

Empirical Analysis of Purchasing Power Parity Theory in the Long-Run: Evidence from Three Time Periods and Four Income Groups

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Abstract. In macroeconomics, one of the most fundamental theories measures society well-being is the Purchasing Power Parity (PPP). This study analyzes data provided by Penn World Table version 10, published in June 2021, to find the relationship between average annually exchange rate and the change in inflation differential, to comment on the applicability of the theory in real world situation. The Penn World Table presents data in the period of 1970 to 2019, with a coverage of cross-section of 211 countries. By converting the measures into the same currency, U.S. dollar, our research leads to the conclusion that the data does not support the strong purchasing power parity theory; the data indicates a weak applicability for the relative purchasing power parity theory in short term, while it holds better in the long run. By conducting cross-sectional regression analyses for three distinct time periods: 1970 to 1986, 1987 to 2003, and 2004 to 2019, and re-organizing the data into countries with different national income levels to further support the hypothesis and conclude the applicability of the PPP theory.

Keywords: Purchasing Power Parity (PPP), Exchange Rate, GDP Deflator, Inflation Differential

1. Introduction

This essay will use data in the period from the 1970s to 2019 to investigate the relationship between exchange rate and inflation differential, to conclude the applicability of the theory of purchasing power parity. In macroeconomics studies, PPP suggests that the exchange rate should be adjust to the same value as the cost of a representative basket of goods and services between countries [1, 2]. In other words, with differences in price levels being eliminated, a unit of currency should have the same purchasing power across countries, in the long run [3, 4]. While the weak PPP theory suggests that exchange rate movements are closely related to inflation differentials between countries [5], where the product of exchange rate and the U.S. price level, divided by the domestic price level, should equal one, implying that the price level across countries should be equalized [3, 4]. This study aims to close the gap between theoretical expectations and the real-world exchange rate

situation by conducting data-based research that addresses questions about currency valuation, price level convergence, and global economic equilibrium. The purpose of this essay is to understand, evaluate, and advance the empirical validity and practical relevance of PPP as a cornerstone theory in international economics.

2. Literature review

Purchasing power parity theory is a tool used to measure society's living standards and market productivities where the cost of the same basket of goods in different countries is the same, through adjustment in the exchange rates, in different price levels [1]. Therefore, purchasing power is compared by using countries' currencies to purchase a common basket of goods; exchange rate adjustment should be equalized to the price of a standardized basket of goods across countries, originating from the law of one price and was formalized by Swedish economist Gustav Cassel in the early 20th century [6]. This theoretical principle, known as purchasing power parity, provides a critical benchmark for assessing currency valuation, inflation differentials, and real economic convergence.

The pure PPP theory in macroeconomics states that without the transaction costs and trade barriers, *ceteris paribus*, the same product should have the same price across countries when measured in the same currency [1-3]. The theory of exchange rate emphasizes the role of inflation and price levels in determining the value of currencies [5]. Purchasing power parity theory can be divided into two forms: absolute purchasing power parity and relative purchasing power parity [7].

2.1. Absolute purchasing power parity

Absolute purchasing power parity theory states that the equilibrium exchange rate between two currencies reflects their relative price levels [1]. With the assumption that the law of one price holds for all goods, with no transaction costs or trade barriers [6]. Implicating that the exchange rate is determined by the overall price levels ratios [7, 8].

$$R = \frac{P_d}{P_f}$$

R is the exchange rate.

P_d is the price level in the domestic country.

P_f is the price level in the foreign country, which is the US dollar.

2.2. Relative purchasing power parity

Foundational studies on purchasing power parity consistently confirm a clear divide between its short-run and long-run empirical performance. Rogoff, Froot and Rogoff, Lothian and Taylor, Taylor and Sarno, and Sarno and Taylo collectively document that real exchange rates exhibit extreme volatility and persistent deviations from PPP in the short-run, yet gradually revert to the purchasing power parity equilibrium over long horizons, confirming purchasing power parity's limited short-run predictive power but enduring long-run relevance [4, 9, 10, 11, 12]. With the assumption that the relaxes strict assumptions, allowing for transaction costs and price stickiness [4, 7, 10]. And the implication of the exchange rate change is determined by inflation rate differences.

$$\frac{\Delta e}{e} = \frac{\Delta P_d}{P_d} - \frac{\Delta P_f}{P_f}$$

$\frac{\Delta e}{e}$ is the percentage change in the nominal exchange rate, often expressed as $\frac{(E_t - E_{t-1})}{E_{t-1}}$.

E_t is the exchange rate at the current time period t in the domestic currency per unit of foreign currency.

E_{t-1} is the exchange rate at the previous time period $t-1$.

$(E_t - E_{t-1})$ is the absolute change in the exchange rate.

Dividing by E_{t-1} converts the absolute change into a percentage change.

$\frac{\Delta P_d}{P_d}$ is the domestic inflation rate, which measures the percentage change in the domestic price level

$\frac{\Delta P_f}{P_f}$ is the foreign inflation rate, measuring the percentage change in the foreign price level, which is in US dollar.

2.3. Real exchange rate

Real Exchange Rate (R_{ex}), the real exchange rate equals to 1 at equilibrium, while the deviations from real exchange rate equals to one shows the short run volatility [11, 12].

$$R_{ex} = \frac{E \cdot P_f}{P_d}$$

E is the nominal exchange rate (domestic currency per unit of foreign currency)

P_f is the foreign price level

P_d is the domestic price level

3. Data sources

3.1. Penn world table (PWT) v10 methodology [appendix 1]

A global macroeconomic database maintained by the Groningen Growth and Development Centre. It serves as a primary source for cross-country comparisons of economic performance and provides internationally comparable price and output data. Covers 217 countries, spanning from 1970 to 2019. With key variables: exchange rate, GDP at current national prices, GDP at constant national prices in 2017, etc.

3.2. World bank country and lending group (FY2026) [appendix 2]

A global country classification system maintained by the World Bank Group (IBRD-IDA). It serves as a primary standard for categorizing economies by income level, lending eligibility, and regional grouping, widely used in global economic research, policy analysis, and development finance. World Bank Country and Lending Group (FY2026) provides a globally consistent, transparent

framework for cross-country economic analysis and development resource allocation. Covers 218 economies, with key variable income groups.

4. Data processing

4.1. Gross domestic product (GDP) deflator

Calculated using Gross Domestic Product at current national prices (vgdp) and GDP at constant national 2017 prices (qgdp) to derive price level indicators [13].

$$\text{GDP Deflator} = \frac{vgdp}{qgdp} \times 100$$

4.2. Purchasing power parity and descriptive statistics

Generated PPP variables ($\frac{e \times P^*}{P}$) and reported mean (1071.5), variance (42177699.2), median (10.4), sample size (11849), and t-test results (significantly rejects the hypothesis that this variable equals to 1).

