International Journal of Multidisciplinary Research and Growth Evaluation
ISSN: 2582-7138
Received: 07-07-2021; Accepted: 23-07-2021
www.allmultidisciplinaryjournal.com
Volume 2; Issue 4; July-August 2021; Page No. 696-705

# Dynamic modeling of exchange rate correlates in Nigeria: Evidence from macroeconomic fundamentals and autoregressive distributed lag

**Ekpete Kingsley Simon [1], Nwaguru Wisdom Ezemndi [2], Agada Franklin A [3]**
[1] Department of Economics, Ignatius Ajuru University of Education, Port Harcourt, Nigeria
[2] Department of Banking and Finance, Imo State University, Owerri, Nigeria
[3] Department of Banking and Finance, Federal Polytechnic, Ekowe, Bayelsa State, Nigeria

Corresponding Email: **Ekpete Kingsley Simon**

**Abstract**
The study is aimed at modeling the dynamics of exchange rate correlates in Nigeria using evidence from macroeconomic fundamentals and Autoregressive Distributed Lag (ARDL). The study further applied the ADF unit root test as methodology to analyze the stationarity properties of the series from 1999 to 2018. The result holds that the selected macroeconomic fundamentals; balance of payment, inflation rate, economic openness, external reserves, interest rate and public debt are correlates of exchange rate in the short and long run. The study therefore recommends that to stabilize the naira to compete with other foreign currencies, the Nigerian economy should encourage export base diversification of the real sector by providing loans and machineries to aid farmers, infant industries and manufacturers in the real sector of the economy.

**Keywords:** Exchange Rate, Macroeconomic, Fundamentals, ARDL

## Introduction
Traditionally, the exchange rate plays a significant role in Nigeria's monetary policy because of its crucial impact on the Nigerian economy's trade relations with other nations. This over the years has led the monetary authorities on many occasions to engage in myriads of policy adjustments in the exchange rate management (fixed and flexible policies) with the aim of achieving broad macro-economic goals of stability in prices. The determination of exchange rate has not been easy as its appreciation and depreciation have influenced other economic variables at the macro level. Prior to the emergence of SAP (structural adjustment programme) in the 1980s which most of the economies of sub-Sahara Africa underwent; the policy of fixed currency rate was the order of the day. This as a prevailing policy resulted in a regime of overvaluation of the naira and other currencies. Based on these issues, it was resolved that the overvalued fixed exchange rate system would not yield the expected growth in Nigeria and even in other African nations. This reason and many more resulted in a paradigm shift from fixed to flexible exchange rate policy where the invisible hands would be given the opportunity to determine the equilibrium price of the naira (currency rate). With this development in policy redirection, it was hoped that problems of exchange rate would have been a thing of the past, but, a new set of problems such as reckless volatility and continuous fall of the naira coupled with increasing importation, has placed the Nigerian currency at the risk of exchanging more of the naira for the American dollar. For example, in 1986, #2 was equal to 1USD, in 1990, #8.03 was exchanged for 1USD. The dollar further skyrocketed from a steady state of #17.02 in 1992 to about #22 in 1998. The presence of the democratic regime appeared to have driven the dollar high to the tune of #92.69 in 1999 and #132.14 in 2005. The exchange rate remained fairly stable within the period 2006 to 2008 and steadily increased from #148.88 in 2009 to #193.27 in the year 2015. Astronomically, the rate rises to #306.08 in 2018, CBN (2019). This further shows that the exchange rate of the naira against the US dollar over the year has been unstable.

To stabilize the exchange rate since it has been bedeviled with serious volatility and weakness compared to the American dollar, the monetary authorities came up with policy prescriptions and modifications such as SFEM, DAS, M-DAS, and W-DAS in the past to rebuild the exchange rate system. They reverted to fixed-rate policy from 1994-1998, after which the central monetary authority after a trial experiment of another round of flexible policy, reverted to a fixed exchange rate system in 2008. The CBN authorities in a quest for a more viable currency rate abandoned the ongoing fixed regime to currency redenomination that was earlier abandoned, Nwude (2012) [12]. The return to the Dutch Auction System (DAS) and many other systems with slight modification and occasional government intervention without getting to the root of stabilizing the exchange rate is a testament that the Nigerian monetary authorities have not yet arrived at a suitable policy for curbing currency fluctuations.

Drawing an inference from the above background and the long history of exchange rate in Nigeria, the question that easily comes to mind is: what factors are responsible for the cyclical fluctuations of exchange rate of the Nigerian naira with respect to the United States dollar? In an attempt to answer this question, scholars such as Oke and Adetan (2018) [13], Hagen and Zhoe (2005) [6], Lucio, Frederico and Fabricio (2018) [10], Nwude (2012) [12], Algierie (2011) [1] etc. have considered factors such as foreign portfolio investment, international liquidity, oil price, productivity, government financial position, gross domestic product, external reserves, inflation rate, balance of payment, lending rate and deposit rate as possible correlates of exchange rate dynamics. In this paper, we deviate from existing studies by considering external reserve, public debt, trade openness, balance of payment and inflation rate as key variables that would enable the investigation of the issues behind macroeconomic fundamentals responsible for exchange rate dynamics in Nigeria. Therefore, this paper is aimed at examining the macroeconomic correlates affecting currency rate in Nigeria with concentration from 1999 to 2018 democratic years. The rest of this study is outline as theoretical literature, empirical literature, methodology, results and conclusion.

