rate period for G-6 and OECD countries. In the short run, there is a possibility that exchange rates deviate from PPP measures however, the vast majority of economic theories suggest that PPP holds in the long run. Quy et al., (2023) found evidence of PPP utility in foreign exchange price determination whereas studies [O'Connell (1998); Wu et al. (1999)] are among those who rejected the influence of PPP in foreign exchange determination.

The PPP is also closely related to the 'law of one price' (Isard, 1977) which states that in the absence of transportation costs and trade barriers, identical goods should have the same price in different markets when expressed in a common currency. The 'Big Mac Index', is another popular and less formal measure of PPP derived from burger prices (Atla, 2014). The PPP has several implications for international economics and finance. It can be applied as an economic measure to predict movements in exchange rates [Taylor (2002); Rogoff

(1996)]. It highlights the arbitrage opportunities in the foreign exchange markets where price differences can be exploited by arbitrageurs [Frankel & Rose (1996); Vo & Vo (2023)]. PPP can be used as a benchmark for assessing the valuation of different currencies in concurrence with Rogoff (1996).

A contrary view (see Rogoff, 1996) for the PPP theory is based on the assumption of identical baskets of goods and services across countries which may not hold in reality due to differences in preferences, quality, and availability of goods. The factors such as transportation costs, trade barriers and taxes will always create a price differential between currencies. Also, that PPP holds better in the long run rather than in the short run as short-term deviations can occur due to sporadic factors such as speculation [see O'Connell (1998); Frankel & Rose (1996); Vo & Vo (2023)].

1.1. Need of the study

The PPP theory is one of the prominent and applied theories of foreign exchange rate determination. This study collects evidences from a sample of G-20 countries to further strengthen the effectiveness and application of the PPP theory. Kasem & Al-Gasaymeh (2022) examines the validity of Purchasing Power Parity between Jordan and Turkey, Qatar, Iraq, United Arab Emirates and Saudi Arabia. There have been several studies on testing the PPP theory but hardly any study is found which focuses on the G-20 nations. The G-20 nations influence the economies and currencies of the world because of their scale of contribution to the global income and thus a study on these countries is expected to shed light on new findings.

G-20 Members: As per 'www.g20.org', the Group of Twenty (G-20) comprises 19 countries (Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Türkiye, United Kingdom and United States) and two regional bodies, the European Union and the African Union (as in the year 2023). The G-20 members represent around 85% of the global GDP, over 75% of the global trade, and about two-thirds of the world population. Any macroeconomic study with G-20 countries as a sample will have wider acceptability and usage.

2. Literature Review

The process of foreign exchange rate determination is an integral part of the international macroeconomic structure [see Gabaix & Maggiori (2015); Dornbusch (1976); Taylor (1995); Flood & Rose (1999)]. Theories such as International Fisher Effect (IFE) and Purchasing Power Parity (PPP) govern the process of exchange rate determination [Hau & Rey (2006); Perera et al. (2018); Quy et al. (2023)]. The earliest reference to PPP dates to sixteenth century in Spain (Rogoff, 1996) when economists began exploring the idea of parity between different currencies based on their purchasing power. However, PPP theory gained prominence in the 20th century with the development of formal economic models and empirical testing methodologies (Cassel, 1918).

Purchasing Power Parity (PPP) theory remains a cornerstone in exchange rate determination studies, positing that currencies will adjust to equalize the cost of a basket of goods across different countries. This theoretical framework, vital for understanding international financial mechanisms, has been extensively explored, analysed, and contested within the academic community. Choji & Sek (2023) delve into the PPP theory through a rigorous cross-sectional dependence panel data analysis encompassing sixteen developed countries and affirm the theory's relevance in gauging exchange rate movements. Khan & Qayyum (2007) present a compelling case for PPP in Pakistan and provide substantive evidence supporting the presence of a long-run PPP effect. Oh (1996) found evidence supporting PPP in a flexible exchange rate regime for G-6 and OECD countries. O'Connell (1998) found no evidence against the random walk null hypothesis in a panel of 64 real exchange rates. Vo & Vo (2023) studied the application of PPP theory and observed that the forces of arbitrage and resource re-allocation are sufficient to overcome many of these distortions of the foreign exchange rates in the longer term. Kasem & Al-Gasaymeh (2022) applied unit root tests and Johansen cointegration test to analyze the data during 2000-2020. Taylor (2002) provides evidence of long-run PPP for OECD countries using panel data analysis. However, empirical support for PPP is mixed in the short run, with deviations from parity attributed to factors such as transaction costs, trade barriers, non-tradable goods, and market imperfections (Engel & Rogers, 1996). PPP also tends to hold better in the long run than in the short run, and short-term deviations can occur due to factors like speculative trading, capital flows, and macroeconomic shocks (Rogoff, 1996).