4.3. Rate calculation

Computed annual percentage changes in exchange rates and inflation rates using logarithmic differences.

$$\frac{\Delta e}{e} = \ln(e_{t+1}) - \ln(e_t)$$

4.4. Outlier removal

Removed missing values and outliers using the 1.5*IQR method, a statistical rule to identify outliers by defining boundaries times the Interquartile Range (IQR) above and below.

Excluding countries with fixed or stable exchange rates, a country is identified as an outlier if the absolute value of its annual exchange rate change is below 0.1% for at least 80% of the years in the sample period.

5. Methodology

By adopting cross-sectional regression, analyzing across multiple countries over three different time periods, 1970-1986, 1987-2003, 2004-2019. Moreover, by reorganizing the countries into different national income levels and repeat cross sectional regression will help to produce a more robust result. Thereby, identifying the relationships between variables and avoiding potential biases that might arise from data of a single period or a single country.

$$\frac{\Delta e}{e} = \alpha + \beta \left(\frac{\Delta P_d}{P_d} - \frac{\Delta P_f}{P_f} \right) + \varepsilon$$

$\frac{\Delta e}{e}$ is the dependent variable, showing the average annual change rate in the exchange rate against US dollar in percentage.

$\left(\frac{\Delta P_d}{P_d} - \frac{\Delta P_f}{P_f} \right)$ is the independent variable, representing the average inflation rate difference to US dollar in percentage.

6. Empirical results and analysis for three different time periods

6.1. Strong purchasing power parity

By summarizing the descriptive statistics of the PPP variable $\frac{e \times P^*}{P}$, we found that this variable is significantly different from 1, whereas it should equal 1 under the strong form of purchasing power parity. The variable exhibits extremely high volatility, with a variance of 42177699.2. Collectively, this evidence strongly suggests the significant of not focusing on the strong form of PPP theory, but instead on the realization of the weak form of PPP theory.

6.2. Weak purchasing power parity

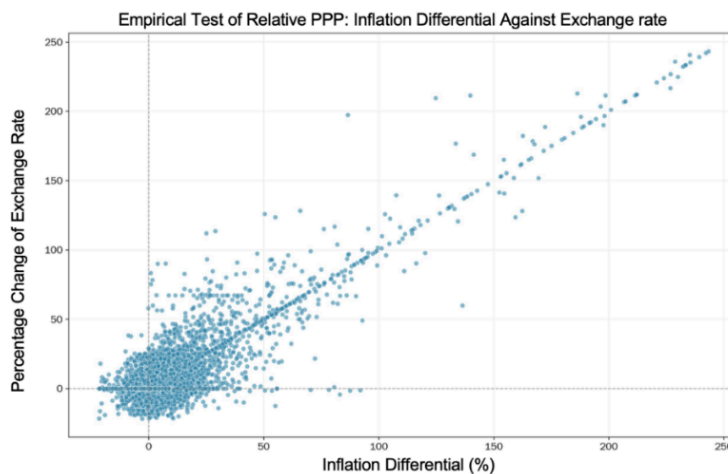


Figure 1. Exchange rate against inflation differentials in short-term

According to Figure 1, in the short run, the weak PPP is not performing well. The scatter plot indicates a clear positive correlation trend; when the inflation differential increases, the exchange rate also presents a trend to increase. This fulfills the basic rule of relative PPP theory. However, exchange rate changes do not fully depend on the adjustment of inflation differences, as the gradient of the slope is less than 1.

The data points are roughly distributed along a straight line, indicating a linear positive correlation between the two factors. However, the dispersion is high, indicating that the exchange rate are influenced by other, such as capital flows, policy intervention, and market expectations.

The existence of many outliers indicates that the law of one price of PPP is affected by factors such as transaction costs, market segmentation and short-term policy intervention.

Therefore, the scatter plot proves the positive relationship between inflation differentials and exchange rate, supporting the "directional consistency" of the weak PPP theory. However, the high dispersion and outliers indicate that exchange rate changes in the short run are driven by multiple factors.

6.2.1. Period: 1970 to 1986

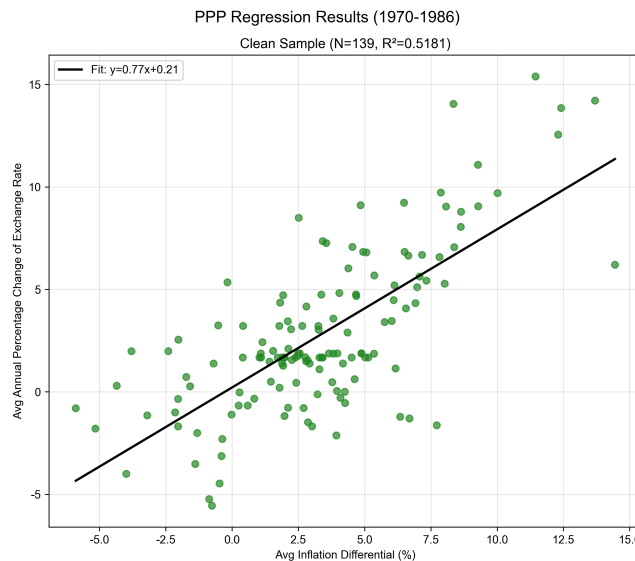


Figure 2. Exchange rate vs inflation differentials (1970-1986)

The regression in Figure 2 from 1970 to 1986, covering 139 countries, presents a relative positive relationship. To be specific, the regression model has a slope coefficient (β) of 0.77, a disturbance term (ε) of 0.21, and R square value (R^2) of 0.5181. The data supports the weaker PPP theory, indicating that in the long run, the difference in the inflation differential between countries is the key driver explaining the direction of nominal exchange rate changes.

However, the regression coefficient of 0.77 failed to reach the theoretically expected 1. This phenomenon indicates that the inflation differential moves in the same direction as the exchange rate, the magnitude of the exchange rate fluctuations is smaller than the inflation differential. In other words, the exchange rate adjustment's response to the inflation differential is insufficient. This suggests that during this period, in addition to the relative price level, other powerful forces in the market, such as the excessive exchange rate volatility, trade barriers, or short-term capital flows, were suppressing excessive exchange rate volatility.