## Literature Review

### Theoretical Review

The theoretical foundation of this work is the Balance of Payment Theory. It's one of the most important theories that explain the building block of exchange rates in economies of developing world. The earliest writings on the theory of balance of payment are traceable to Richard Cantilon and David Hume.

The BOP theory holds that the conversion rate of currencies is controlled by autonomous but exogenous factors with no association with domestic prices and money supply. The naive form of the balance of payment (BOP) theory argues that the rates of exchange are influenced principally by the Position of countries BOP.

The BOP theory assumes that the market forces of supply and demand determine the state of international balance of payments, which in turn governs exchange rates. Thus, just like the market forces govern any other price (or the other way round), they also influence exchange rate through the channel of the state of international balance of payments. It is not in contest that the market forces affect the rate of exchange but what is in contest is what then determines the demand as well as supply of foreign currency rates**.** The sophisticated BOP theorists responded by asserting that BOP position (and therefore, the supply of and demand for foreign exchanges) is a major function of factors that are dependent on changes in the rate of exchanges, such as autonomous payments; including repatriation, interest on foreign loan, etc. and the demand for certain imports particularly for essential raw materials, which may be inelastic and this insensitive to ups and downs in the exchange rate.

According to Ezirim (2005) [5], the BOP theory has been ascribed some good points. Firstly, it is consistent with the general theory of value by recognizing that like price of goods and services, the exchange rate is determinable by the demand cum supply currencies. Secondly, it brings the determination of exchange rate under the umbrella of the general equilibrium theory. Thirdly, it stressed that there are many important factors, other than those of imports and exports which are influenced by prices that are incorporated into the BOP which by influencing the supply of and demand for currency exchange affects the exchange rate. Finally, it explains that BOP dis-equilibrium can be rectified by making appropriate adjustments in the foreign exchange rate through the processes of devaluation and revaluation.

Another theory considered in this section is the Purchasing Power Parity Theory. The idea of the purchasing power parity was first conceived in 16th century school of Salamanca. The PPP theory propounded by David Ricardo in the 19th century, its current form was developed by Prof. Gustav Cassel of Sweden and it states that, "the normal equilibrium rate of exchange between two inconvertible currencies is determined by the ratios of their purchasing powers", (Krugman, Obsfield & Melitz, 2013) [9]. The PPP theory is built on the law of one price and it assumes that prices of goods in a particular country are similar to price of goods in other country with their exchange rate currencies.

Opponents of the PPP theory on empirical grounds have faulted its legitimacy alongside the law of one price that all the versions of the theory do badly in explaining facts. For instance, changes in price levels often explain relatively little about movement of exchange rates. The failure of these theoretical propositions in real world analysis is link to barriers and departures from free competition. Again, empirical definitions of price levels in different countries of the world have bedeviled series of attempts to test and examine the validity and soundness of PPP theory using price statistics publish by government (Krugman, et al. 2013) [9]. Furthermore, Taylor and Taylor (2004) [15] have added that the purchasing power parity model has not held up well in explaining RAND/DOLLAR exchange rates for the period 1980 to 2009. However, the purchasing-power-parity theory is still very much relevant to modern day analysis of exchange rate correlates. The PPP proposition of exchange rates tends to established at the point of equality between the purchasing powers of the two currencies, (Ezirim, 2005) [5]. If the prevailing rate of exchange between the two currencies is not in line with this norm, then the forces of equilibrium must act to bring back the long-run exchange rate to the established norm according to the theory.

### Empirical Literature

Many views on foreign exchange rate dynamics have over the years evolved to delineate the factors responsible for the fluctuations or movement of foreign exchange rates in developing economies. In an attempt to cross-examine these factors that influences exchange rate, Makin (1984) [11] modeled the determinants of the exchange rates from the monetary perspective. The paper outlined that exchange rate as a financial variable like every other financial asset and price are strongly determined by prevailing expectations. From the monetary perspective, exchange rate is noted to be a reflection of the conduct of monetary policy (domestic/external) at the long run. Mungule (2004) investigated the fundamental factors influencing exchange rate in Zambia and discovered that capital flows, openness, terms of trade and domestic credit supply significantly explains the movement in exchange rate in the Zambia**.** Todani and Munyama (2005) [16] while employing the technique of ARDL to analyze the short-term impact of currency volatility on export flows in South African for the period 1984 through 2004 revealed that export flows is greatly extent related to exchange rate volatility.

Hagen and Zhou (2005) [6] studied on the choice of exchange regimes with European and the CIS countries after 1990. The results outlined that the traditional OCA consideration provide import guidance on regime choices for European, in addition to the CIS economics. All the same, regime types are dictated by inflation, cumulative-inflation differentials and external reserve adequacy. The authors further hold that macro-economic stabilization play significant roles in pegging currency rates. Also increased government deficits are likely to shift flexible regimes to intermediates regimes as well as fixed to intermediates regimes.

