Efficient Exchange Rate Determination: A Modified Purchasing Power Parity Model (Mppp)

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DOI: https://doi.org/10.47772/IJRISS.2026.101000717

Received: 22 August 2026; Accepted: 24 October 2026; Published: 17 November 2026

ABSTRACT

Over time, the exchange rate of developing nations, such as Nigeria, has remained a varying issue of conceptual value versus real value. The model commonly applied by developing nations such as Nigeria is the Market Value Model (MVM), which is based on the forces of demand and supply of foreign currency, especially the United States dollar. However, the Market Value System is not without its enduring issues, particularly its denomination in a single currency. It is rather a fait accompli model and is non-explanatory in nature regarding the interaction of other forces of value beyond a basket of fiat money (paper money). The denomination of the MVM is historical in nature rather than an estimation based on the accurate measurement of a basket of goods. It is a product of human and personal influence rather than the interaction of basic value and has, over time, become detached from the original basis of value estimation.

The Purchasing Power Parity (PPP) model, on the other hand, is based on a basket of goods denominated in their monetary values and represents a total and more reliable means of currency valuation. The method adopted in this research is the Modified Purchasing Power Parity Model (MPPP), developed for this purpose using the weighted average model developed by the study. The results show that the Nigerian exchange rate is rather poor and unrealistic. They also reveal that the exchange rate is not realistic and is value-expensive. The naira has been grossly undervalued under the current exchange-rate regime. It does not provide a true expression of the real growth stage of the Nigerian economy. The current exchange-rate system is retrogressive and dull in its predictive capacity, while the MPPP produces the best estimate and the true value of the Nigerian currency. The MPPP exchange rate conforms with the Efficiency Frontier assumption.

The study recommends a change from the MVM to the MPPP model. It also recommends the rebasing of the naira using the MPPP model. Furthermore, the study recommends the adoption of the MPPP for Nigeria's exchange-rate determination to enhance the inflow of foreign investment and promote the growth of the real sector of the economy. The study also recommends the Efficiency Frontier Model for efficient exchange-rate determination.

Keywords: Purchasing Power Parity Theory(PPP), Efficiency Frontier, Exchange Rate, Commodity Price, Moving Average.

INTRODUCTION

The need to maintain a strong, stable and realistic exchange rate remains an important concern to every nation and the international economic system. Exchange rates are fundamental to international trade because they provide the basis upon which the currencies, goods and services of different countries are valued and exchanged. No modern economy can operate permanently in autarky; hence, international trade and financial transactions require an acceptable mechanism for establishing the relative values of national currencies. Consequently, the determination of the value of a basket of goods and the rate at which such value can be exchanged across countries remains pivotal to international trade and exchange-rate management.

At the early stage of international trade, transactions were substantially conducted through barter. The barter system was, however, characterised by several rudimentary problems, particularly the absence of a common measure of value, the problem of double coincidence of wants and difficulties associated with the settlement of transactions. These limitations contributed to the development of commodity money and subsequently monetary systems based on precious metals, particularly gold.

The classical Gold Standard became an important international monetary arrangement during the late nineteenth and early twentieth centuries. Under the system, national currencies were convertible into gold at predetermined rates, thereby providing a relatively stable mechanism for international payments and exchange-rate determination. The classical Gold Standard operated principally from the 1870s until the outbreak of the First World War. The First World War disrupted gold convertibility, and subsequent attempts to restore a modified gold standard during the interwar period encountered considerable difficulties. The economic and political pressures associated with the Great Depression eventually contributed to its collapse. (IMF)

The instability of the interwar international monetary system and the economic disruptions associated with the Second World War subsequently created the need for a new international monetary arrangement. Consequently, representatives of allied countries met at Bretton Woods in 1944 and established a new international monetary system. The Bretton Woods arrangement created a fixed but adjustable exchange-rate system under which the US dollar was linked to gold at US$35 per ounce, while other participating currencies maintained fixed parities against the US dollar. The arrangement also led to the establishment of two major international financial institutions: the International Monetary Fund (IMF) and the International Bank for Reconstruction and Development, which later became a major component of the World Bank Group. (IMF eLibrary)

The Bretton Woods arrangement therefore placed the US dollar at the centre of the international monetary system. However, increasing pressure on the system eventually resulted in the suspension of the convertibility of the US dollar into gold in 1971. This development effectively marked the collapse of the original Bretton Woods fixed exchange-rate arrangement and contributed to the emergence of the contemporary international monetary system, characterised by different combinations of fixed, managed and floating exchange-rate regimes. (IMF eLibrary)

Underlying the development of these exchange-rate systems has been a persistent question: what constitutes the appropriate or realistic value of one national currency relative to another? Different theoretical approaches have attempted to provide answers to this question. One of the most prominent is the Purchasing Power Parity (PPP) theory. Unlike exchange-rate arrangements based primarily on gold or prevailing foreign-exchange market prices, PPP relates the value of currencies to the relative prices of comparable baskets of goods and services across countries. PPPs essentially represent currency-conversion rates that equalise the purchasing power of currencies by eliminating differences in national price levels. (OECD)

The theoretical foundation of PPP predates the Bretton Woods system and was particularly developed and popularised by Gustav Cassel following the First World War. The fundamental proposition is that the exchange rate between two currencies should reflect their relative purchasing powers. Thus, if comparable baskets of goods and services have different monetary prices in two countries, the exchange rate should, in principle, adjust to reflect the difference in their purchasing powers.

Other approaches to exchange-rate determination have also been developed. These include Interest Rate Parity (IRP), which links exchange-rate movements to interest-rate differentials; balance-of-trade approaches, which emphasise the relationship between exports and imports; balance-of-payments approaches, which consider a broader range of international transactions; and asset-market approaches, which emphasise financial assets, expectations and international capital movements. These models represent different attempts to explain how exchange rates are determined and why currencies appreciate or depreciate relative to one another.

Nevertheless, the problem of determining an appropriate and realistic exchange rate remains relevant, particularly in developing economies where foreign-exchange markets may be relatively shallow and susceptible to supply constraints, external shocks, expectations, policy interventions and structural imbalances. Nigeria

provides an important example. In June 2023, the Central Bank of Nigeria unified its foreign-exchange windows and moved towards a willing-buyer, willing-seller framework intended to strengthen market-based price discovery. Further reforms undertaken in 2024 sought to improve the functioning of the official foreign-exchange market. The World Bank subsequently described the resulting system as increasingly market-reflective, while the IMF similarly recognised Nigeria's transition towards a market-determined exchange rate. (Open Knowledge)

Despite these reforms, the question of whether a market-determined exchange rate necessarily represents the underlying purchasing-power or commodity-value relationship between currencies remains important. Market exchange rates are principally outcomes of the demand for and supply of foreign currencies. Such demand and supply can themselves be influenced by international capital flows, foreign reserves, monetary policy, expectations, speculative activities, import requirements, export receipts and other financial-market conditions. Consequently, a market exchange rate may differ considerably from an exchange rate implied by relative commodity prices and purchasing power.

This distinction is particularly relevant to Nigeria because the naira has experienced substantial exchange-rate adjustments and periods of misalignment. Empirical evidence from Nigeria also demonstrates that the validity of PPP depends considerably on the particular formulation employed. Nakorji et al. (2021), for example, examined the naira against the US dollar, British pound and Chinese yuan and found limited support for absolute PPP but stronger evidence supporting relative PPP in explaining exchange-rate misalignment in Nigeria. (CBN Digital Commons)

It is against this background that this study proposes a Modified Purchasing Power Parity Model (MPPP) as an alternative framework for estimating the exchange rate. The proposed model modifies the conventional price-to-price PPP approach through the application of the weighted-average methodology developed in this study. The objective is to generate an exchange rate that reflects the relative values of selected baskets of goods more comprehensively and to determine whether such an exchange rate provides a more realistic estimate of the value of the Nigerian naira.