Moreover, the model's explanatory power, of R^2 value 0.518 is only moderate. This means that while half of exchange rate fluctuations can be explained by the change in inflation differential, but the other half are driven by other factors which are not captured by this model. Due to the historical background, the low R^2 value is reasonable. The collapse of the Bretton Woods system in the early 1970s ushered in the era of floating exchange rates, and the period from 1970 to 1986 was the early adjustment phase of this new system. The global trade system was not yet fully mature, the mechanisms for coordinating economic policies among countries were still developing, where the world faced the impact of the 1973 and 1979 oil crises. Against this backdrop, multiple non-

inflationary factors, such as geopolitical risks, capital controls, and central bank intervention in the foreign exchange market worked together to cause exchange rate fluctuations to deviate from a simple PPP trajectory.

The data from 1970 to 1986 proves that the long-term trend of the weak PPP theory, it also reveals the institutional transition. The dynamics of the real exchange rate are more complex than the theoretical model and are significantly affected by macroeconomic policies and external shocks.

6.2.2. Period: 1987 to 2003

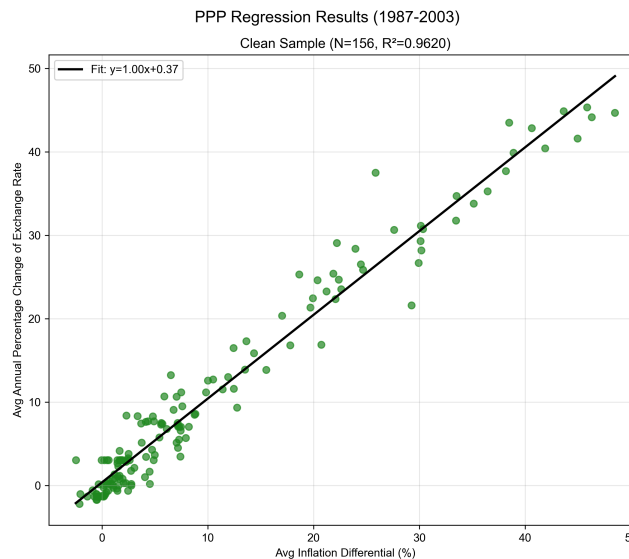


Figure 3. Exchange rate vs inflation differentials (1987-2003)

The regression in Figure 3 from 1987 to 2003, covering 156 countries, showed a strong positive correlation. Specifically, the regression model had a slope coefficient (β) of 1.00, a disturbance term (ε) of 0.37, and R square value (R^2) of 0.9620. The data provides a perfect fit for the weak PPP theory, indicating that in the long run, the magnitude and direction of exchange rate fluctuation is mainly dependent on the inflation differential among countries.

The regression coefficient of 1.00 aligns perfectly with the theoretically expectation: 1. This phenomenon indicates that the magnitude of exchange rate fluctuations is virtually identical to the inflation differential. This suggests that during this period, the real economy's price mechanisms were highly efficient, and other market forces did not significantly suppress or exaggerate the exchange rate volatility relative to inflation.

Moreover, the R^2 value of 0.9620, means that 96.2% change in inflation differentials can be explained through exchange rate changes, leaving less than 4% to other factors not captured by the model. Considering the historical context, this high R^2 suggests the stabilization in global economic structures compared to the previous search, 1970 to 1986. Between the late 1980s and 1990s, global financial markets had matured, trade barriers had lowered significantly, and many countries had successfully transitioned to market-oriented policies. In this background, the distortions caused by geopolitical uncertainty and strict capital controls have weakened, making the potential link between price levels and exchange rates more apparent.

Based on the information analyzed, the data from 1987 to 2003 validates the long-term trend of the weak PPP theory and demonstrates that under stable economic conditions with a large global

sample, the PPP holds with surprising accuracy, proving that inflation is the primary determinant of long-term exchange rate movements.

6.2.3. Period: 2004 to 2019



Figure 4. Exchange rate vs inflation differentials (2004-2019)

The regression in Figure 4 from 2004 to 2019, covering 161 countries, showed a relative positive correlation. Specifically, the regression model had a slope coefficient (β) of 0.67, a disturbance term (ε) of 0.21, and R square value (R^2) of 0.6679. The data supports the weak PPP theory, indicating that, in the long run, inflation differences between countries are the main factor causing the direction of nominal exchange rate changes.

However, the regression coefficient 0.67 is far from the theoretical expectation value 1. This suggests that while the inflation differential and the exchange rate move in the same direction, exchange rate changes are less pronounced than the differences in inflation. In other words, the exchange rate adjustment is insufficient to respond to the inflation differential. This may mean that during this period, in addition to the relative price level, other powerful forces in the market—such as the correction of exchange rate overshoot, trade barriers, or short-term capital flows—restrained excessive exchange rate volatility.

Furthermore, the R^2 value of 0.6679, is only moderate. This means that while inflation differentials explain more than half of exchange rate fluctuations, nearly half are still driven by other factors not captured by the model. During the 2008 financial crisis, the European debt crisis, and the rise of trade protectionism. By considering the historical context, a lower R^2 value for this period is reasonable. In this context, various non-inflationary factors, such as shifts in global supply chains, unconventional central bank policies, and geopolitical uncertainties have jointly lead the exchange rate movements to diverge from the straightforward path predicted by PPP.

Based on the information provided, the data from 2004 to 2019 validates the long-term trend of the weak PPP theory, but it reveals the dynamic changes in the real exchange rate, where policies and external shocks make the theoretical model invalid.

6.3. Exchange rate against inflation differentials for different income group

6.3.1. Period: 1970 to 1986

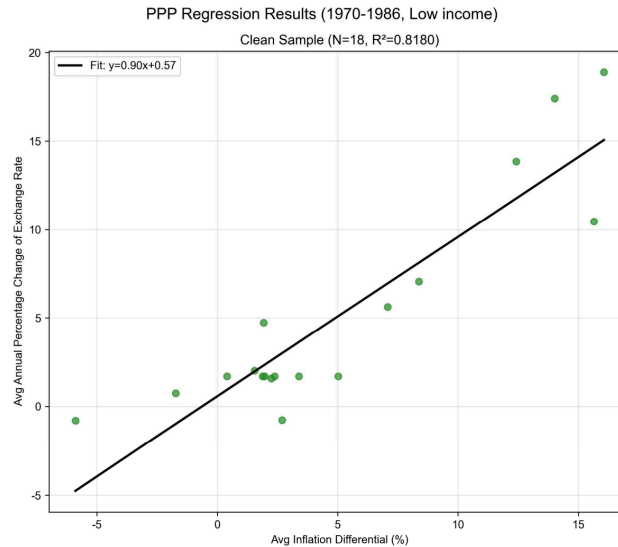


Figure 5. Exchange rate against inflation differentials for low income (1970-1986)

Figure 5 presents the results of PPP regression in low-income countries from 1970 to 1986. Having clean sample data from 18 countries, with R^2 of 0.8180; regression equation $y = 0.90x + 0.57$; the slope coefficient beta of 0.90 close to the theoretical value of 1, suggesting a strong correlation between exchange rate fluctuations and inflation differences in low-income countries [Appendix 3].