In Nigeria, Amaghionyeodiwe and Osinubi (2005) [2] explored the choice of exchange rate determinants with respect to Nigeria. The study applied multi-nominal logit and simultaneous limited independent models to estimate time series data from 1960-2000. The study holds that during relatively high inflation, the fixed regime was preferred. All the same, the study reports that domestic monetary disturbances appreciated the real currency rate and favored a more flexible regime, while incidence of BOP shocks, the fixed regime was likely to be favored.

Stancik (2007) [14] applied the threshold GARCH to study the factors responsible for exchange rate volatility using the new European Union members as case study. The paper concluded that economic insignificantly affect exchange rate while news factor majorly affects currency rate dynamics. Furthermore, regimes driven by demand and supply are link to high volatility in EU members. Benita and Lauterbach (2007) [3] applied the GARCH methodology on daily exchange rate of 43 countries and the US dollar for the period 1990 to 2001. From the GARCH results, the study conclude that currency volatility is positive with interest rate (domestic) and central bank intervention degree while currency volatility, real-interest rate and central bank intervention are associated.

Algieri (2011) [1] modeled the determinants of the real effective currency rate of the Russian economy within transition period of the early 1990's. From the regressed time series data, the result outlined a long run association between real exchange rate, oil price, productivity and public sector financial position. He submitted that managing external reserves and fiscal policies have effect of mitigating the impact of oil and terms of trade as well as shocks on the real exchange rate. Udoh, Akpan, John and Patrick (2012) [17] modeled the impact of macro-economic fundamentals on currency instability in Nigeria through the methodology of co-integration and partial adjustment estimation. The study holds that total import, rate of capacity utilization (industry), bank lending rate, foreign investment (private) and the period of policy liberalization were significant during the long-run, whereas in the short-run, external became significant.

Nwude (2012) [12] surveyed the correlates of exchange rate in Nigeria with the application of the least squares (LS) framework on annualized data spanning 1960 through 2011. The result revealed that there are no ties between BOP, GDP, lending rate, inflation rate external reserves, deposit rate, and exchange rate in Nigeria.

Insah and Chiaraah (2013) [7] explored on the correlates of real currency rate explosive nature in economy of Ghana using ARDL method of estimation for series spanning 1980 through 2012. The paper holds that government expenditure correlates with currency rates while domestic and public debt reacted negatively. Public debt at lag four affected currency rate significantly.

Ezeanyeyi and Onwuteaka (2016) [4] using the ECM and the Johansen long run test on rate of currency sensitivity in Nigeria and its contributing factors with emphasis on the manufacturing-sector and concluded that production sector in Nigerian in the long-run is insensitive to behavior of exchange rate while GDP and inflation were noted as major factors affecting currency rates.

Oke and Adetan (2018) [13] examined the factors influencing exchange rate in Nigeria using the ARDL bond co-integration approach for the period 1986 to 2016. The result showed that HDP, interest rate and inflation contributed to exchange rate in Nigeria while trade openness has a negative relationship with exchange rate. Lucio, Frederico and Fabricio (2018) [10] presented a framework for evaluating long-run correlates of currency rates in developing/emerging countries with the use of the Kalten Brunner model developed in the general theory of J.M. Keynes. Data on Foreign portfolio investment flow, and external vulnerability measures were annually collected and the result showed that the financial factors explain the long run movement in exchange rates. Wasiu, Oyegoke and Gylyeh (2019) [18] explored on the factors that determines exchange rates in Nigeria's official and parallel markets for the period 1986-2017 with respect to quarterly monthly series in Nigeria. The ARDL method was adopted to analyze the regression. The results reveal that HDP, interest rate, inflation, non-oil export, oil export and reserves are key factors in explaining currency rate movements in Nigeria.

**Methodology**

The study was aimed at analyzing the macroeconomic correlates of exchange rate in Nigeria over the period of 1999 to 2018 with data generated from Central Bank of Nigeria 2018 edition. In all, a total of six macroeconomic fundamentals were selected as key factors influencing the behavior of exchange rate in Nigeria.

This study employed an investigative research process re-informed by the ARDL model which results from theoretical constructs. The ARDL model according to Iyeli (2010) [8] is a least squares regression approach containing lags of both the dependent and explanatory variables. ARDLs are usually denoted with the notation ARDL (p, $q_1$… qk), where p is the number of lags of the dependent variables, $q_1$ is the number of lags of the first explanatory y variable, and qk is the number of lags of the k-th explanatory variable.

According to Pesaran and Shin (1999), ARDL is necessary because it is a dynamic approach for analyzing systems that are integrated of the form 1(0) or 1(1) without needing to pre-specify which 1(0) are or 1(1). The ARDL model for the purpose of this study could be specified as follows:

**Functional model**

$$EXCR = f(BPAY, ECOP, EXTR, INFR, INTR, PDEB) \quad (1)$$

**Econometric model**

$$EXCR_t = \alpha_0 + \alpha_1 BPAY_t + \alpha_2 ECOP_t + \alpha_3 EXTR_t + \alpha_4 INFR_t + \alpha_5 INTR_t + \alpha_6 PDEB_t + \alpha_1 BPAY_{t-1} + \alpha_2 ECOP_{t-1} + \alpha_3 EXTR_{t-1} + \alpha_4 INFR_{t-1} + \alpha_5 INTR_{t-1} + \alpha_6 PDEB_{t-1} + e_t \quad (2)$$

Where:

EXCR, *BPAY, ECOP, EXTR, INFR*, INTR, PDEB and $e_t$ is respectively defined as Naira-Dollar Exchange Rate, Balance of payment, Economic Openness, External Reserves, Inflation Rate, Interest Rate, Public Debt and Error Term.