The study further introduces the concept of an Efficient Exchange Rate (EER) within an efficiency-frontier framework. In this context, the MPPP is expected to provide an alternative basis for examining whether the prevailing market exchange rate appropriately represents the underlying purchasing power of the naira. The study therefore adopts the Modified Purchasing Power Parity theory to estimate and evaluate a potentially more realistic and responsive exchange rate for Nigeria.

Statement Of the Problem

Exchange-rate determination remains one of the major challenges confronting developing economies, particularly economies such as Nigeria that depend considerably on foreign exchange for imports, international financial transactions, external debt servicing and other cross-border economic activities. The fundamental problem is not simply the existence of an exchange rate but whether the prevailing rate provides a realistic representation of the underlying economic and purchasing-power value of the domestic currency.

Nigeria's exchange-rate system has undergone several reforms. More recently, the authorities moved towards the unification of foreign-exchange windows and a willing-buyer, willing-seller market framework. The objective has been to strengthen price discovery and allow market forces to play a greater role in exchange-rate determination. The IMF has recognised these reforms as strengthening price discovery and supporting the transition towards a market-determined exchange rate. (IMF) The World Bank similarly reported that the reforms initiated in June 2023 and strengthened in 2024 produced a more market-reflective official foreign-exchange market. (Open Knowledge)

However, a market-reflective exchange rate is not necessarily synonymous with a purchasing-power-based equilibrium exchange rate. The prevailing Market Value Model (MVM), as conceptualised in this study, essentially depends on the interaction of demand and supply in the foreign-exchange market. The difficulty is

that demand and supply for foreign currency may be influenced by factors beyond the underlying real value of domestically and internationally traded goods. Foreign-exchange scarcity, expectations, capital movements, speculative activities, monetary-policy decisions, reserve availability and external shocks can influence the observed market rate. This raises an important question as to whether the resulting exchange rate accurately represents the real economic value and purchasing power of the naira.

The problem becomes more significant when the US dollar serves as the principal reference currency for many international transactions. Although the dollar's central international role has historical foundations in the Bretton Woods system, contemporary countries are permitted to adopt different exchange-rate arrangements, including floating rates, pegs to another currency or baskets of currencies. (IMF eLibrary) Therefore, the dominance of the dollar in international transactions does not by itself establish that a bilateral market exchange rate represents the complete underlying economic value of another country's currency.

Furthermore, the use of GDP size alone cannot establish that one country's currency should exchange at a stronger nominal rate than another country's currency. Nominal currency units are affected by monetary history, price levels, redenomination and other institutional factors. The more relevant issue for this study is whether the exchange rate reflects relative purchasing power and the underlying prices of comparable baskets of goods. This provides a stronger conceptual basis for evaluating currency value than comparing nominal exchange rates solely on the basis of GDP.

Existing PPP approaches also present an unresolved problem. Conventional absolute PPP assumes a relatively direct correspondence between price levels and exchange rates, whereas empirical evidence frequently shows persistent deviations from this relationship. In the Nigerian context, Nakorji et al. (2021) found that absolute PPP performed poorly, although relative PPP received greater empirical support. (CBN Digital Commons) This suggests that the theoretical relevance of purchasing power may remain valid while the conventional method through which PPP is measured requires further refinement.

Consequently, there is a methodological and empirical problem concerning how the relative purchasing power embedded in commodity prices can be incorporated into exchange-rate determination in a manner that accounts for the relative importance of the commodities constituting the selected basket. A simple price-to-price comparison may inadequately represent differences in commodity importance, consumption and value. This constitutes the principal gap addressed by the present study.

The study therefore develops a Modified Purchasing Power Parity Model (MPPP) using a weighted-average approach to the prices of the selected basket of goods. Rather than accepting the prevailing market exchange rate as the only representation of currency value, the study estimates an alternative exchange rate based on the underlying purchasing-power relationship between the countries being examined. It subsequently compares the MPPP-generated exchange rate with the prevailing market exchange rate to determine the extent of convergence, divergence, overvaluation or undervaluation.

The central problem addressed by the study is therefore whether the prevailing market-determined exchange rate of the Nigerian naira adequately reflects its underlying purchasing-power value and whether the proposed Modified Purchasing Power Parity Model can provide a more realistic and efficient estimate of the naira's exchange rate. In addressing this problem, the study further examines whether the MPPP-generated exchange rate satisfies the proposed Efficiency Frontier condition and can therefore provide an alternative framework for determining an Efficient Exchange Rate (EER) for Nigeria.

Objectives of the Study

The main objective of this study is to evaluate the **Modified Purchasing Power Parity (MPPP) Model** as a framework for exchange-rate valuation and to assess its performance relative to conventional Purchasing Power Parity (PPP).

The specific objectives are to:

1. determine whether there is a significant difference between the MPPP-implied exchange rate and the observed Naira/US Dollar exchange rate;

2. examine the relationship between the MPPP-implied exchange rate and the observed Naira/US Dollar exchange rate; and

3. determine whether the MPPP provides statistically superior exchange-rate valuation accuracy compared with conventional Purchasing Power Parity (PPP).

Research Questions

In line with the objectives of the study, the following research questions are formulated:

1. Is there a significant difference between the MPPP-implied exchange rate and the observed Naira/US Dollar exchange rate?

2. Is there a significant relationship between the MPPP-implied exchange rate and the observed Naira/US Dollar exchange rate?

3. Does the MPPP provide statistically superior exchange-rate valuation accuracy compared with conventional Purchasing Power Parity (PPP)?

Research Hypotheses

Based on the above objectives, the following hypotheses are formulated and tested:

Hypothesis 1

There is no significant difference between the MPPP-implied exchange rate and the observed Naira/US Dollar exchange rate.

Hypothesis 2

There is no significant relationship between the MPPP-implied exchange rate and the observed Naira/US Dollar exchange rate.

Hypothesis3

The MPPP does not provide statistically superior valuation accuracy to conventional PPP

CONCEPTUAL REVIEW

Relative Country Study of PPP

Hussein (2015) studied the long-run movement between the Canadian dollar and the US dollar exchange rates using a two-country approach. The study employed monthly data for the period 1995–2008. The results suggested that absolute purchasing power parity (PPP) did not hold, as no long-run relationship was found between the actual exchange rate and the PPP-generated exchange rate. In other words, the actual exchange rate and the PPP rate did not cointegrate. The study also observed that output prices adjust relatively slowly, providing evidence against PPP in the short run. However, the time frame covered by the study may have been relatively short for capturing the very long-run adjustment generally associated with PPP. The study nevertheless concluded that relative price movements are important in explaining the actual exchange rate between the United States and Canada.

Absolute Purchasing Power Parity Theory

Lawrence (1978), in a study of Absolute Purchasing Power Parity (APPP), asserted that the equilibrium exchange rate is determined by the ratio of the domestic price level to the foreign price level. Relative PPP, on the other hand, states that the change in the equilibrium exchange rate between a current period (t) and a base period (0) is determined by changes in the relative price indices of the domestic and foreign countries. Thus, while absolute PPP compares price levels directly, relative PPP focuses on changes in price levels and the corresponding change in the exchange rate (Lawrence, 1978). Contemporary PPP methodology retains this basic price-comparison logic, although modern international comparisons use carefully specified baskets, expenditure weights and multilateral aggregation procedures (European Union & OECD, 2024; OECD, 2024).

Exchange Rate And Economic Growth

Li et al. (2021) studied the effect of COVID-19 on the exchange rates of selected countries using the Autoregressive Distributed Lag (ARDL) model. The results indicated that exchange rates were negatively affected by increases in COVID-19 cases. The study further noted that the effects of the pandemic occurred in both the short run and the long run, particularly in China and the United States. This evidence reinforces the view that exchange rates may deviate from levels implied by relative prices when economies are exposed to major common shocks.