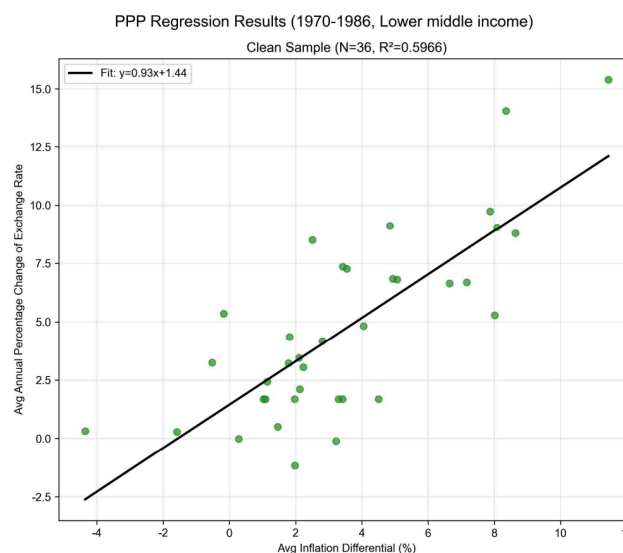


Figure 6. Exchange rate against inflation differentials for lower middle income (1970-1986)

Figure 6 presents the results of PPP regression in lower middle-income countries from 1970 to 1986. Having clean sample data from 36 countries, with R^2 of 0.5966; regression equation $y = 0.93x + 1.44$; slope coefficient beta of 0.93, very close to the theoretical value of 1, demonstrating a

strong positive correlation between exchange rate fluctuations and inflation differences, however, the moderate R^2 indicates its low applicability in these countries [Appendix 4].

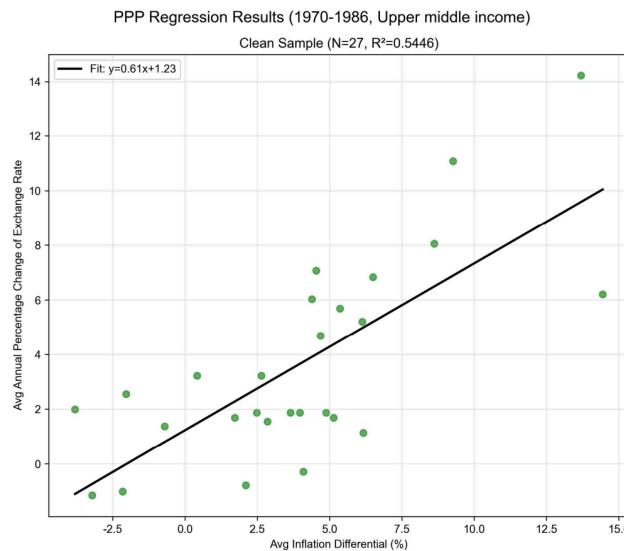


Figure 7. Exchange rate against inflation differentials for upper middle income (1970-1986)

Figure 7 presents the results of PPP regression in upper middle income countries from 1970 to 1986. Having clean sample data from 27 countries, with R^2 of 0.5446; regression equation $y = 0.61x + 1.23$; slope coefficient beta of 0.61, significantly deviating from the theoretical value of 1. While a low R^2 value indicating its relatively weak applicability in these countries [Appendix 5].

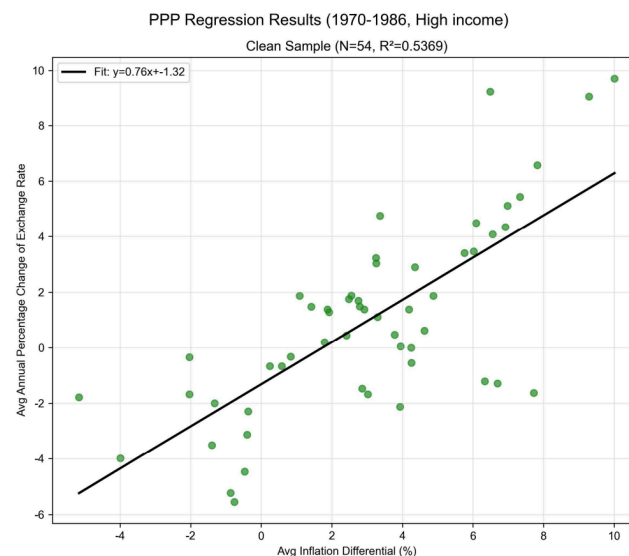


Figure 8. Exchange rate against inflation differentials for high income (1970-1986)

Figure 8 presents the results of PPP regression in high income countries from 1970 to 1986. Having clean sample data from 54 countries, with R^2 of 0.5369; regression equation $y = 0.76x - 1.32$; slope coefficient beta of 0.76, significantly deviating from the theoretical value of 1. Due to the low R^2 , the model has a weak applicability in these countries [Appendix 6].

6.3.2. Period: 1987 to 2003

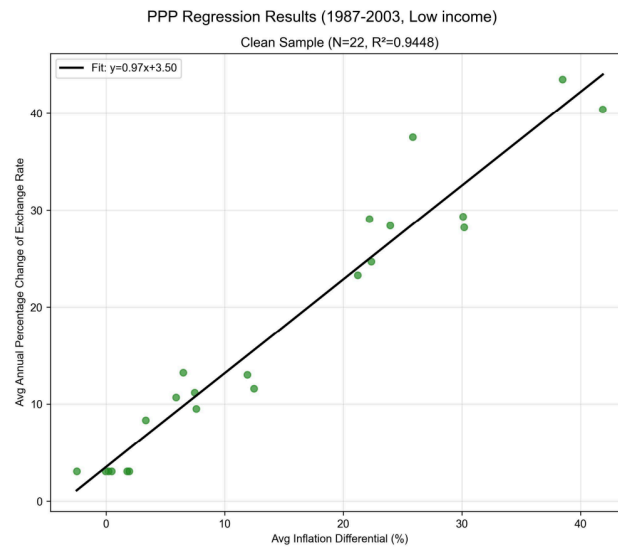


Figure 9. Exchange rate against inflation differentials for low income (1987-2003)

Figure 9 presents the results of PPP regression in low income countries from 1987 to 2003. Having clean sample data from 22 countries, with R^2 of 0.9448; regression equation $y = 0.97x + 3.50$; slope coefficient beta of 0.97, very close to the theoretical value of 1. Suggesting that the weak PPP theory is well-suited in these countries [Appendix 7].