Apriori expectation of the variables: $\alpha_{0...}\alpha_6 > 0$.

## Results

**Table 1:** Unit Root Test Result

| Variables | ADF Statistic | Critical Value 5% | Order of Integration |
|---|---|---|---|
| EXCR | -3.419205 | -3.052169 | I (0) |
| BPAY | -4.157434 | -3.065585 | I (1) |
| ECOP | -3.068462 | -3.001002 | I (1) |
| EXTR | -4.842026 | -3.052169 | I (0) |
| INFR | -4.635219 | -3.065585 | I (0) |
| INTR | -4.452374 | -3.052169 | I (1) |
| PDEB | -3.469310 | -3.040391 | I (0) |

The table above shows that exchange rate, external reserve, inflation rate and public debt are stationary at levels, while balance of payment, economic openness and interest rate are stationary at first difference. This implies that the series is free from unit roots and therefore requires the ARDL test as estimation tool.

**Table 2:** ARDL Result

| Variable | Coefficient | Stan. Error | T- statistics | Probability |
|---|---|---|---|---|
| EXCR (-1) | 0.008967 | 0.106433 | 0.084255 | 0.9344 |
| BPAY | 0.005434 | 0.013841 | 0.392613 | 0.7021 |
| ECOP | 0.020534 | 0.026059 | 0.787983 | 0.4474 |
| EXTR | 0.156837 | 0.190663 | 0.822587 | 0.4282 |
| INFR | 0.042721 | 0.004737 | 9.018681 | 0.0000 |
| INTR | 0.515269 | 0.210541 | 2.447356 | 0.0324 |
| PDEB | 0.000772 | 0.006569 | 0.117449 | 0.9086 |
| C | 0.020987 | 0.086833 | 0.241700 | 0.8135 |
| Adjusted $R^2$ = 0.845390, F-statistics = 15.06032, Probability (F-statistics) = 0.000079, DWS = 3.097391 | | | | |

Given the ARDL results above, the individual statistics of the model testifies that all the coefficients of the variables (balance of payment, economic openness, external reserves, inflation rate, interest rate and public debt) are positively related to exchange rate at lag 1 but are not significant while inflation and interest rates tends to be significant in building exchange rates. The adjusted R-Square is statistically fit to account for the variations in exchange rate at 84.5% with an unexplained variation of about 15.5% which may be due to factors outside the model. The F-statistic ratio of 15.06032 is significant, given the probability value of 0.000079, while the Durbin Watson statistics for testing serial correlation is within normal.

**Table 3:** Co-Integration Bound Result

| Level of Significance | I(0) Bound | I(1) Bound |
|---|---|---|
| 10% | 2.12 | 3.23 |
| 5% | 2.45 | 3.61 |
| 2.5% | 2.75 | 3.99 |
| 1% | 3. 15 | 4.43 |

F-statistic Value = 3.663429 and K=6

The ARDL bound test for co-integration shows that the F-value 3.663429 is greater than the upper bound value at 5% level of significance. Thus, there is a long run relationship between exchange rate and its selected determinants (balance of payment, economic openness, inflation rate, interest rate, external reserves and public debt).

**Table 4:** ECM Result

| Variable | Coefficient | Stan. Error | T- statistics | Probability |
|---|---|---|---|---|
| ECM (-1) | -0.383031 | 0.222669 | -6.211156 | 0.0002 |
| C | 0.013005 | 0.043422 | 0.299497 | 0.7714 |

The result of the error correction model (ECM) shows a value of -1.383031 and its rightly signed with a probability value of 0.0002 (significant). By implication, the speed of adjustment is
-138.3%, indicating that the model is fast enough to adjust from its previous errors (disequilibrium) to equilibrium.

## Conclusion

This study analyzes the macroeconomic fundamentals that influence the behaviour of exchange rates in Nigeria with the application of Autoregressive Distributed Lag Model (ARDL). These set of macroeconomic fundamentals include balance of payment, economic openness, external reserves, inflation rate, interest rate and public debt. The result holds that Balance of payment is not a significant determinant of exchange rate. This may be due to unfavorable external balances over the years in Nigeria. Economic openness is also found to be positive and insignificantly linked to exchange rate. This could be adduced to the fact that the import values outweigh the export values since the Nigerian economy depends more on importation than exportation of goods. This study contradicts the findings of Stancik (2006) [14] who concluded that economic openness has a negative effect on exchange rate volatility among the new EU members. External reserve turned insignificant and positive on the behavior of exchange rate within the period under review. This means that an increase in Nigeria's external reserve abroad, will confidently build the value of the naira in terms of other foreign currency say the American dollar. Inflation and interest rates were found to be positive and significant to exchange rate. This view corroborates with the findings of Ezeanyeji and Onwuteaka (2016) [4]. Public debt is insignificantly contributed to exchange rate in Nigeria. Nevertheless, this result confirms the fact that money borrowed by the government over the years has not been fully utilize in building social infrastructures and productive channels that will stabilize the dynamics of naira exchange rates as well as promoting economic prosperity in Nigeria. This is similar to the observation made by Insah and Chiaraah (2013) [7] that public debt minimally influenced exchange rate in Nigeria.