The literature reviewed the reasons for floating exchange-rate movements across countries and noted that exchange-rate fluctuations may reflect the strength of an economy, inflation and interest-rate conditions, and international capital flows arising from exports and imports. In general, an economy with stronger export performance relative to imports may experience support for its currency, although the actual exchange-rate outcome also depends on capital flows, monetary policy, expectations and market conditions.

Agya et al. (2020) studied the determination of the equilibrium real exchange rate and the misalignment of the naira vis-à-vis the US dollar and British pound. The study reported episodes of both overvaluation and undervaluation and showed that productivity, interest-rate differentials and terms of trade were important in explaining movements in the naira. Related Nigerian evidence by Nakorji et al. (2021), using absolute and relative PPP specifications with allowance for structural breaks and nonlinearity, found little support for absolute PPP but stronger empirical support for relative PPP in explaining exchange-rate misalignment. More recent Nigerian studies continue to identify exchange-rate instability, inflation and other macroeconomic conditions as important for purchasing power and economic performance (Oriakpono & Dang, 2024; Onyejekwe et al., 2024).

THEORETICAL REVIEW

The Purchasing Power Parity Theory

Purchasing Power Parity (PPP) is a theory of exchange-rate determination which holds that, after conversion into a common currency, equivalent baskets of goods and services should have comparable prices across countries. In its modern statistical application, PPPs are currency-conversion rates that equalise purchasing power by eliminating differences in national price levels (OECD, 2024, 2026). The theory therefore links exchange rates to relative prices and is sometimes described as an inflation-based theory of exchange-rate determination (Rudiger, 1985).

The PPP proposition implies a long-run relationship between exchange rates and prices (Hussein, 2015; Chortareas & Kapitanios, 2013). It is rooted in the law of one price: in the absence of transport costs, trade barriers and other market frictions, identical tradable goods should sell for the same price when expressed in a common currency. If a price difference persists, arbitrage should encourage purchases in the cheaper market and sales in the more expensive market, thereby putting pressure on prices and/or the exchange rate until the gap narrows. David Ricardo is commonly associated with the early idea, while Gustav Cassel formalised and popularised the term purchasing power parity (Cassel, 1918; Rudiger, 1985).

The concept of PPP has two major applications. First, it provides a theoretical benchmark for exchange-rate determination. Second, PPP conversion factors are used to compare real income, output and standards of living across countries. From the exchange-rate perspective, when two trading countries experience different inflation rates, the currency of the relatively higher-inflation country is expected, other things being equal, to depreciate over time so that the relative purchasing power of the two currencies is restored (Robert & Lawrence, 2002).

When PPP is used to compare living standards, comparable baskets of goods and services are priced across countries and converted into a common purchasing-power unit. Modern PPP programmes extend beyond simple consumer baskets: price relatives are calculated at the product level, aggregated into product groups and then weighted by expenditure shares up to broader aggregates such as GDP (European Union & OECD, 2024; OECD, 2024). The OECD also emphasises that PPPs used for international volume comparisons should not automatically be interpreted as the market-clearing or equilibrium nominal exchange rate because market exchange rates are affected by financial flows, expectations, policy and other factors.

Recent evidence also shows why PPP should principally be treated as a long-run benchmark rather than an exact short-run rule. A comprehensive panel study covering 63 economies over 1994–2025 found that real exchange rates remained non-stationary at the overall panel level once common factors and structural breaks were allowed for, although PPP-type stationarity appeared for a limited subset of economies (2025 panel evidence). This supports the long-standing argument that adjustment toward PPP can be slow, nonlinear and sensitive to structural change.

The Asset Market Equilibrium Model

The asset market equilibrium model explains exchange-rate determination through the demand for and supply of assets denominated in different currencies. It broadens the analysis beyond traded consumer goods to include financial assets such as shares, bonds, debentures and other investment instruments. The approach assumes that investors compare expected returns, risks, interest rates and expected currency movements when allocating wealth between domestic and foreign assets. Consequently, exchange rates may respond rapidly to financial information and expectations even when goods prices adjust slowly. This helps to explain short-run departures from PPP, while PPP may still provide a longer-run price-based benchmark (Boundless, 2019).

Balance of Payments Equilibrium Model

The balance-of-payments model explains the exchange rate in relation to a country's external transactions. Persistent trade or current-account deficits may place pressure on foreign reserves and the domestic currency, while stronger export receipts and capital inflows may support the currency. Currency depreciation can improve the price competitiveness of exports but also makes imports more expensive. Therefore, external balance, capital movements and reserve conditions can influence the exchange rate alongside relative prices. In practice, equilibrium does not require exports and imports to be exactly equal because capital and financial-account transactions also form part of the balance of payments (Boundless, 2019).

De Ridder (1981), in a study of exchange-rate determination and the balance of payments, constructed a non-dynamic model linking the balance of payments to more fundamental determinants of the exchange rate. The study identified three broad influences: real factors, such as natural-resource exploitation and relative economic activity; nominal factors, such as relative prices of goods and services; and monetary-policy factors, such as interest-rate differentials, exchange-rate expectations and official intervention. The price-interaction component is particularly relevant to PPP and provides part of the theoretical foundation for the present study.

Samudram and Argy (1981) studied exchange-rate determination from the perspective of interest-rate parity. They used interest-rate differentials and exchange-rate expectations to explain movements in the effective exchange rate. The approach assumes that expected exchange-rate movements are influenced by relative prices, the current account and interest-rate differentials. More recent work continues to show that parity conditions may be nonlinear and may interact with monetary-policy behaviour, implying that PPP, interest-rate parity and

policy expectations should be viewed as complementary rather than mutually exclusive explanations of exchange-rate movements (Anderl & Caporale, 2022).

EMPIRICAL REVIEW

The essence of this study is to examine the relationship between exchange rates and Purchasing Power Parity theory. Earlier studies approached exchange-rate determination from several perspectives, including balance-of-payments conditions, real interest-rate differentials and relative prices (Artus, 1976; Frankel, 1979; De Ridder, 1981; Samudram & Argy, 1981; Rudiger, 1985). The PPP approach differs by emphasising the relative price of comparable goods and services across trading economies and the tendency of exchange rates to adjust to differences in purchasing power.

Empirical evidence on PPP is mixed. Hussein (2015) did not find support for absolute PPP in the Canada–United States case over the period examined. Chortareas and Kapitanios (2013) similarly illustrate the importance of econometric specification when testing PPP. In Nigeria, Nakorji et al. (2021) applied absolute and relative PPP approaches to the naira against the US dollar, British pound and Chinese yuan using monthly data from 2008 to 2018. Their fractional cointegration framework incorporated smooth structural breaks and nonlinearity. The results rejected the practical validity of absolute PPP but provided support for relative PPP and showed substantial periods of exchange-rate misalignment.

More recent studies extend the relevance of PPP to Nigeria's broader macroeconomic conditions. Oriakpono and Dang (2024), using Nigerian data for 2009–2022, reported significant relationships among exchange rates, inflation, interest rates, trade openness, public finance variables, PPP and per-capita income. Onyejekwe, Ifebi and Ibekillo (2024) incorporated PPP, nominal and real exchange rates, inflation and trade openness in analysing exchange-rate volatility and economic growth in Nigeria. Sadibo and Adigun (2024) also used PPP in examining currency devaluation and capital-market performance, reporting a significant long-run relationship among the variables considered. These studies reinforce the continued empirical relevance of purchasing power and relative-price conditions in the analysis of Nigeria's exchange-rate behaviour.

At the regional level, recent evidence from selected ECOWAS economies indicates that exchange-rate pass-through to inflation and imports may be asymmetric, suggesting that relative prices and exchange rates do not always adjust proportionately or immediately. Such findings are consistent with the view that transaction costs, policy interventions, import dependence, market segmentation and structural changes can delay or distort PPP adjustment.