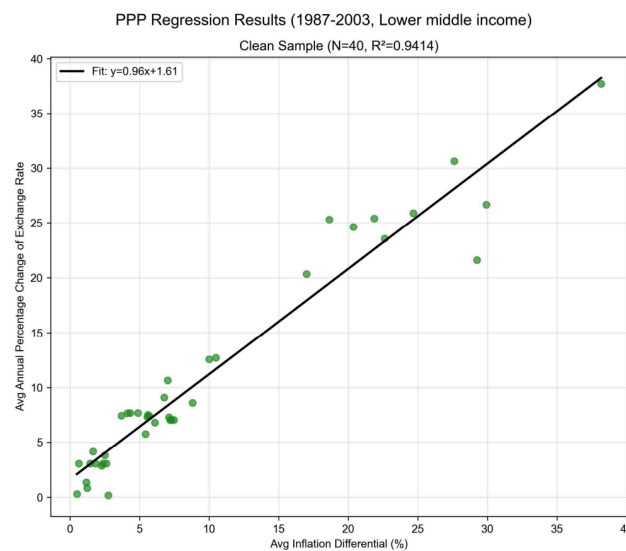


Figure 10. Exchange rate against inflation differentials for lower middle income (1987-2003)

Figure 10 presents the results of PPP regression in lower middle income countries from 1987 to 2003. Having clean sample data from 40 countries, with R^2 of 0.9414; regression equation $y = 0.96x + 1.61$; slope coefficient beta of 0.96, very close to the theoretical value of 1. Suggesting that the high applicability of weak PPP theory in these countries [Appendix 8].

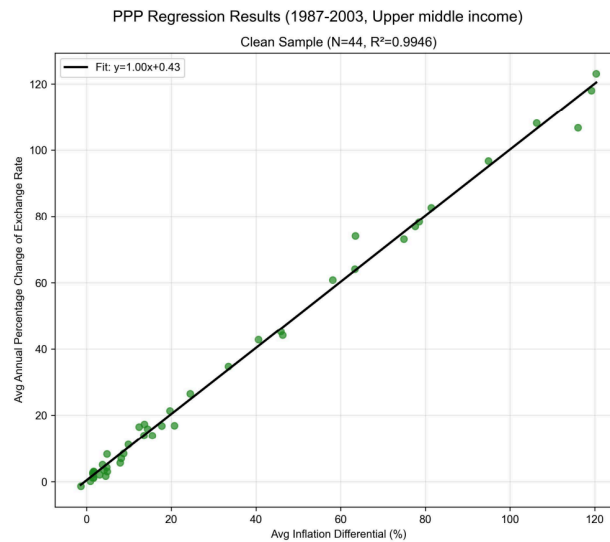


Figure 11. Exchange rate against inflation differentials for upper middle income (1987-2003)

Figure 11 presents the results of PPP regression in upper middle income countries from 1987 to 2003. Having clean sample data from 44 countries, with R^2 of 0.9946; regression equation is $y = 1.00x + 0.43$; slope coefficient beta of 1.00, equal to the theoretical value of 1. Demonstrating a high correlation between exchange rate fluctuations and inflation differences in upper-middle-income countries, showing excellent applicability of the weak PPP theory in these countries [Appendix 9].

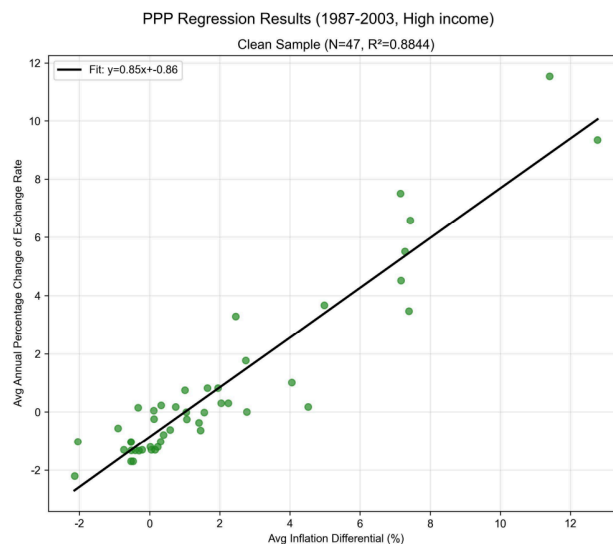


Figure 12. Exchange rate against inflation differentials for high income (1987-2003)

Figure 12 presents the results of PPP regression in high income countries from 1987 to 2003. Having clean sample data from 47 countries, with R^2 of 0.8844; regression equation is $y = 0.85x + 0.86$; slope coefficient beta of 0.85, lower than the theoretical value of 1, suggesting a correlation between exchange rate fluctuations and inflation differences in high-income countries, but weaker than in other income groups during this period. The weak purchasing power parity theory has relatively limited applicability in these countries [Appendix 10].

6.3.3. Period: 2004 to 2019

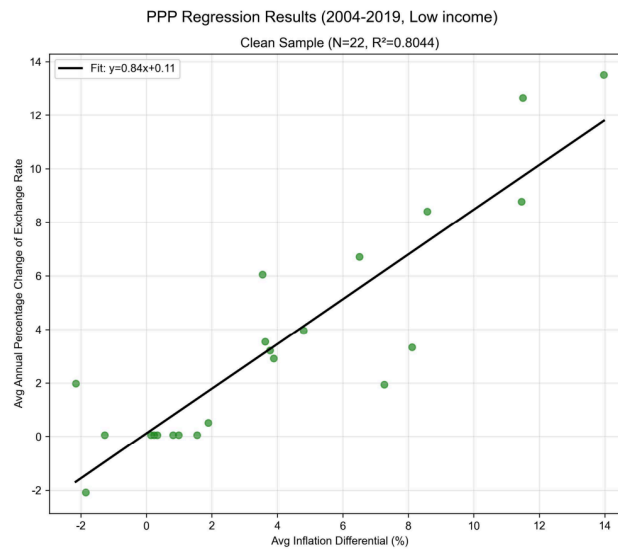


Figure 13. Exchange rate against inflation differentials for low income (2004-2019)

Figure 13 presents the results of PPP regression in low income countries from 2004 to 2019. Having clean sample data from 22 countries, with R^2 of 0.8044; regression equation is $y = 0.84x + 0.11$; slope coefficient beta of 0.84 is lower than the theoretical value of 1, suggesting the adjustments do not adequately respond to inflation differences, indicating that the weak PPP theory has relatively limited applicability in these countries [Appendix 11].