There have been several studies [see Gasaymeh (2022); Quy et al. (2023)] on testing the PPP theory but no study was found focused on the G-20 countries. This study adds to the novelty by deriving a PPP based exchange rate and comparing it with the actual exchange to analyse the inefficiencies. Considering the research aim and objective, three null hypotheses are formulated,

- Null Hypothesis 1 (H01): *Derived ER and Inflation rate are not significantly correlated [see Stockman (1980); Rossi (2013); Gabaix & Maggiori (2015)].*
- Null Hypothesis 2 (H02): *Actual ER and Inflation rate are not significantly correlated [see Dornbusch (1976); Altavilla & De Grauwe (2010)].*
- Null Hypothesis 3 (H03): *There is no significant difference between the derived ER and actual ER[see Taylor (1995); Flood & Rose (1999)].*

3. Research Methodology

The primary objective of the research is to evaluate the PPP theory and its effectiveness in exchange rate determination. Additionally, PPP theory is evaluated over the time horizon and its interactions with price and inflation. Researchers have employed various econometric techniques to test PPP theory, including unit root tests, cointegration analysis, panel data methods, and time series models [see MacDonald (1996); Narayan (2022); Kilicarslan (2018)]. These methodologies aim to assess the stationarity of exchange rates and relative prices, estimate long-run equilibrium relationships, and identify deviations from PPP (Cheung & Lai, 1993). This research applies descriptive analysis, correlation analysis, regression analysis (see Sbeiti et al., 2025) including panel regressions (Hausman,

1978) and the Ganger causality analysis (Granger, 1987). A 'paired t test' is conducted to validate the difference in actual exchange rate and the derived exchange rate.

Inflation, prices and exchange rates have been used as the primary study variables for the sample countries (see table 1 and 2). Annual average values for these variables have been considered for the time period 1960 to 2022. Effectively the analysis is done for 18 countries, excluding the European Union and African Union. Inflation is measured as the consumer price index reflecting the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services. Official exchange rate refers to the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages (local currency units relative to the U.S. dollar). Economists widely use CPI or basket of goods to derive and compare foreign exchange rates *(www.forex.com)*.

Table 1. *Study variables*

Variable	Explanation	Source
Inflation	Inflation, consumer prices (annual %)	World Development Indicators, The World Bank
Exchange rate	Official exchange rate (LCU per US$, period average)	World Development Indicators, The World Bank
Prices	Consumer price index (base 2010 = 100). Data is period averages.	World Development Indicators, The World Bank

To study the PPP theory, exchange rates have been derived as in equation 1. For the purpose a derived measure (DER) and the actual measure of foreign exchange rates (AER) are considered or analysis. Derived Exchange Rates (DER_{xy}) were calculated following the PPP theory and using the prices for respective countries (see equation 1). The prices for the United States (US) were considered as the common standard country prices.

$$DER_{xy} = Price_x / Price_y \quad \ldots (1)$$

Here, 'x' is the foreign country price and 'y' is the US Price. The Consumer Price Index (see table 1) has been used as proxy to represent country prices, respectively. Subsequently, deviations were calculated between actual exchange rates (AER) and derived exchange rates as equation 2. Here, 't' is the respective year which varies from 1960 to 2022.

$$DEV_t = AER_t - DER_t \quad \ldots (2)$$

$$DEV_t = [(AER_t - DER_t)/AER_t] * 100 \quad \ldots (3)$$

Two types of averages and one yearly time series, based on DEV_t, were used to analyse the short term, medium term and long-term trends in the gap or deviations of PPP exchange rate (DER) from the actual exchange rate (AER). The 63 years average represents long term deviations and 5 years average indicating medium term deviations. The annual deviations represent the short-term deviations between AER and DER.