International evidence also remains divided. A 2025 study of 63 economies using monthly real effective exchange-rate data from 1994 to 2025 and panel procedures that accommodate common factors and structural breaks found that the joint evidence did not support stationary real exchange rates for the panel as a whole, although stationarity was found for a small number of individual economies. Thus, contemporary evidence does not establish PPP as an exact universal relationship; rather, it supports treating PPP as a long-run benchmark whose empirical validity depends on the country, sample period, price measure, structural breaks and econometric technique.

The approaches to exchange-rate determination in the literature are therefore founded on relative prices and inflation, interest-rate differentials, balance-of-payments conditions, asset-market considerations and expectations. Each approach has limitations when applied in isolation. Interest rates are strongly influenced by monetary-policy decisions; balance-of-payments equilibrium is dynamic and may coexist with persistent trade imbalances; and PPP can be weakened by tariffs, transport costs, non-tradable goods, market segmentation, administered prices and other trade barriers. These limitations explain why absolute PPP often performs poorly empirically, while relative PPP tends to receive comparatively stronger support, especially over longer horizons.

The present study retains PPP as its principal theoretical framework because it directly connects exchange-rate movements with changes in the prices of goods and, therefore, with the purchasing power and cost-of-living conditions of the countries being compared. Prices incorporate inflationary pressures generated by demand,

supply and policy conditions. Nevertheless, the study recognises that observed market exchange rates may deviate from PPP-implied rates because of monetary policy, financial flows, expectations, structural breaks and market imperfections.

The study will also attempt to construct the relative exchange rate between the two countries using a Moving Average (MA) method, with the exchange rate in the base period (0) serving as the basis for the exchange rate in period (t). This follows the logic of the Lawrence (1978) relative exchange-rate model under the PPP assumption, while allowing the empirical procedure to smooth short-term fluctuations that could obscure the underlying relative-price relationship.

The study will further adjust for the inflationary tendency inherent in the prices of the basket of goods selected for analysis. The weakness associated with relying on simple unweighted prices in conventional PPP calculations will be addressed through the use of a Weighted Average Price (WAP) of the selected goods. This is conceptually consistent with contemporary PPP practice, in which price relatives are aggregated and expenditure weights are used at higher levels of aggregation (European Union & OECD, 2024; OECD, 2024). The objective is to obtain a price measure that more adequately reflects the relative importance of the selected goods.

The equilibrium exchange rate will also be determined using the logarithm of the weighted average price of the selected goods (log W_1P_1) and the demand for the goods in the foreign country. This specification preserves the original analytical direction of the study while providing a clearer basis for examining whether a price- and demand-adjusted PPP measure can explain the observed exchange rate more effectively than a simple PPP formulation.

Method Of Study

The attempt in this study is to evaluate the exchange rate of a nation. in this study the approach is to estimate the exchange rate using the modify purchasing power parity theory (MPPP) the modify purchasing power parity theory is the remodelling done by this study. The attempt is to secure the efficient purchasing power parity theory (EPPP) exchange rate that will be the best for the nation.

The method adopted in this study is to secure the weighted average price of both the domestic and the foreign nation product price involve the Party theory. The average price is also deflated to secure the real price for the two nations. The two nations in focus in this study is Nigeria and USA, the choice of Nigeria to USA is to measure the Naira to dollar rate(N/$). the products selected for this study as our sample products is the petroleum products exported mostly from Nigeria to USA. The study adopted a three-products price-deflated weighted average over the selected period of time(years) for the study. The MPPP was therefore applied, the robustness test was also done to ensure a realistic result. The study also developed both the graphical and the regression model evaluation model for comprehensive and realistic overview determination method.

1. Model Specification

The revised empirical design uses 36 quarterly observations from 2017Q1 to 2025Q4. The MPPP is treated as a fundamental purchasing-power valuation benchmark rather than a short-run market-rate forecasting equation. The baseline basket comprises five household goods—rice, eggs, beef, bread and tomato—with equal weights of 0.20 each. Where Nigerian commodity-price observations were unavailable, the underlying dataset uses explicitly disclosed model-imputed values; these simulated observations must not be described as official NBS data.

Component	Formula	Interpretation
Real commodity price	$P^R_{i,,\ C,\ ,t} = P^N_{i,c,\ ,t} / (CPI_{\ c,\ ,t} / 100)$	Nominal commodity prices are deflated by the country-specific CPI.
Weighted real basket	$B^R_{,\ c,\ ,t} = \Sigma_i\ w_i P^R_{i,C,\ ,t}$, with $\Sigma_i w_i = 1$	For the baseline five-good basket, w_i = 0.20.

Corrected MPPP	$MPPP_t = B^R NG_{,t} / B^R US_{,t}$	This yields the purchasing-power-consistent naira value per U.S. dollar.
Absolute misalignment	$MIS_t = E^A_t - MPPP_t$	A positive value means the observed market rate is above the MPPP benchmark.
Percentage misalignment	$MIS\%_t = [(E^A_t - MPPP_t) / MPPP_t] \times 100$	This measures the percentage deviation of the observed market rate from MPPP.
Mean Squared Error	$MSE = (1/T) \Sigma_t (E^A_t - MPPP_t)^2$	Average squared valuation error.
Root Mean Squared Error	$RMSE = \sqrt{MSE}$	Valuation error expressed in ₦/US$.
Mean Absolute Error	$MAE = (1/T) \Sigma_t \lvert E^A_t - MPPP_t \rvert$	Average absolute valuation gap.
Mean Absolute Percentage Error	$MAPE = (100/T) \Sigma_t \lvert (E^A_t - MPPP_t)/E^A_t \rvert$	Scale-free average absolute error.
Validation regression	$E^A_t = \alpha + \beta MPPP_t + \varepsilon_t$	Tests the systematic association between the MPPP benchmark and the observed exchange rate.

Analysis And Interpretations

2. Empirical Results

Statistic	Result
Number of observations (T)	36
Mean corrected MPPP (₦/US$)	244.93
Mean actual exchange rate (₦/US$)	670.03
Mean percentage misalignment	208.61%
MSE	293,277.31
RMSE (₦/US$)	541.55
MAE (₦/US$)	425.10
MAPE	61.82%
Pearson correlation (r)	0.913
Paired t statistic	-7.496
Paired t-test p-value	<0.001
Regression intercept (α)	-12.451
Regression slope (β)	2.786
Regression R^2	0.833

3. Interpretation of Results

The corrected MPPP model was estimated with 36 quarterly observations covering 2017Q1–2025Q4. The mean MPPP-implied exchange rate was ₦244.93/US$, compared with a mean observed exchange rate of ₦670.03/US$. The average percentage misalignment was 208.61%, indicating that, on average, the observed market rate lay above the MPPP-implied purchasing-power benchmark.

The error statistics were MSE = 293,277.31, RMSE = ₦541.55/US$, MAE = ₦425.10/US$, and MAPE = 61.82%. These statistics quantify the magnitude of the difference between the observed exchange rate and the model-implied benchmark. They should be interpreted as valuation-gap measures and not, by themselves, as proof that the MPPP rate is the uniquely correct market-clearing exchange rate.

The Pearson correlation coefficient between the corrected MPPP and the observed exchange rate was r = 0.913, indicating a strong positive co-movement over the study period. The validation regression is estimated as: E^{A}_{t} = -12.451 + 2.786($MPPP_t$) + ε_t, with R^2 = 0.833. Thus, approximately 83.3% of the variation in the observed exchange rate is associated with variation in the MPPP benchmark in this bivariate validation regression.

The paired-sample test produced t(35) = -7.496, p < 0.001, showing a statistically significant difference between the mean MPPP-implied rate and the mean observed exchange rate. Accordingly, the null hypothesis of equality of the two mean rates is rejected. This result establishes a systematic valuation gap; it does not independently establish that the MPPP benchmark is the sole equilibrium exchange rate.

Where the observed ₦/US$ exchange rate exceeds the MPPP benchmark, the appropriate conclusion is that the naira is 'undervalued relative to the MPPP purchasing-power benchmark.' This qualified wording is preferable to an unconditional claim that the naira is undervalued.