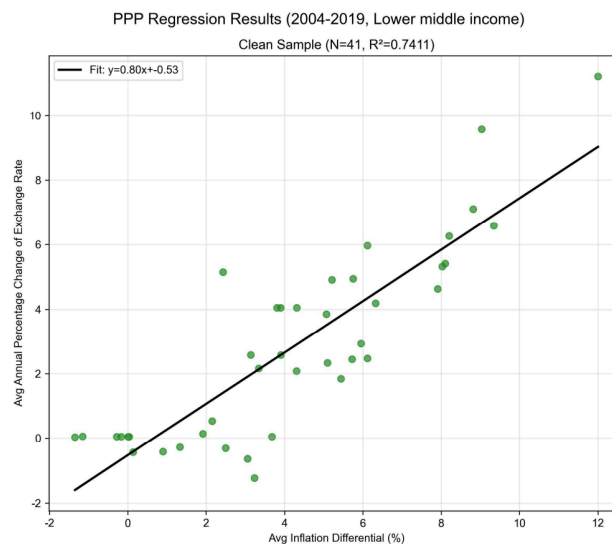


Figure 14. Exchange rate against inflation differentials for lower middle income (2004-2019)

Figure 14 regression presents the results of PPP regression in lower middle income countries from 2004 to 2019. Having clean sample data from 41 countries, with R^2 of 0.7411; regression equation is $y = 0.80x - 0.53$; slope coefficient beta of 0.80 is lower than the theoretical value of 1, suggesting that the exchange rate adjustments do not adequately respond to inflation differences, indicating relatively limited applicability of the weak PPP theory in these countries [Appendix 12].

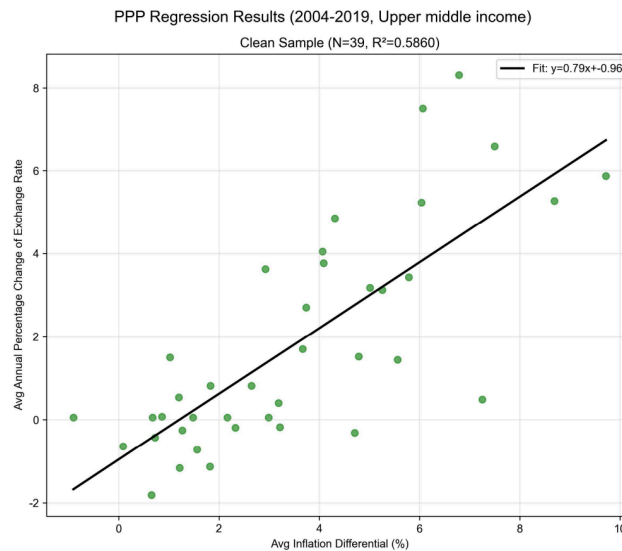


Figure 15. Exchange rate against inflation differentials for upper middle income (2004-2019)

Figure 15 presents the results of PPP regression in upper middle income countries from 2004 to 2019. Having clean sample data from 39 countries, with R^2 of 0.5860; regression equation is $y = 0.79x + 0.96$; slope coefficient beta of 0.79 is lower than the theoretical value of 1. Indicating relatively limited applicability of the weak PPP theory in these countries [Appendix 13].

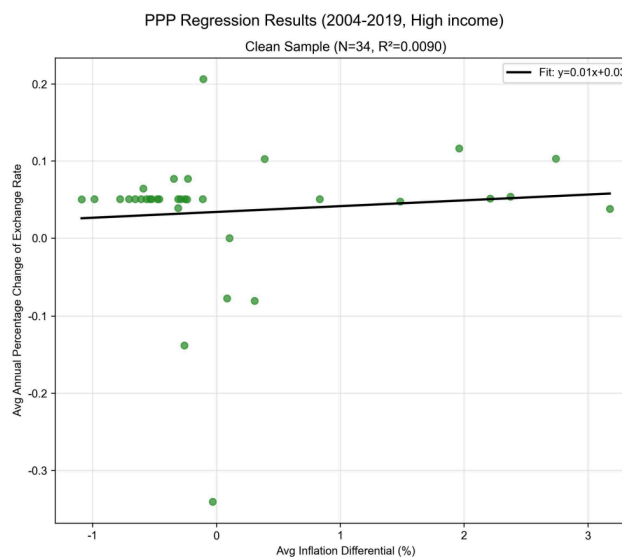


Figure 16. Exchange Rate against inflation differentials for high income (2004-2019)

Figure 16 presents the results of PPP regression in high-income countries from 2004 to 2019. Having clean sample data from 34 countries, with R^2 of 0.0090, indicating extremely weak explanatory power. The regression equation is $y = 0.01x + 0.03$, and the slope coefficient beta of 0.01 is far below the theoretical value of 1, demonstrating a very low correlation between exchange rate fluctuations and inflation differences in high-income countries. The weak purchasing power parity theory is essentially inapplicable to such countries [Appendix 14]. The data points are extremely dispersed along the regression line, further confirming that exchange rate fluctuations are

primarily driven by factors other than inflation differences, such as global capital flows, monetary policy divergence, and financial market volatility.

6.4. Discussion

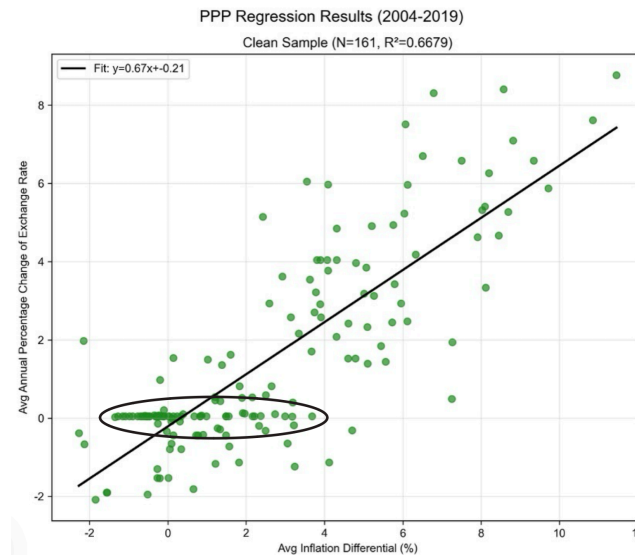


Figure 17. Exchange rate against inflation differentials with circle highlighting countries with similar exchange rate from 2004 to 2019