Conclusively, balance of payment, economic openness, external reserves, inflation rate, interest rate and public debt are determinants of exchange rate in the short and long run. The study therefore recommends that to stabilize the naira to compete with other foreign currencies, the Nigerian economy should encourage export base diversification of the real sector by providing loans and machineries to aid farmers, infant industries and manufacturers in the real sector of the economy.

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## Appendix

| **ARDL Result** Dependent Variable: EXCR | | | | |
|---|---|---|---|---|
| Method: ARDL | | | | |
| Date: 03/02/20 Time: 09:33 | | | | |
| Sample (adjusted): 1999 2018 | | | | |
| Included observations: 19 | | | | |
| Maximum dependent lags: 1 (Automatic selection) | | | | |
| Model selection method: Akaike info criterion (AIC) | | | | |
| Dynamic regressors (0 lag, automatic): BPAY ECOP EXTR INFR INTR | | | | |
| PDEB | | | | |
| Fixed regressors: C | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.* |
| EXCR(-1) | 0.008967 | 0.106433 | 0.084255 | 0.9344 |
| BPAY | 0.005434 | 0.013841 | 0.392613 | 0.7021 |
| ECOP | 0.020534 | 0.026059 | 0.787983 | 0.4474 |
| EXTR | 0.156837 | 0.190663 | 0.822587 | 0.4282 |
| INFR | 0.042721 | 0.004737 | 9.018681 | 0.0000 |
| INTR | 0.515269 | 0.210541 | 2.447356 | 0.0324 |
| PDEB | 0.000772 | 0.006569 | 0.117449 | 0.9086 |
| C | 0.020987 | 0.086833 | 0.241700 | 0.8135 |
| R-squared | 0.905516 | Mean dependent var | | 0.197890 |
| Adjusted R-squared | 0.845390 | S.D. dependent var | | 0.805813 |
| S.E. of regression | 0.316849 | Akaike info criterion | | 0.834781 |
| Sum squared resid | 1.104328 | Schwarz criterion | | 1.232439 |
| Log likelihood | 0.069584 | Hannan-Quinn criter. | | 0.902080 |
| F-statistic | 15.06032 | Durbin-Watson stat | | 3.097391 |
| Prob(F-statistic) | 0.000079 | | | |
| *Note: p-values and any subsequent tests do not account for model selection. | | | | |

## Co-Integration Test

| ARDL Bounds Test | | | | |
|---|---|---|---|---|
| Date: 03/02/20 Time: 09:34 | | | | |
| Sample: 2000 2018 | | | | |
| Included observations: 19 | | | | |
| Null Hypothesis: No long-run relationships exist | | | | |
| Test Statistic | Value | K | | |
| F-statistic | 3.663429 | 6 | | |
| Critical Value Bounds | | | | |
| Significance | I0 Bound | I1 Bound | | |
| 10% | 2.12 | 3.23 | | |
| 5% | 2.45 | 3.61 | | |
| 2.5% | 2.75 | 3.99 | | |
| 1% | 3.15 | 4.43 | | |
| Test Equation: | | | | |
| Dependent Variable: D(EXCR) | | | | |
| Method: Least Squares | | | | |
| Date: 03/02/20 Time: 09:34 | | | | |
| Sample: 1999 2018 | | | | |
| Included observations: 19 | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| C | 0.490872 | 0.259990 | 1.888038 | 0.0857 |
| BPAY(-1) | 0.001717 | 0.004786 | 0.358804 | 0.7265 |
| ECOP(-1) | -0.041709 | 0.080643 | -0.517207 | 0.6153 |
| EXTR(-1) | -1.092970 | 0.688657 | -1.587104 | 0.1408 |
| INFR(-1) | 0.082105 | 0.043023 | 1.908406 | 0.0828 |
| INTR(-1) | 0.220612 | 0.731773 | 0.301476 | 0.7687 |
| PDEB(-1) | 0.007067 | 0.016956 | 0.416776 | 0.6849 |
| EXCR(-1) | -2.823225 | 0.932380 | -3.027975 | 0.0115 |
| R-squared | 0.693968 | Mean dependent var | | -0.052632 |
| Adjusted R-squared | 0.499221 | S.D. dependent var | | 1.181386 |
| S.E. of regression | 0.836017 | Akaike info criterion | | 2.775225 |
| Sum squared resid | 7.688161 | Schwarz criterion | | 3.172884 |
| Log likelihood | -18.36464 | Hannan-Quinn criter. | | 2.842525 |
| F-statistic | 3.563429 | Durbin-Watson stat | | 1.716170 |
| Prob(F-statistic) | 0.029750 | | | |
| ECM RESULT | | | | |