4. Quarterly Estimation Table

Quarter	Corrected MPPP	Actual FX	Misalignment	Misalignment %	Absolute % Error
2017Q1	52.10	306.40	254.30	488.11%	83.00%
2017Q2	55.46	370.46	315.00	568.03%	85.03%
2017Q3	60.65	359.99	299.34	493.59%	83.15%
2017Q4	62.04	360.68	298.64	481.34%	82.80%
2018Q1	72.24	360.21	287.96	398.60%	79.94%
2018Q2	81.30	361.06	279.76	344.10%	77.48%
2018Q3	87.32	364.22	276.90	317.12%	76.03%
2018Q4	91.66	364.76	273.09	297.93%	74.87%
2019Q1	102.77	360.49	257.72	250.77%	71.49%
2019Q2	116.87	360.63	243.75	208.56%	67.59%
2019Q3	123.52	362.27	238.75	193.29%	65.90%
2019Q4	133.56	363.57	230.01	172.21%	63.26%
2020Q1	192.94	373.04	180.10	93.34%	48.28%
2020Q2	142.14	386.39	244.25	171.84%	63.21%
2020Q3	170.92	386.01	215.09	125.84%	55.72%
2020Q4	184.94	394.92	209.99	113.55%	53.17%
2021Q1	200.93	409.89	208.96	104.00%	50.98%
2021Q2	209.93	410.12	200.19	95.36%	48.81%
2021Q3	220.50	410.80	190.30	86.30%	46.32%
2021Q4	237.15	414.34	177.19	74.72%	42.76%
2022Q1	253.51	415.72	162.21	63.98%	39.02%
2022Q2	262.84	415.61	152.78	58.13%	36.76%
2022Q3	275.77	435.57	159.80	57.95%	36.69%
2022Q4	267.05	450.71	183.66	68.78%	40.75%
2023Q1	281.60	460.97	179.37	63.70%	38.91%
2023Q2	307.37	610.71	303.34	98.69%	49.67%
2023Q3	317.54	762.02	444.48	139.98%	58.33%
2023Q4	335.00	899.07	564.06	168.38%	62.74%
2024Q1	420.90	1,511.34	1,090.44	259.07%	72.15%
2024Q2	539.16	1,482.27	943.10	174.92%	63.63%
2024Q3	477.15	1,618.22	1,141.07	239.14%	70.51%
2024Q4	551.27	1,553.73	1,002.46	181.84%	64.52%
2025Q1	468.93	1,526.37	1,057.44	225.50%	69.28%
2025Q2	500.46	1,549.79	1,049.34	209.68%	67.71%

2025Q3	536.61	1,497.79	961.18	179.12%	64.17%
2025Q4	423.41	1,450.97	1,027.56	242.69%	70.82%

5. Data and Methodological Disclosure

The quarterly structure uses March, June, September and December observations to represent Q1–Q4 respectively, consistent with the commodity-price dataset. Nigeria CPI is expressed on the December 2024 = 100 reference scale, while the U.S. CPI is rebased internally to December 2024 = 100 before deflation. The exchange-rate benchmark uses the corresponding quarter-end-month average rate in the underlying dataset.

Missing Nigerian commodity-price observations in the underlying basket were simulated using the previously documented log-linear imputation procedure. For publication, the paper should explicitly distinguish observed and simulated values and report a robustness analysis using verified-only observations and, where feasible, an alternative expenditure-weighted basket.

6. Sources Used

The data sources for the study includes

A) Central Bank of Nigeria (CBN), Quarterly Statistical Bulletin: exchange-rate and Nigerian CPI series.
B) U.S. Bureau of Labor Statistics (BLS), Consumer Price Index for All Urban Consumers (CPI-U), used for U.S. inflation adjustment.
C) Underlying five-item commodity-price dataset developed for the revised MPPP model, including disclosed simulated Nigerian observations where source data were unavailable.

Robustness Analysis Of The Modified Purchasing Power Parity (Mppp) Mode

7 . Purpose of the Robustness Analysis

The robustness analysis was conducted to determine whether the improved performance of the revised MPPP model depends materially on two methodological choices: (i) the inclusion of simulated Nigerian commodity-price observations where directly observed values were unavailable, and (ii) the use of equal weights of 20% for the five commodities in the baseline basket. Three alternative specifications were therefore estimated and compared.

8 . Robustness Specifications

Specification	Sample	Weighting Rule	Purpose
Model A: Full Sample - Equal Weight	36 quarters, 2017Q1-2025Q4; verified + simulated Nigerian observations	Rice 20%; Eggs 20%; Beef 20%; Bread 20%; Tomato 20%	Tests the revised baseline model using the complete quarterly panel.
Model B: Verified-Only - Equal Weight	10 quarters with all five Nigerian commodity prices verified from NBS materials	Rice 20%; Eggs 20%; Beef 20%; Bread 20%; Tomato 20%	Tests whether the principal result remains when simulated Nigerian observations are completely excluded.
Model C: Full Sample - CPI Expenditure-Proxy Weight	36 quarters, 2017Q1-2025Q4; verified + simulated Nigerian observations	Weights derived from published CPI food-subgroup expenditure weights and normalized within the five-item basket	Tests whether the result depends on the arbitrary equal-weight assumption.

9. Alternative Expenditure-Proxy Weighting

For the alternative weighting test, the published Nigerian CPI food-subgroup expenditure weights were used as an external weighting benchmark. The detailed published subgroup weights are: Bread and Cereals = 216.656; Meat = 47.780; Milk, Cheese and Eggs = 12.776; and Vegetables = 54.355. Because both rice and bread represent the Bread and Cereals subgroup in the five-item MPPP basket, that subgroup weight was divided equally between rice and bread. The resulting five weights were then normalized to sum to one.

Commodity	Normalized Weight	Basis
Rice	0.3267 (32.67%)	Half of Bread and Cereals subgroup
Bread	0.3267 (32.67%)	Half of Bread and Cereals subgroup
Beef	0.1441 (14.41%)	Meat subgroup
Eggs	0.0385 (3.85%)	Milk, Cheese and Eggs subgroup
Tomato	0.1639 (16.39%)	Vegetables subgroup

Important qualification: these are used as CPI-expenditure-proxy weights for sensitivity analysis, not as current 2024 official item-level expenditure weights. They provide an externally grounded alternative to equal weighting and are therefore suitable as a robustness check rather than as the preferred final weighting scheme.

10 . Robustness Model and Evaluation Formulae

Measure	Formula
Weighted real basket	$B^R(c,t) = \Sigma_i w_i P^R(i,c,t)$, with $\Sigma_i w_i = 1$
Corrected MPPP	$MPPP_t = B^R(NG,t) / B^R(US,t)$
Absolute misalignment	$MIS_t = E^A_t - MPPP_t$
Percentage misalignment	$MIS\%_t = [(E^A_t - MPPP_t) / MPPP_t] \times 100$
MSE	$MSE = (1/T)\Sigma_t(E^A_t - MPPP_t)^2$
RMSE	$RMSE = \sqrt{MSE}$
MAE	$MAE = (1/T)\Sigma_t\|E^A_t - MPPP_t\|$
MAPE	$MAPE = (100/T)\Sigma_t\|(E^A_t - MPPP_t)/E^A_t\|$
Validation regression	$E^A_t = \alpha + \beta MPPP_t + \varepsilon_t$

11. Comparative Robustness Results

Statistic	Model A: Full Equal	Model B: Verified Only	Model C: Expenditure-Proxy
Observations	36	10	36
Mean MPPP (₦/US$)	243.62	412.23	247.77
Mean Actual FX (₦/US$)	670.03	1,187.57	670.03
Mean Misalignment	210.35%	179.39%	218.45%
MSE	293,810.80	719,942.69	280,448.70
RMSE (₦/US$)	542.04	848.49	529.57
MAE (₦/US$)	426.41	775.33	422.26
MAPE	62.17%	62.06%	62.55%
Pearson correlation, r	0.914	0.908	0.927
Paired t statistic	-7.538	-6.748	-7.816
Paired t-test p-value	<0.001	<0.001	<0.001
Regression slope, β	2.780	4.174	2.577
Regression intercept, α	-7.194	-533.024	31.571
Regression R^2	0.836	0.824	0.860

12. Interpretation of the Robustness Results

The principal finding of the revised MPPP model is robust to the exclusion of simulated Nigerian commodity-price observations. In the full equal-weight specification, the MPPP and the observed exchange rate are strongly positively correlated ($r = 0.914$) and the validation regression produces $R^2 = 0.836$. When all simulated Nigerian observations are removed, the verified-only sample still produces a very similar correlation of $r = 0.908$ and $R^2 = 0.824$. The persistence of the strong positive relationship in the verified-only sample indicates that the improved empirical relationship is not merely an artefact of the simulation procedure.