4. Data Analysis

This section illustrates the data and related calculations and comment on the outcome. Based on equation (1, 2, 3), table 2 indicates the average gap (deviation) between actual exchange rate and derived exchange rate for the full time period (63 years) across countries. The maximum difference between actual and derived exchange rate was observed for Japan (99.9%) while the lowest was observed for Canada (12.7%). The composite overall average

for 63 years across countries is 62%, implying that in long term PPP theory does not holds and the PPP exchange rates deviates from the actual exchange rates. Table 2 can also be read together with chart 1, which depicts the trends in annual average deviations across countries. A country is represented by the respective serial number (see table 2).

Table 2. *Average deviations (1960-2022)*

Sl.No.	*Country*	*Average deviation (%)*
1	Argentina	NA
2	Australia	26.21
3	Brazil	72.28
4	Canada	12.73
5	China	91.66
6	France	43.15
7	United Kingdom (UK)	88.88
8	Indonesia	97.4
9	India	55.01
10	Italy	99.11
11	Japan	99.91
12	South Korea	92.48
13	Mexico	NA
14	Russian Federation	67.95
15	Saudi Arabia	51.59
16	Turkiye	84.88
17	United States	-54.19
18	South Africa	NA

Chart 1: *Yearly deviations (%)*

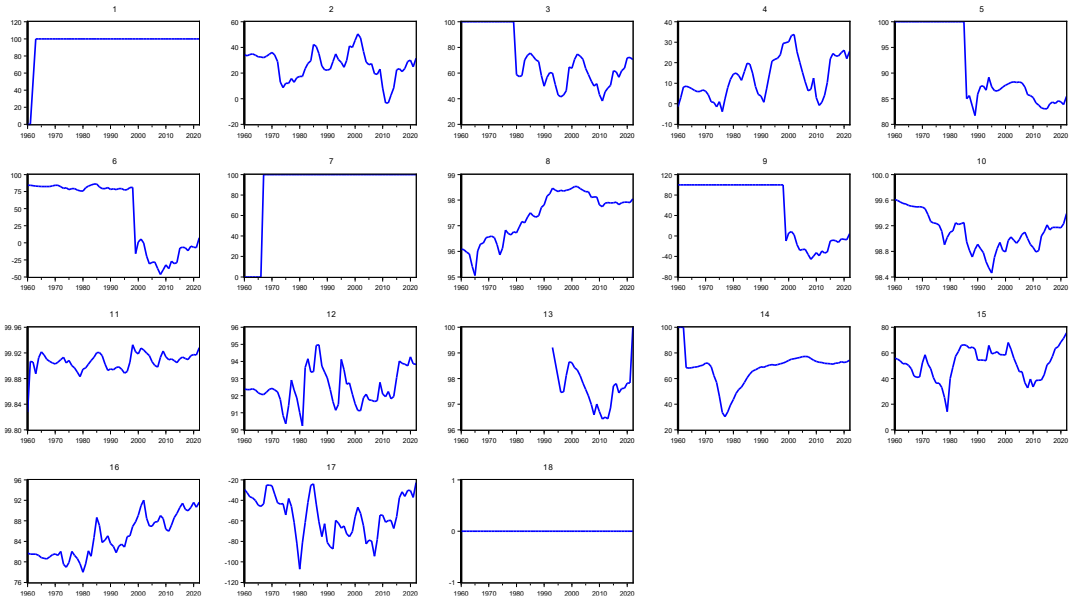
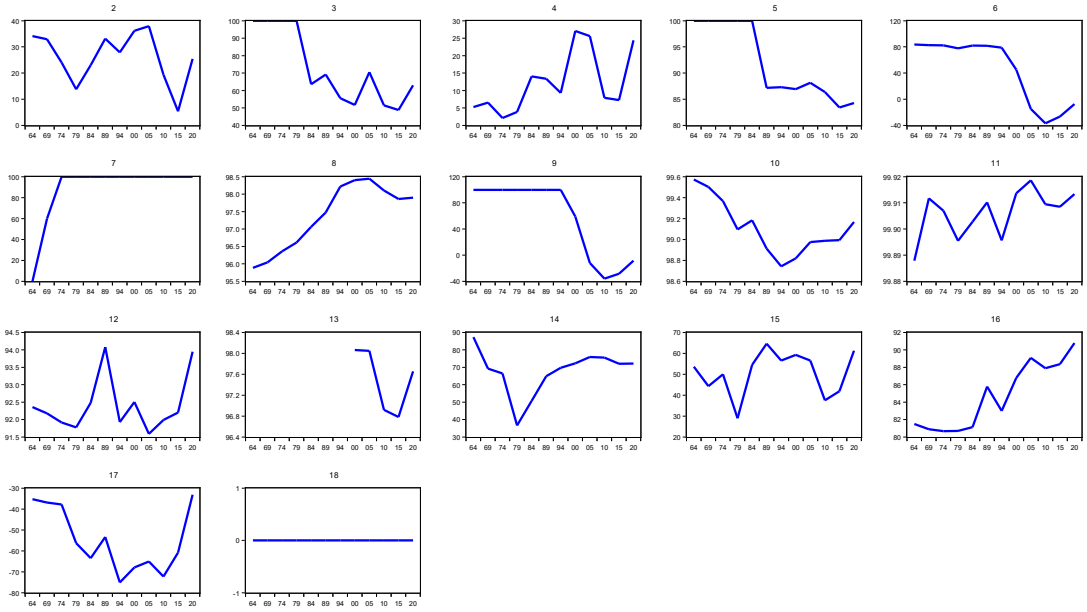
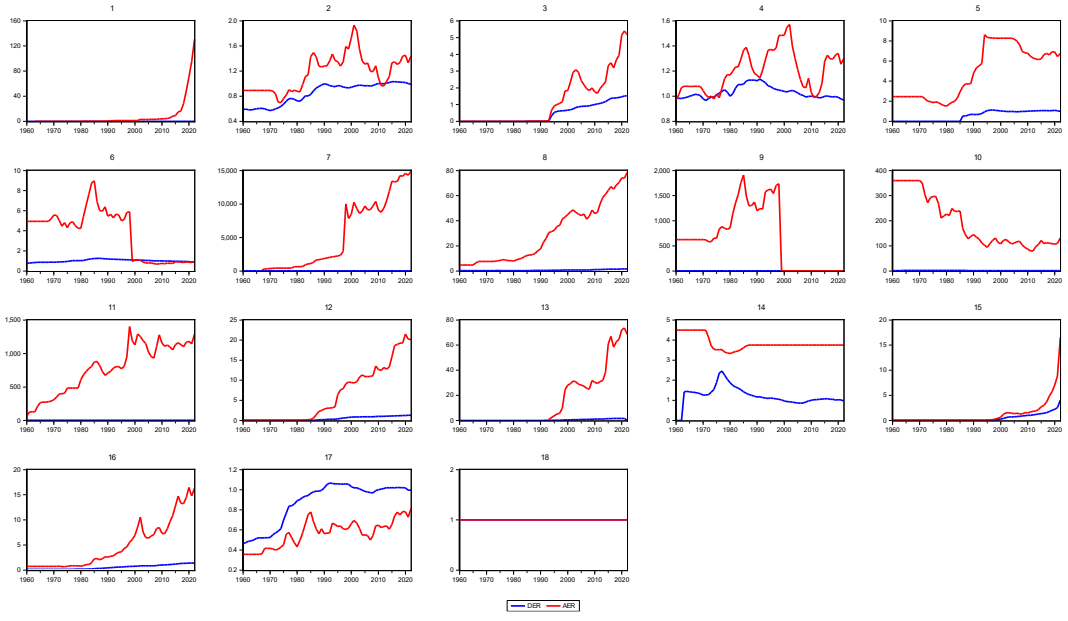


Chart 2: *5 year deviations (%)*



The chart 2 graphically demonstrates the trends in medium term (5 years) deviations across countries. A country is represented by the respective serial number (see table 2). Chart 1 and chart 2 are read together for a comparative analysis in deviations across countries. Countries numbered 2, 6, 11, 12 and 17 show a divergent trend while other countries show a similar trend in medium term and long-term deviations.