| Dependent Variable: EXCR | | | | |
|---|---|---|---|---|
| Method: ARDL | | | | |
| Date: 03/02/18 Time: 09:40 | | | | |
| Sample (adjusted): 2001 2018 | | | | |
| Included observations: 18 after adjustments | | | | |
| Maximum dependent lags: 1 (Automatic selection) | | | | |
| Model selection method: Akaike info criterion (AIC) | | | | |
| Dynamic regressors (0 lag, automatic): BPAY ECOP EXTR INFR INTR | | | | |
| PDEB ECM(-1) | | | | |
| Fixed regressors: C | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob.* |
| EXCR(-1) | 0.041810 | 0.051503 | 0.811800 | 0.4378 |
| BPAY | -0.006717 | 0.006966 | -0.964267 | 0.3601 |
| ECOP | -0.002545 | 0.013070 | -0.194712 | 0.8499 |
| EXTR | -0.143628 | 0.106003 | -1.354945 | 0.2085 |
| INFR | 0.046188 | 0.002343 | 19.71077 | 0.0000 |
| INTR | 0.080172 | 0.123020 | 0.651698 | 0.5309 |
| PDEB | 0.006835 | 0.003311 | 2.064404 | 0.0690 |
| ECM(-1) | -0.383031 | 0.222669 | -6.211156 | 0.0002 |
| C | 0.013005 | 0.043422 | 0.299497 | 0.7714 |
| R-squared | 0.982096 | Mean dependent var | | 0.208884 |
| Adjusted R-squared | 0.966181 | S.D. dependent var | | 0.827707 |
| S.E. of regression | 0.152216 | Akaike info criterion | | -0.620182 |
| Sum squared resid | 0.208527 | Schwarz criterion | | -0.174996 |
| Log likelihood | 14.58164 | Hannan-Quinn criter. | | -0.558797 |
| F-statistic | 61.70879 | Durbin-Watson stat | | 1.716012 |
| Prob(F-statistic) | 0.000001 | | | |
| *Note: p-values and any subsequent tests do not account for model selection. | | | | |

**Unit root test for EXCR I (0)**

| | | | | |
|---|---|---|---|---|
| Null Hypothesis: D(EXCR,2) has a unit root | | | | |
| Exogenous: Constant | | | | |
| Lag Length: 0(Automatic - based on SIC, maxlag=4) | | | | |
| | | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | | -3.419205 | 0.0250 |
| Test critical values: | 1% level | | -3.886751 | |
| | 5% level | | -3.052169 | |
| | 10% level | | -2.666593 | |
| *MacKinnon (1996) one-sided p-values. | | | | |
| Warning: Probabilities and critical values calculated for 20 observations | | | | |
| and may not be accurate for a sample size of 17 | | | | |
| Augmented Dickey-Fuller Test Equation | | | | |
| Dependent Variable: D(EXCR,3) | | | | |
| Method: Least Squares | | | | |
| Date: 02/23/20 Time: 06:52 | | | | |
| Sample (adjusted): 2002 2018 | | | | |
| Included observations: 17 after adjustments | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| D(EXCR(-1),2) | -1.437008 | 0.420275 | -3.419205 | 0.0038 |
| C | 8.912344 | 10.87786 | 0.819311 | 0.4254 |
| R-squared | 0.438012 | Mean dependent var | | 8.783859 |
| Adjusted R-squared | 0.400546 | S.D. dependent var | | 57.92785 |
| S.E. of regression | 44.85029 | Akaike info criterion | | 10.55467 |
| Sum squared resid | 30173.23 | Schwarz criterion | | 10.65269 |
| Log likelihood | -87.71468 | Hannan-Quinn criter. | | 10.56441 |
| F-statistic | 11.69096 | Durbin-Watson stat | | 1.272869 |
| Prob(F-statistic) | 0.003805 | | | |

**Unit root test for BPAY I(1)**

| | | | | |
|---|---|---|---|---|
| Null Hypothesis: D(BPAY) has a unit root | | | | |
| Exogenous: Constant | | | | |
| Lag Length: 1 (Automatic - based on SIC, maxlag=4) | | | | |
| | | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | | -4.157434 | 0.0063 |
| Test critical values: | 1% level | | -3.920350 | |
| | 5% level | | -3.065585 | |
| | 10% level | | -2.673459 | |
| *MacKinnon (1996) one-sided p-values. | | | | |
| Warning: Probabilities and critical values calculated for 20 observations | | | | |
| and may not be accurate for a sample size of 16 | | | | |
| Augmented Dickey-Fuller Test Equation | | | | |
| Dependent Variable: D(BPAY,2) | | | | |
| Method: Least Squares | | | | |
| Date: 02/23/20 Time: 06:55 | | | | |
| Sample (adjusted): 2003 2018 | | | | |
| Included observations: 16 after adjustments | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| D(BPAY(-1)) | -2.746327 | 0.660582 | -4.157434 | 0.0013 |
| D(BPAY(-1),2) | 1.082952 | 0.473497 | 2.287135 | 0.0411 |
| D(BPAY(-2),2) | 0.440966 | 0.284828 | 1.548187 | 0.1475 |
| C | -482.8830 | 361.9271 | -1.334200 | 0.2069 |
| R-squared | 0.776865 | Mean dependent var | | -34.81250 |
| Adjusted R-squared | 0.721081 | S.D. dependent var | | 2579.411 |
| S.E. of regression | 1362.258 | Akaike info criterion | | 17.48399 |
| Sum squared resid | 22268969 | Schwarz criterion | | 17.67714 |
| Log likelihood | -135.8719 | Hannan-Quinn criter. | | 17.49388 |
| F-statistic | 13.92636 | Durbin-Watson stat | | 1.819486 |
| Prob(F-statistic) | 0.000325 | | | |