The paired-sample test remains statistically significant in every specification. Model A produces $t = -7.538$, Model B produces $t = -6.748$, and Model C produces $t = -7.816$, with $p < 0.001$ in all three cases. The evidence therefore consistently rejects equality between the MPPP-implied rate and the observed market exchange rate. This supports the existence of a systematic valuation gap between the market rate and the purchasing-power benchmark.

The alternative CPI-expenditure-proxy weighting also produces results that are very close to the equal-weight baseline. The correlation rises from 0.914 under equal weighting to 0.927 under the alternative weighting, while R^2 rises from 0.836 to 0.860. RMSE falls from ₦542.04/US$ to ₦529.57/US$ and MAE falls from ₦426.41/US$ to ₦422.26/US$. Accordingly, the main conclusion is not dependent on assigning an equal 20% weight to each commodity.

The verified-only sample records a higher RMSE and MAE than the full-sample specifications. This should not be interpreted as evidence that simulation improves the model mechanically. The verified-only sample contains only ten observations concentrated in 2023-2025, a period characterized by a substantially higher and more volatile naira-dollar exchange rate. Its error magnitudes are therefore not directly comparable with those of the 36-quarter sample without recognizing the different time composition.

13. Robustness Decision

Taken together, the robustness tests support the stability of the core empirical finding. First, the strong positive MPPP-market relationship survives when simulated Nigerian observations are excluded. Second, the relationship also survives, and marginally strengthens, when equal commodity weights are replaced by externally grounded CPI-expenditure-proxy weights. Third, the statistically significant difference between the MPPP benchmark and the observed exchange rate remains under all specifications. The revised model's principal conclusions are therefore not driven solely by either data simulation or the equal-weight assumption.

8. Publishable Robustness Statement for the Article

Robustness tests were conducted using three alternative empirical specifications: the full quarterly sample with equal commodity weights, a verified-only subsample excluding all simulated Nigerian commodity-price observations, and the full sample using CPI-expenditure-proxy weights. The results were qualitatively stable across the three specifications. The correlation between the MPPP-implied exchange rate and the observed market rate remained high, ranging from 0.908 to 0.927, while the validation-regression R^2 ranged from 0.824 to 0.860. The paired-sample difference remained statistically significant at $p < 0.001$ in all specifications. These results indicate that the empirical conclusions are robust to both the treatment of missing Nigerian commodity-price observations and the choice between equal and expenditure-proxy commodity weights.

14. Methodological Caution

The expenditure-proxy robustness specification should be presented strictly as a sensitivity test. The detailed subgroup weights used for this alternative specification come from published CPI subgroup expenditure weights, whereas Nigeria's CPI has subsequently been rebased with a newer weight reference period. If current item-level expenditure weights for the five exact commodities become available, the robustness exercise should be repeated with those weights. This would further strengthen the final published version.

Conventional Ppp Versus Modified Purchasing Power Parity (Mppp)

15. Objective of the Comparison

This analysis compares the conventional relative Purchasing Power Parity (PPP) benchmark with the study's Modified Purchasing Power Parity (MPPP) model using the same 36 quarterly observations and the same observed naira/US-dollar exchange-rate series. The purpose is to determine whether the proposed modification provides a closer empirical valuation benchmark than conventional PPP.

16. Conventional PPP Model

The conventional comparator is constructed as a relative PPP path anchored to Nigeria's 2017 World Bank private-consumption PPP conversion factor of ₦115.98 per international dollar. Thereafter, the benchmark is updated quarterly by the relative movement in Nigerian and U.S. consumer prices.

The model is:

$$PPP_t = PPP_0 \times [(CPI^{NG}_t / CPI^{NG}_0) / (CPI^{Us}_t / CPI^{Us}_0)]$$

where PPP_0 is the 2017 benchmark PPP, CPI^{NG} is Nigeria's consumer price index, and CPI^{Us} is the U.S. consumer price index. This CPI-relative updating rule is consistent with the standard extrapolation logic used for private-consumption PPP time series.

17 . MPPP Model

$$MPPP_t = B^{RNG}_t / B^{RUs}_t$$

B^{RNG}_t and B^{RUs}_t are the inflation-adjusted weighted basket prices for Nigeria and the United States. The MPPP therefore incorporates direct commodity-price information in addition to general inflation adjustment.

18 . Model Performance Criteria

$$MSE = (1/T)\ \Sigma(E_t - P_t)^2$$

$$RMSE = \sqrt{MSE}$$

$$MAE = (1/T)\ \Sigma|E_t - P_t|$$

$$MAPE = (100/T)\ \Sigma|(E_t - P_t)/E_t|$$

$$\text{Validation regression: } E_t = \alpha + \beta P_t + \varepsilon_t$$

19. Comparative Results

Statistic	Conventional PPP	MPPP	Preferred
Observations	36	36	Same sample
Mean model rate (₦/US$)	208.16	244.93	—
MSE	372,395.67	293,277.31	MPPP
RMSE (₦/US$)	610.24	541.55	MPPP
MAE (₦/US$)	461.87	425.10	MPPP
MAPE	63.37%	61.82%	MPPP
Correlation with actual FX	0.921	0.913	PPP
Validation R^2	0.848	0.833	PPP
Regression slope β	5.501	2.786	Diagnostic
Regression intercept α	-475.157	-12.451	Diagnostic

20. Incremental Performance of MPPP

Relative to conventional PPP, the MPPP changes RMSE by 11.26% and MAE by 7.96%. The MSE improvement is 21.25%. Positive percentages indicate lower error under MPPP.

Using squared-error loss, the paired loss-differential test gives t = 2.944, p = 0.0057. Using absolute-error loss, the corresponding test gives t = 2.659, p = 0.0117. These tests assess whether the quarter-by-quarter error difference between the two models is statistically distinguishable from zero.

21. Interpretation

The comparison gives mixed evidence across the performance criteria. The MPPP should therefore not be described as unconditionally superior to conventional PPP; the conclusion should identify precisely the criteria on which each model performs better.

22. Hypothesis for Model Superiority

H_{02}: The MPPP does not provide a statistically superior exchange-rate valuation performance to conventional PPP.

H_{12}: The MPPP provides statistically superior exchange-rate valuation performance to conventional PPP.

Decision based on the squared-error loss differential: Reject H_{02}. The mean loss differential is 79,118.36; t = 2.944, p = 0.0057.

23. Comparative Statement

A comparative performance test was conducted between conventional relative PPP and the proposed MPPP using 36 quarterly observations from 2017Q1 to 2025Q4. Conventional PPP was anchored to the 2017 private-consumption PPP benchmark and updated using relative Nigerian and U.S. CPI movements. The conventional model produced RMSE = ₦610.24/US$, MAE = ₦461.87/US$, MAPE = 63.37%, correlation r = 0.921, and validation R^2 = 0.848. The MPPP produced RMSE = ₦541.55/US$, MAE = ₦425.10/US$, MAPE = 61.82%, correlation r = 0.913, and validation R^2 = 0.833. The evidence is mixed and should be interpreted criterion by criterion rather than as unconditional superiority.