Table 1. Countries with similar exchange rate

Countrycode	Avg_xr2	Avg_infdiff
AND	0.0509	-0.607
AUT	0.0509	-0.1106
BEL	0.0509	-0.2535
BGR	0.0515	2.2113
DEU	0.0509	-0.5637
ESP	0.0509	-0.5227
EST	0.0540	2.3735
FIN	0.0509	-0.3091
FRA	0.0509	-0.7058
GRC	0.0509	-0.985
IRL	0.0509	-0.7789
ITA	0.0509	-0.4622
LTU	0.0477	1.484
LUX	0.0509	0.8346
MCO	0.0509	-0.6558
NCL	0.0505	-0.237
NLD	0.0509	-0.5376
PRT	0.0509	-0.2897

Table 1. (continued)

PYF	0.0505	-1.0881
SMR	0.0509	-0.4771

According to Figure 17 and Table 1, the regression model presents a clustering of European countries' data points around zero, with similar and constant exchange rate changes to other countries in the latest period, from 2004 to 2019, this is linked to the managed float regime within the Eurozone. Managed floats, also known as dirty float, is an exchange rate regime where a currency's value is primarily determined by market forces (supply and demand) but is periodically influenced by central bank or government interventions [14].

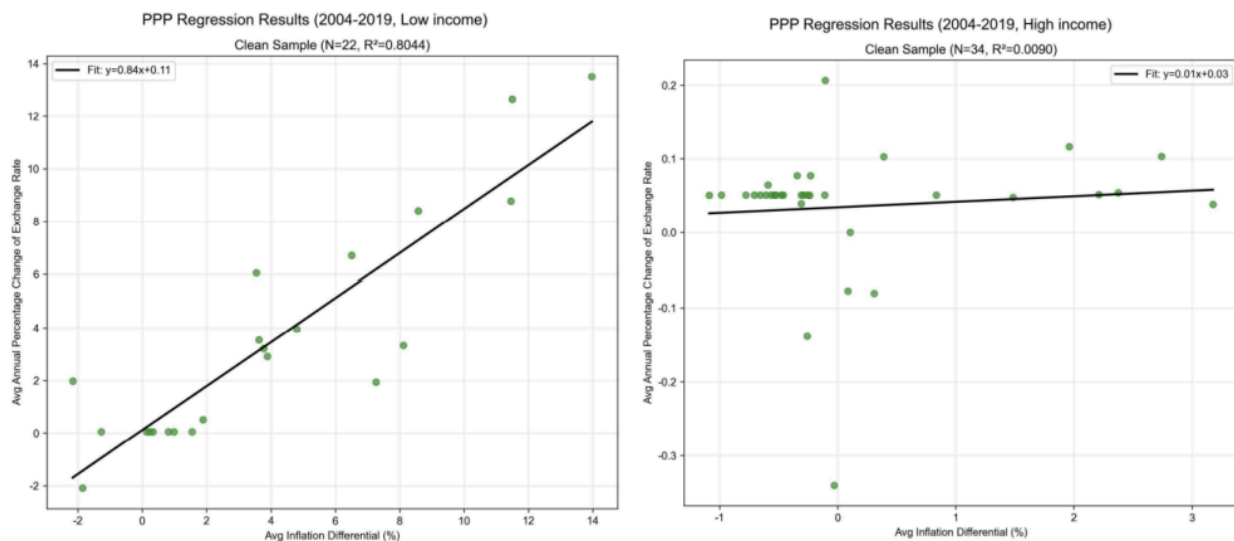


Figure 18. Exchange rate against inflation differentials for the comparison between low- and high-income countries (2004-2019)

The results for low income and the high-income countries shows that the lower income groups are presenting a more proportionate relation between exchange rate and inflation differentials compared to the higher income countries, especially during the period of 2004 to 2019. This may be due to the fact that high income countries have the ability to control their country's exchange rate with the USA. This better proves the possibility that the government interferes in the market by carrying out policies such as managed float and monetary policy [15, 16].

The reason for why high-income countries can defy the predictions of weak purchasing power parity (PPP) theory lies in their powerful policy tools and financial hegemony, which enable them to proactively intervene in the market rather than passively adapt [17]. To maintain financial stability, central banks in developed countries use their massive reserves to smooth exchange rate fluctuations, preventing stock market crashes or capital flight caused by sharp devaluations due to inflation differences [18]. Simultaneously, through independent monetary policies such as quantitative easing (QE), they lock the released liquidity into financial assets rather than the consumer goods market, thus achieving a special state of "high money supply, low inflation, and a strong exchange rate," directly severing the traditional transmission chain between inflation and exchange rates [17, 18]. Furthermore, leveraging their pricing power over high-value-added products and the safe-haven properties of their currencies, high income countries can attract capital inflows and push up their exchange rates during crises [15]. This proactive "manipulation" and

deviation from market rules is the core reason why the regression data of weak purchasing power parity theory in high-income countries failed between 2004 and 2019.

However, low income countries cannot manipulate the weak purchasing power parity theory due to the limited foreign exchange reserves, making it difficult to stabilize exchange rates through market intervention [16, 19]; their high dependence on imports makes them highly vulnerable to imported inflation, with rising international commodity prices directly pushing up domestic prices; and their singular economic structure, relying mainly on the export of tradable goods such as raw materials, leaves them lacking product pricing power and forced to follow the global price system [20]. These factors lead low-income countries to passively follow purchasing power parity theory predictions, resulting in a close correlation between exchange rates and inflation, with data showing a high correlation [19]. This reflects their weak position in the global economy and their lack of policy autonomy.

7. Conclusion

In conclusion, our analysis shows that the average annual exchange rate change and the average inflation difference have a positive linear relationship across all three time periods we studied. The relationship was strongest in the period of 1987-2003. The results align perfectly with the weak form of the purchasing power parity theory. This confirms that the weak purchasing power parity theory holds well in the long run.

Additionally, as national income levels rise, the explanatory power of the weak purchasing power parity theory declines significantly. Purchasing power parity is most applicable to low-income countries and least applicable to high-income countries. Thus, when analyzing exchange rates in different countries, their income levels and economic structures must be considered; the weak purchasing power parity theory cannot be simply applied. Therefore, our results indicate that the strength of this relationship is influenced by the prevailing international economic conditions and specific national policies, such as the fixed exchange rate, managed floats and monetary policy in the Eurozone.