Chart 3. *Actual exchange rate vs derived exchange rate (Log values)*



The chart 3 compares the actual exchange rates (in red colour) against the derived exchange rates (in blue colour) across countries and over the years. The data is presented as annual averages. A country is represented by the respective serial number (see table 2). The chart 3 can be used to compare the trends in movements of both the exchange rates. It is observed that for China (5), Saudi Arabia (15), Turkiye (16) and USA (17), the trend (graph) for both the exchange rates is similar while for Russia (14), a divergent trend is observed.

Null hypothesis H01 and H02 could be validated based on panel correlations (table 3) while the null hypothesis H03 could be validated based on the paired sample 't' test. Derived ER and Inflation rate demonstrate a negative and significant correlation (-0.174) while Actual ER and Inflation rate demonstrate a negative and non-significant correlation (-0.022). Thus, null hypothesis (H01) was rejected and null hypothesis (H02) could not be rejected. A paired sample 't' test rejected the third null hypothesis (p-value=0).

Table 3. *Panel correlations*

	AER	Inflation	Prices	DER
AER	1			
Inflation	-0.022	1		
Prices	0.125***	-0.124***	1	
DER	0.042	-0.174***	0.715***	1
*'***' indicates significance at 99% level*				

Table 4. *Pairwise Granger causality tests (lag 2)*

Null Hypothesis	p-value
INFLATION does not Granger Cause AER	*0.994*
AER does not Granger Cause INFLATION	*0.939*
PRICES does not Granger Cause AER	*0.604*
AER does not Granger Cause PRICES	*0.037*
DER does not Granger Cause AER	*0.401*
AER does not Granger Cause DER	*0.812*
PRICES does not Granger Cause INFLATION	*0.007*
INFLATION does not Granger Cause PRICES	*0.044*
DER does not Granger Cause INFLATION	*0.000*
INFLATION does not Granger Cause DER	*0.028*
DER does not Granger Cause PRICES	*0.000*
PRICES does not Granger Cause DER	*0.000*

The causality tests (table 4) indicate that prices cause inflation as the Consumer Price Index is based on prices of a basket of commodities. It also indicates that inflation (p-value=0.028) and prices (p-value=0) cause DER. However, no causal relationship was observed between AER and DER and no impact of inflation (p-value=0.9) or prices (p-value=0.6) was observed on AER.

Table 5. *Paired sample test*

Paired Differences				p-value
		Mean	*Standard deviation*	
Pair 1	AER - DER	379.8	1691.79	0

Subsequent to the comparative analysis between DER and AER, as a robustness test, a panel data pooled regression was applied to further understand the impact of inflation on actual exchange rates.

In panel data analysis (the analysis of data over time), the Hausman test (Hausman, 1978) helps to choose between fixed effects model or a random effects model (see Hahn et al., 2011). The null hypothesis for Hausman test is that the preferred model is random effects while the alternate hypothesis is for a fixed effects model. The Hausman test to validate the significance of random effects in panel cross-sections was rejected (p-value=0.8). Thus, the POLS regression was tested for the significance of fixed effects in cross-sections (see table 6). The null hypothesis of fixed effect redundancy was rejected indicating the relevance of fixed effects in this data panel. A significant regression (with fixed effects) with an R-squared of 51% was reported however a negative coefficient is observed (table 7) for inflation when regressed over AER.

Table 6. *Fixed effect redundant test results*

Effects Test	p-value
Cross-section F	0
Cross-section Chi-square	0

Table 7. *Fixed effect panel regression results (Dependent Variable: AER)*

Sample: 1960-2022 periods included: 63, Cross-sections included: 17		
Variable	**Coefficient**	**p-value**
Inflation	-0.10	0.73
Constant	426.17	0

5. Discussion

The 'absolut PPP' theory suggests that the exchange rate between two currencies should be such that a basket of goods and services costs the same in both countries when measured in a common currency. The 'relative PPP' theory relaxes the assumption of identical baskets of goods and services. It suggests that the rate of change in exchange rates should be equal to the rate of change in relative price levels between countries [see Taylor (2002); Rogoff (1996); O'Connell (1998); Frankel & Rose (1996); Vo & Vo (2023)].