24. Methodological Qualification

The conventional PPP comparator used here is a CPI-extrapolated private-consumption PPP benchmark, not the nominal market exchange rate and not a direct quarterly ICP survey. Official ICP/World Bank PPP benchmarks are primarily annual/spatial price measures; quarterly values in this comparison are constructed by relative CPI extrapolation. This distinction should be stated explicitly in the article.

Final Consolidated Empirical Analysis And Decision Table

This section consolidates the corrected main MPPP estimation, the robustness tests, and the direct comparison between the Modified Purchasing Power Parity model and conventional Purchasing Power Parity. The objective is to provide one internally coherent decision framework that can be inserted into the empirical-results section of the article.

25. Final Corrected Model

The revised study uses 36 quarterly observations from 2017Q1 to 2025Q4. The MPPP is interpreted as a fundamental purchasing-power valuation benchmark rather than as a short-run forecasting equation.

Real commodity price: $P^R(i,c,t) = P^N(i,c,t) / (CPI(c,t) / 100)$

Weighted real basket: $B^R(c,t) = \Sigma_i w_i P^R(i,c,t)$, with $\Sigma_i w_i = 1$

Corrected MPPP: $MPPP_t = B^R(NG,t) / B^R(US,t)$

Absolute misalignment: $MIS_t = E^A_t - MPPP_t$

Percentage misalignment: $MIS\%_t = [(E^A_t - MPPP_t) / MPPP_t] \times 100$

Validation regression: $E^A_t = \alpha + \beta MPPP_t + \varepsilon_t$

26. Consolidated Main Results

Statistic	Final Result	Interpretation
Observations	36 quarters	Sample expanded substantially beyond the original six annual observations.
Mean MPPP benchmark	₦243.62/US$	Average purchasing-power benchmark under the full equal-weight specification.
Mean observed exchange rate	₦670.03/US$	Average market benchmark over the same quarterly sample.
Mean percentage misalignment	210.35%	Observed market rate is, on average, materially above the MPPP benchmark.
Pearson correlation	r = 0.914	Strong positive co-movement between MPPP and the observed exchange rate.
Validation regression R^2	0.836	About 83.6% of observed-rate variation is associated with MPPP in the bivariate validation model.
Paired t-test	t = -7.538; p < 0.001	Reject equality of the mean MPPP and observed exchange rates.
RMSE	₦542.04/US$	Average model error measured in exchange-rate units.
MAE	₦426.41/US$	Average absolute valuation gap.
MAPE	62.17%	Scale-free average absolute valuation error.

The main result should therefore be stated carefully: the observed naira/US-dollar exchange rate differs significantly from the MPPP-implied benchmark, while the two series nevertheless exhibit a strong positive relationship. The appropriate valuation conclusion is that the naira is undervalued relative to the MPPP purchasing-power benchmark, not that the MPPP is the uniquely correct market-clearing exchange rate.

28. Consolidated Robustness Results

Specification	Correlation (r)	R^2	Paired t / p-value	Robustness Decision
Full verified + simulated, equal weights	0.914	0.836	-7.538; p<0.001	Baseline result supported
Verified-only sample	0.908	0.824	-6.748; p<0.001	Result survives removal of simulated values
Full sample, CPI-expenditure-proxy weights	0.927	0.860	-7.816; p<0.001	Result survives alternative weighting

The robustness evidence shows that the strong MPPP-market relationship does not disappear when simulated Nigerian observations are excluded, and it does not depend on assigning equal 20% weights to each commodity. The expenditure-proxy specification marginally strengthens both correlation and R^2.

30. Conventional PPP versus MPPP

Criterion	Conventional PPP	MPPP	Comparative Decision
MSE	372,395.67	293,277.31	MPPP lower error
RMSE	₦610.24/US$	₦541.55/US$	MPPP lower by about 11.26%
MAE	₦461.87/US$	₦425.10/US$	MPPP lower by about 7.96%
MAPE	63.37%	61.82%	MPPP lower error
Correlation with actual FX	0.921	0.913	Conventional PPP marginally higher
Validation R^2	0.848	0.833	Conventional PPP marginally higher
Squared-error loss test	—	t = 2.944; p = 0.0057	MPPP error advantage statistically significant
Absolute-error loss test	—	t = 2.659; p = 0.0117	MPPP error advantage statistically significant

The comparison gives a nuanced but favourable conclusion for the proposed model. MPPP does not dominate conventional PPP on every statistical criterion: conventional PPP has a slightly higher correlation and R^2. However, MPPP produces significantly lower valuation errors on MSE, RMSE, MAE and MAPE, and the paired loss-differential tests show that the improvement in error performance is statistically significant.

31. Final Hypotheses and Decision Table

Hypothesis	Null Hypothesis	Test / Criterion	Statistic	p-value	Decision	Conclusion
H01	There is no significant difference between the MPPP-implied exchange rate and the observed Naira/US Dollar exchange rate.	Paired-sample t-test	t(35) = -7.538	<0.001	Reject H01	A statistically significant valuation gap exists between the MPPP benchmark and the observed market rate.
H02	There is no significant relationship between the MPPP-implied exchange rate and the observed Naira/US	Correlation / validation regression	r = 0.914; R^2 = 0.836	<0.001 (relationship statistically strong)	Reject H02	The corrected MPPP is strongly and positively related to the observed exchange rate.

	Dollar exchange rate.					
H03	The MPPP does not provide statistically superior valuation accuracy to conventional PPP.	Paired squared-error loss differential	t = 2.944	0.0057	Reject H03	MPPP provides significantly lower valuation error than conventional PPP, although conventional PPP has marginally higher r and R^2.

32. Robustness Decision Table

Robustness Concern	Evidence	Decision	Implication
Dependence on simulated Nigerian values	Verified-only sample: r=0.908; R^2=0.824; p<0.001	Concern not supported	The main relationship remains strong when all simulated Nigerian observations are excluded.
Dependence on equal 20% commodity weights	Expenditure-proxy sample: r=0.927; R^2=0.860; p<0.001	Concern not supported	The result survives and slightly strengthens under alternative externally grounded weights.
Dependence on one PPP formulation	MPPP has significantly lower error loss than conventional PPP: p=0.0057	Concern substantially addressed	The modification adds measurable valuation accuracy, although it does not dominate conventional PPP on every association statistic.

Final Empirical Conclusion

The final evidence supports the Modified Purchasing Power Parity model as a viable supplementary benchmark for assessing the fundamental purchasing-power value of the Nigerian naira against the U.S. dollar. The corrected MPPP is strongly associated with the observed exchange rate, the mean valuation gap is statistically significant, and the principal result remains stable when simulated observations are removed and when the basket-weighting scheme is altered.

The direct comparison with conventional PPP further shows that the proposed MPPP materially improves valuation accuracy as measured by MSE, RMSE, MAE and MAPE. The improvement in squared-error and absolute-error loss is statistically significant. However, conventional PPP retains a marginally higher correlation and validation R^2. Accordingly, the article should claim that MPPP provides superior valuation-error performance, not that it unconditionally dominates conventional PPP on every empirical criterion.

Overall, the empirical evidence indicates that the Modified Purchasing Power Parity Model provides a robust purchasing-power-based benchmark for evaluating the Naira/US Dollar exchange rate. The MPPP-implied

exchange rate differs significantly from the observed market rate, yet exhibits a strong positive relationship with it. Robustness tests confirm that this result is not driven solely by simulated Nigerian commodity-price observations or by the equal-weight assumption. In comparison with conventional PPP, the MPPP generates significantly lower valuation errors, supporting the proposition that the modification improves the empirical accuracy of the purchasing-power approach to exchange-rate valuation. The resulting misalignment should therefore be interpreted as evidence of undervaluation of the naira relative to the MPPP benchmark, rather than as proof of a uniquely correct market-clearing exchange rate.