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Appendix

- [1] The National Accounts data of PWT 10.0, as available on www.ggdcc.net/pwt, the document "National Accounts in PWT8.0"
The Penn World Table (PWT) is a set of national-accounts data developed and maintained by scholars at the University of California, Davis and the Groningen Growth Development Centre of the University of Groningen to measure real GDP across countries and over time.
- [2] World Bank Country and Lending Group (FY2026), <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>
The World Bank Country and Lending Group is a system that categorizes nations based on GNI per capita (economic standing) and access to financing.
- [3] Afghanistan, Burundi, Burkina Faso, Central African Republic, The Gambia, Guinea-Bissau, Madagascar, Mali, Mozambique, Malawi, Niger, North Korea, Rwanda, Sudan, Sierra Leone, Somalia, Chad, Togo.
- [4] Angola, Benin, Bangladesh, Bhutan, Ivory Coast, Cameroon, Republic of the Congo, Comoros, Djibouti, Egypt, Guinea, India, Jordan, Kenya, Cambodia, Kiribati, Lebanon, Sri Lanka, Lesotho, Morocco, Myanmar, Mauritania, Namibia, Nigeria, Nepal, Pakistan, Philippines, Papua New Guinea, Senegal, Solomon Islands, São Tomé and Príncipe, Eswatini, Tunisia, Tanzania, Vanuatu, Zambia.
- [5] Algeria, Belize, Botswana, China, Colombia, Cape Verde, Cuba, Dominica, Fiji, Gabon, Equatorial Guinea, Grenada, Indonesia, Iran, Iraq, Jamaica, Libya, Saint Lucia, Maldives, Mauritius, Malaysia, Thailand, Tonga, Tuvalu, Saint Vincent and the Grenadines, Samoa, South Africa.
- [6] Andorra, United Arab Emirates, Antigua and Barbuda, Australia, Austria, Belgium, Bulgaria, Bahrain, Barbados, Brunei, Canada, Switzerland, Cayman Islands, Cyprus, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Greenland, Guyana, Hong Kong, Hungary, Ireland, Italy, Japan, Saint Kitts and Nevis, South Korea, Kuwait, Liechtenstein, Luxembourg, Macau, Monaco, Malta, New Caledonia, Netherlands, Norway, Nauru, New Zealand, Oman, Poland, Portugal, French Polynesia, Qatar, Romania, Saudi Arabia, Singapore, San Marino, Sweden, Seychelles, Trinidad and Tobago, Taiwan
- [7] Afghanistan, Burundi, Burkina Faso, Central African Republic, Eritrea, The Gambia, Guinea-Bissau, Madagascar, Mali, Mozambique, Malawi, Niger, North Korea, Rwanda, Sudan, Sierra Leone, Somalia, Syria, Chad, Togo, Uganda, Yemen.
- [8] Benin, Bangladesh, Bolivia, Bhutan, Ivory Coast, Cameroon, Republic of the Congo, Comoros, Egypt, Ghana, Guinea, Honduras, Haiti, India, Jordan, Kenya, Cambodia, Kiribati, Laos, Lebanon, Sri Lanka, Lesotho, Morocco, Myanmar, Mauritania, Namibia, Nigeria, Nepal, Pakistan, Philippines, Papua New Guinea, Senegal, Solomon Islands, São Tomé and Príncipe, Eswatini, Tunisia, Tanzania, Vietnam, Vanuatu, Zambia

- [9] Albania, Argentina, Armenia, Azerbaijan, Bosnia and Herzegovina, Belarus, Brazil, Botswana, China, Colombia, Cape Verde, Cuba, Dominican Republic, Algeria, Fiji, Gabon, Georgia, Equatorial Guinea, Guatemala, Indonesia, Iran, Iraq, Jamaica, Kazakhstan, Libya, Moldova, Maldives, Mexico, North Macedonia, Montenegro, Mongolia, Mauritius, Malaysia, Peru, Paraguay, Suriname, Thailand, Turkmenistan, Tonga, Turkey, Tuvalu, Ukraine, Samoa, South Africa.
- [10] Andorra, Australia, Austria, Belgium, Brunei, Canada, Switzerland, Chile, Costa Rica, Cyprus, Czech Republic, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Greenland, Hong Kong, Hungary, Ireland, Iceland, Israel, Italy, Japan, South Korea, Kuwait, Liechtenstein, Luxembourg, Macau, Monaco, Malta, New Caledonia, Netherlands, Norway, Nauru, New Zealand, Portugal, French Polynesia, Singapore, San Marino, Slovakia, Sweden, Seychelles, Trinidad and Tobago, Taiwan
- [11] Afghanistan, Burundi, Burkina Faso, Central African Republic, Democratic Republic of the Congo, Eritrea, The Gambia, Guinea-Bissau, Madagascar, Mali, Mozambique, Malawi, Niger, North Korea, Rwanda, Sierra Leone, Somalia, Syria, Chad, Togo, Uganda, Yemen.
- [12] Benin, Bangladesh, Bolivia, Bhutan, Ivory Coast, Cameroon, Republic of the Congo, Comoros, Egypt, Ghana, Guinea, Honduras, Haiti, India, Kenya, Kyrgyzstan, Cambodia, Kiribati, Laos, Sri Lanka, Lesotho, Morocco, Myanmar, Mauritania, Namibia, Nigeria, Nicaragua, Nepal, Pakistan, Philippines, Papua New Guinea, Senegal, Solomon Islands, São Tomé and Príncipe, Eswatini, Tajikistan, Tunisia, Tanzania, Vietnam, Vanuatu, Zambia.
- [13] Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Brazil, Botswana, China, Colombia, Cape Verde, Dominican Republic, Algeria, Fiji, Gabon, Georgia, Equatorial Guinea, Guatemala, Indonesia, Iraq, Jamaica, Kazakhstan, Libya, Moldova, Mexico, North Macedonia, Montenegro, Mongolia, Mauritius, Malaysia, Peru, Paraguay, Serbia, Suriname, Thailand, Turkmenistan, Tonga, Turkey, Tuvalu, Samoa, South Africa
- [14] Andorra, Austria, Belgium, Bulgaria, Canada, Chile, Cayman Islands, Cyprus, Germany, Denmark, Spain, Estonia, Finland, France, Greece, Greenland, Hong Kong, Croatia, Ireland, Italy, South Korea, Kuwait, Lithuania, Luxembourg, Macau, Monaco, Malta, New Caledonia, Netherlands, Poland, Portugal, French Polynesia, San Marino, Slovenia