**Unit root test for ECOP 1(1)**

| | | | | |
|---|---|---|---|---|
| Null Hypothesis: D(ECOP) has a unit root | | | | |
| Exogenous: Constant | | | | |
| Lag Length: 1 (Automatic - based on SIC, maxlag=4) | | | | |
| | | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | | -3.068462 | 0.0411 |
| Test critical values: | 1% level | | -3.059148 | |
| | 5% level | | -3.001002 | |
| | 10% level | | -2.681330 | |
| *MacKinnon (1996) one-sided p-values. | | | | |
| Warning: Probabilities and critical values calculated for 20 observations | | | | |
| and may not be accurate for a sample size of 15 | | | | |
| Augmented Dickey-Fuller Test Equation | | | | |
| Dependent Variable: D(ECOP,2) | | | | |
| Method: Least Squares | | | | |
| Date: 02/23/20 Time: 06:57 | | | | |
| Sample (adjusted): 2004 2018 | | | | |
| Included observations: 15 after adjustments | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| D(ECOP(-1)) | -2.275997 | 0.741739 | -3.068462 | 0.0119 |
| D(ECOP(-1),2) | 1.038240 | 0.714260 | 1.453588 | 0.1767 |
| D(ECOP(-2),2) | 0.997897 | 0.624126 | 1.598870 | 0.1409 |
| D(ECOP(-3),2) | 1.169873 | 0.472299 | 2.476976 | 0.0327 |
| C | 0.075906 | 0.287586 | 0.263942 | 0.7972 |
| R-squared | 0.858061 | Mean dependent var | | -0.050683 |
| Adjusted R-squared | 0.801285 | S.D. dependent var | | 2.346651 |
| S.E. of regression | 1.046078 | Akaike info criterion | | 3.189175 |
| Sum squared resid | 10.94279 | Schwarz criterion | | 3.425191 |
| Log likelihood | -18.91881 | Hannan-Quinn criter. | | 3.186660 |
| F-statistic | 15.11315 | Durbin-Watson stat | | 1.635929 |
| Prob(F-statistic) | 0.000305 | | | |

**Unit root test for EXTR I (0)**

| | | | | |
|---|---|---|---|---|
| Null Hypothesis: D(EXTR,2) has a unit root | | | | |
| Exogenous: Constant | | | | |
| Lag Length: 0 (Automatic - based on SIC, maxlag=4) | | | | |
| | | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | | -4.842026 | 0.0015 |
| Test critical values: | 1% level | | -3.886751 | |
| | 5% level | | -3.052169 | |
| | 10% level | | -2.666593 | |
| *MacKinnon (1996) one-sided p-values. | | | | |
| Warning: Probabilities and critical values calculated for 20 observations | | | | |
| and may not be accurate for a sample size of 17 | | | | |
| Augmented Dickey-Fuller Test Equation | | | | |
| Dependent Variable: D(EXTR,3) | | | | |
| Method: Least Squares | | | | |
| Date: 02/23/20 Time: 07:01 | | | | |
| Sample (adjusted): 2002 2018 | | | | |
| Included observations: 17 after adjustments | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| D(EXTR(-1),2) | -1.219838 | 0.251927 | -4.842026 | 0.0002 |
| C | -192.2028 | 2234.694 | -0.086009 | 0.9326 |
| R-squared | 0.609834 | Mean dependent var | | 461.1449 |
| Adjusted R-squared | 0.583823 | S.D. dependent var | | 14256.42 |
| S.E. of regression | 9197.067 | Akaike info criterion | | 21.20129 |
| Sum squared resid | 1.27E+09 | Schwarz criterion | | 21.29931 |
| Log likelihood | -178.2109 | Hannan-Quinn criter. | | 21.21103 |
| F-statistic | 23.44521 | Durbin-Watson stat | | 2.012077 |
| Prob(F-statistic) | 0.000215 | | | |