The highest difference between actual and derived exchange rate was observed for Japan (99.9%) while the lowest was observed for Canada (12.7%). The composite overall average is observed as 62% (deviation) for 63 years across countries indicating that the PPP theory does not holds in the long run and the PPP exchange rate deviates from the actual exchange rates in long run. This finding is contrary to Rogoff (1996) and Vo & Vo (2023). Comparing the medium term and long term graphs, five countries show a divergent trend while other countries show a similar trend in medium term and long term deviations. Thus, no conclusive evidence is found studying the graphs. Comparing the deviations (chart 3), it is observed that for China (5), Saudi Arabia (15), Turkiye (16) and USA (17), the trend (graph) for both the exchange rates is similar while for Russia (14) a divergent trend is observed. This implies that for large economies like China and USA, the actual and derived exchange rates show a similar movement.

The null hypothesis (H01) was rejected implying that DER and Inflation rate are significantly correlated (-0.174) and thus holding the PPP theory true (see Rogoff, 1996 and VO &Vo, 2023).

A paired sample 't' test rejected the third null hypothesis (H03) (p-value=0) of 'no difference' indicating that there is a difference between DER and AER rates. This was further validated by the acceptance of null hypothesis (H01).

The causality tests (table 4) indicate that prices cause inflation in concurrence with the concept of the Consumer Price Index. It also indicates that inflation (p-value=0.028) and prices (p-value=0) cause DER, holding the PPP theory true, in principle [see Vo & Vo (2023); Rogoff (1996)]. However, no causal relationship was observed between AER and DER and no impact of inflation (p-value=0.9) or prices (p-value=0.6) was observed on AER. This implies a disconnect between the actual prevailing exchange rates and the PPP derived exchange rates. This also highlights the fact that the actual exchange rates are not caused by price dynamics [see Gabaix & Maggiori (2015); Dornbusch (1976); Altavilla & De Grauwe (2010)]. This is revalidated in robustness test using a cross-country panel of AER and inflation data where a negative and insignificant coefficient (-0.1) is observed for inflation when regressed with AER with a R-squared value of 51%.

6. Conclusion

Since the primary objective of the research was to understand the dynamics between prices and exchange rates, the research was successful in contributing to the literature considering this context. For the purpose a derived measure (DER) of prices and a direct measure (AER) of foreign exchange rates have been used in the study along with evaluation of three hypotheses.

The impact of price and inflation on the derived measure of exchange rate validates the rationale of the PPP theory. This finding is supported by results from the panel correlation test and the causality test. Alternatively, the study also concluded that the actual prevailing exchange rates across the countries is not caused by prices and inflation. This finding was validated by causality tests and the panel data analysis.

The study found no evidence of connect between AER and DER indicating that the PPP theory in reality does not determines the actual exchange rates. This poses a question on the validity of the PPP theory in exchange rate determination. This finding also makes a pertinent case for further studies on the effectiveness of PPP in international macroeconomics. The DER formulae (equation 1) may be a suggestive rationale for future PPP studies.

Limitations and future scope: The PPP theory considers the view that the assumption of identical baskets of goods and services across countries may not hold in reality due to differences in preferences, quality, and availability of goods. Also, that PPP holds better in the long run rather than in the short run as short-term deviations can occur due to sporadic factors such as speculation. Despite its limitations, PPP theory has important implications for international trade, investment, and monetary policy. PPP serves as a benchmark for assessing whether currencies are overvalued or undervalued, informing decisions on currency trading, investment allocation, and policy interventions by central banks. Understanding the dynamics of exchange rates and relative price levels is crucial for

policymakers, investors, and businesses operating in global markets. Although the study is from the domain of international finance with a focus on foreign exchange theory, the scope of the study spreads to other areas of managerial decisions making such as currency trading, investment allocation, and policy interventions. The learnings will keep the researchers and practitioners interested from the domains of economics, general management and banking to look for further improvements in the PPP based exchange rate determination policy.

This study not only reinforces PPP's empirical validity but also stresses the importance of monetary policy in stabilizing exchange rates, imparting valuable policy implications. The PPP theory, by assuming away transaction costs, tariffs, and the differentiated baskets of goods across countries, opens up avenues for critique and further investigation. Future research might build upon these foundations by incorporating such factors into the analysis, exploring the nonlinear aspects of PPP, or examining the impact of digital currencies and globalization on the theory's predictions.

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