CONCLUSION, RECOMMENDATIONS, CONTRIBUTION TO KNOWLEDGE AND SUGGESTIONS FOR FURTHER STUDIES

1. Conclusion

This study developed and empirically evaluated a Modified Purchasing Power Parity (MPPP) Model as an alternative framework for assessing the purchasing-power-consistent value of the Nigerian naira relative to the United States dollar. The study was motivated by the limitations of conventional PPP, particularly its dependence on broad price indices and its limited ability to reflect differences in the prices of specific goods that directly affect household purchasing power.

The analysis was expanded to 36 quarterly observations covering 2017Q1–2025Q4. The MPPP incorporated a diversified basket of goods, country-specific inflation adjustments, quarterly exchange-rate observations and explicit measures of exchange-rate misalignment. The model was evaluated using correlation analysis, a validation regression, paired-sample testing and error measures including MSE, RMSE, MAE and MAPE.

The empirical findings show a strong positive relationship between the MPPP-implied exchange rate and the observed naira/US-dollar exchange rate. In the principal specification, the correlation coefficient was approximately $r = 0.914$, while the validation regression produced $R^2 = 0.836$. The paired-sample test also established a statistically significant difference between the MPPP-implied and observed exchange rates ($p < 0.001$). This indicates the existence of a systematic valuation gap between the market exchange rate and the purchasing-power benchmark generated by the model.

Importantly, the robustness analysis demonstrates that the principal result is not simply an artefact of the simulation of missing Nigerian commodity prices. When the analysis was restricted to verified observations, the relationship remained strong, with $r = 0.908$ and $R^2 = 0.824$. Similarly, replacing the equal-weight basket with CPI-expenditure-proxy weights produced $r = 0.927$ and $R^2 = 0.860$. The findings are therefore reasonably robust to both missing-data treatment and alternative basket weighting.

The comparison with conventional PPP provides further support for the proposed modification. MPPP generated lower MSE, RMSE, MAE and MAPE than conventional PPP. Its RMSE was approximately 11.26% lower and its MAE approximately 7.96% lower. The difference in squared-error loss was statistically significant ($t = 2.944$, $p = 0.0057$), while the absolute-error comparison was also significant ($t = 2.659$, $p = 0.0117$). However, conventional PPP recorded a marginally higher correlation and validation R^2. Consequently, the evidence supports the conclusion that MPPP improves valuation-error performance over conventional PPP, rather than establishing that it dominates conventional PPP on every statistical criterion.

Overall, the study concludes that MPPP provides a useful supplementary framework for assessing the fundamental purchasing-power value of the naira. The persistent difference between the market exchange rate and the MPPP benchmark suggests that the naira was undervalued relative to the MPPP purchasing-power benchmark over substantial portions of the study period. This conclusion should not be interpreted as establishing the MPPP rate as the uniquely correct market-clearing exchange rate, since exchange rates are also influenced by monetary conditions, capital flows, expectations, external reserves, interest rates, risk and other macroeconomic factors.

2. Recommendations

1. Based on the findings, the study recommends that monetary and exchange-rate authorities should complement conventional exchange-rate indicators with commodity-based purchasing-power measures when assessing currency valuation. The MPPP may not replace market exchange rates or conventional PPP, but it can provide an additional benchmark for identifying persistent departures of the market exchange rate from domestic purchasing-power fundamentals.
2. Institutions responsible for price statistics should strengthen the collection and dissemination of high-frequency, internationally comparable commodity-price data. Consistent monthly or quarterly observations using identical product specifications and measurement units would significantly improve the empirical reliability of commodity-based PPP models and reduce dependence on simulated observations.
3. Policymakers should distinguish between short-run exchange-rate movements and long-run purchasing-power fundamentals. Temporary exchange-rate volatility caused by liquidity conditions, expectations or capital movements should not automatically be interpreted as a permanent change in the underlying purchasing power of the naira.
4. The Central Bank and other policy institutions may consider developing a broader purchasing-power valuation dashboard incorporating conventional PPP, real effective exchange-rate indicators and commodity-based measures of MPPP. Agreement or divergence among these indicators could provide additional information about exchange-rate pressures.
5. Future implementation of MPPP should preferably employ actual household-expenditure weights rather than relying exclusively on equal weights. The present robustness analysis shows that the conclusion survives alternative CPI-expenditure-proxy weighting, but more precise expenditure weights would further improve economic interpretation.
6. Because the study finds persistent divergence between the observed exchange rate and the purchasing-power benchmark, exchange-rate policy should be supported by measures that address the underlying sources of currency pressure—including domestic production capacity, productivity, export diversification and foreign-exchange supply—rather than relying solely on nominal exchange-rate intervention.

3. Contribution to Knowledge

1. The principal contribution of the study is the development and empirical evaluation of a Modified Purchasing Power Parity Model that incorporates directly comparable commodity prices into exchange-rate valuation while retaining the fundamental purchasing-power logic underlying conventional PPP.
2. A second contribution is methodological. Rather than relying exclusively on aggregate price indices, the study constructs a cross-country basket-based exchange-rate benchmark from the relative real prices of selected goods. This creates a transparent connection between observable commodity purchasing power and the implied currency valuation.
3. Third, the study demonstrates empirically that the modification provides lower valuation errors than the conventional PPP comparator. The statistically significant reduction in squared and absolute error provides quantitative evidence that incorporating commodity-level price information can add useful information to conventional purchasing-power valuation.
4. Fourth, the study contributes by distinguishing valuation accuracy from statistical association. Although MPPP records lower MSE, RMSE, MAE and MAPE, conventional PPP retains marginally higher correlation and R^2. This demonstrates that a model can track the direction of an exchange-rate series closely while still producing larger absolute valuation errors. This distinction is important for empirical exchange-rate research.
5. Fifth, the study provides a robustness framework for commodity-based PPP estimation by comparing verified-plus-simulated data, verified-only data and alternative basket weights. The stability of the main relationship across these specifications strengthens the empirical case for the proposed framework.
6. Finally, within the Nigerian context, the study provides an alternative way of examining the long-standing question of whether movements in the naira reflect changes in underlying domestic purchasing

power. The MPPP therefore contributes an additional empirical instrument for researchers and policymakers studying exchange-rate misalignment.

4. Suggestions for Further Studies

1. Further research should extend the MPPP model to a larger and more representative basket of goods and services. The present five-good basket provides an empirical foundation, but future studies could include transportation, housing, energy, clothing, healthcare, communication and other important household expenditure categories.
2. Subsequent studies should use fully observed monthly or quarterly commodity-price data wherever possible. This would eliminate the need for model-imputed observations and permit more rigorous evaluation of the model's high-frequency behavior.
3. Researchers should estimate MPPP using household expenditure survey weights, CPI item-level weights and alternative weighting systems and formally compare their performance. This would help determine the optimal weighting structure for the model.
4. The MPPP framework should be tested across several currencies and countries, particularly other African and emerging economies. A multi-country panel would establish whether the improvement observed for Nigeria represents a general feature of the model or is specific to the Nigerian exchange-rate environment.
5. Future studies should investigate the long-run and short-run dynamics between MPPP and the observed exchange rate using time-series techniques such as unit-root tests, cointegration analysis, error-correction models, ARDL models and, where appropriate, nonlinear adjustment models. Such analysis could determine whether market exchange rates eventually converge toward the MPPP benchmark.
6. Future research could compare MPPP with additional currency-valuation measures such as the real effective exchange rate, behavioural equilibrium exchange rate and fundamental equilibrium exchange rate, rather than limiting the comparison to conventional PPP.
7. Finally, future studies could examine whether deviations from MPPP have predictive information for subsequent exchange-rate movements. If unusually large MPPP misalignments systematically precede exchange-rate corrections, the model could potentially develop from a valuation benchmark into an early-warning indicator of currency adjustment.

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ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue X October 2026

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