**Unit root test for INFR I(0)**

| | | | | |
|---|---|---|---|---|
| Null Hypothesis: INFR has a unit root | | | | |
| Exogenous: Constant | | | | |
| Lag Length: 0 (Automatic - based on SIC, maxlag=4) | | | | |
| | | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | | -4.635219 | 0.0026 |
| Test critical values: | 1% level | | -3.920350 | |
| | 5% level | | -3.065585 | |
| | 10% level | | -2.673459 | |
| *MacKinnon (1996) one-sided p-values. | | | | |
| Warning: Probabilities and critical values calculated for 20 observations | | | | |
| and may not be accurate for a sample size of 16 | | | | |
| Augmented Dickey-Fuller Test Equation | | | | |
| Dependent Variable: D(INFR) | | | | |
| Method: Least Squares | | | | |
| Date: 02/23/20 Time: 07:03 | | | | |
| Sample (adjusted): 2003 2018 | | | | |
| Included observations: 16 after adjustments | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| INFR(-1) | -1.878489 | 0.405264 | -4.635219 | 0.0007 |
| D(INFR(-1)) | 0.858496 | 0.318996 | 2.691241 | 0.0210 |
| D(INFR(-2)) | 0.757645 | 0.263064 | 2.880080 | 0.0150 |
| D(INFR(-3)) | 0.625959 | 0.180145 | 3.474741 | 0.0052 |
| C | 22.85695 | 4.902199 | 4.662591 | 0.0007 |
| R-squared | 0.752124 | Mean dependent var | | 0.093750 |
| Adjusted R-squared | 0.661987 | S.D. dependent var | | 5.923790 |
| S.E. of regression | 3.444028 | Akaike info criterion | | 5.561467 |
| Sum squared resid | 130.4746 | Schwarz criterion | | 5.802901 |
| Log likelihood | -39.49174 | Hannan-Quinn criter. | | 5.573830 |
| F-statistic | 8.344235 | Durbin-Watson stat | | 2.021494 |
| Prob(F-statistic) | 0.002393 | | | |

**Unit root for INTR I (1)**

| | | | | |
|---|---|---|---|---|
| Null Hypothesis: D(INTR) has a unit root | | | | |
| Exogenous: Constant | | | | |
| Lag Length: 1 (Automatic - based on SIC, maxlag=4) | | | | |
| | | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | | -4.452374 | 0.0033 |
| Test critical values: | 1% level | | -3.886751 | |
| | 5% level | | -3.052169 | |
| | 10% level | | -2.666593 | |
| *MacKinnon (1996) one-sided p-values. | | | | |
| Warning: Probabilities and critical values calculated for 20 observations | | | | |
| and may not be accurate for a sample size of 17 | | | | |
| Augmented Dickey-Fuller Test Equation | | | | |
| Dependent Variable: D(INTR,2) | | | | |
| Method: Least Squares | | | | |
| Date: 02/23/20 Time: 07:05 | | | | |
| Sample (adjusted): 2002 2018 | | | | |
| Included observations: 17 after adjustments | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| D(INTR(-1)) | -2.153149 | 0.483596 | -4.452374 | 0.0005 |
| D(INTR(-1),2) | 0.508648 | 0.277516 | 1.832862 | 0.0882 |
| C | -0.896636 | 1.064725 | -0.842129 | 0.4139 |
| R-squared | 0.729311 | Mean dependent var | | 0.280588 |
| Adjusted R-squared | 0.690641 | S.D. dependent var | | 7.379147 |
| S.E. of regression | 4.104282 | Akaike info criterion | | 5.820724 |
| Sum squared resid | 235.8319 | Schwarz criterion | | 5.967762 |
| Log likelihood | -46.47615 | Hannan-Quinn criter. | | 5.835340 |
| F-statistic | 18.85996 | Durbin-Watson stat | | 1.885588 |
| Prob(F-statistic) | 0.000106 | | | |

**Unit root test for PDEB I(0)**

| | | | | |
|---|---|---|---|---|
| Null Hypothesis: D(PDEB) has a unit root | | | | |
| Exogenous: Constant | | | | |
| Lag Length: 0 (Automatic - based on SIC, maxlag=4) | | | | |
| | | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | | -3.469310 | 0.0218 |
| Test critical values: | 1% level | | -3.857386 | |
| | 5% level | | -3.040391 | |
| | 10% level | | -2.660551 | |
| *MacKinnon (1996) one-sided p-values. | | | | |
| Warning: Probabilities and critical values calculated for 20 observations | | | | |
| and may not be accurate for a sample size of 18 | | | | |
| Augmented Dickey-Fuller Test Equation | | | | |
| Dependent Variable: D(PDEB,2) | | | | |
| Method: Least Squares | | | | |
| Date: 02/23/20 Time: 07:10 | | | | |
| Sample (adjusted): 2001 2018 | | | | |
| Included observations: 18 after adjustments | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| D(PDEB(-1)) | -0.844336 | 0.243373 | -3.469310 | 0.0032 |
| C | 4874.227 | 2133.488 | 2.284628 | 0.0363 |
| R-squared | 0.429308 | Mean dependent var | | 409.9046 |
| Adjusted R-squared | 0.393639 | S.D. dependent var | | 9271.780 |
| S.E. of regression | 7219.858 | Akaike info criterion | | 20.71150 |
| Sum squared resid | 8.34E+08 | Schwarz criterion | | 20.81043 |
| Log likelihood | -184.4035 | Hannan-Quinn criter. | | 20.72514 |
| F-statistic | 12.03611 | Durbin-Watson stat | | 2.087461 |
| Prob(F-statistic) | 0.003162 | | | |