APPLICATION OF STOCHASTIC-MARKOV TRANSITION ANALYSIS TO PREDICT EXCHANGE RATE MOVEMENT IN NIGERIA

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Abstract

The Nigerian economy has faced a lot of disruptive, sharp and volatile movements in its exchange rate since 1986 when Naira lost its value. The unstable nature of the exchange rate has serious effect on the business activities either positive or negative which in turn affect the nation growth and development. Understanding the dynamism and control of exchange rate movement is paramount but predicting exchange rate behaviour poses a serious problem that needs a lasting solution. This study is designed to apply stochastic markov transition model to predict exchange rate behaviour in Nigeria. The variable of concerned is Naira – dollar exchange rate with emphasis on post Structural Adjustment Programme (SAP) era when naira lost its value. Cross sectional survey was adopted while secondary data was used which comprises of information obtained from Federal office of statistics, Central Bank of Nigeria and daily financial news papers. Asymptotic Chi-square distribution and predictive models were used to test the formulated hypotheses. Based on the findings, it was revealed that; the Nigeria exchange rate movement is memoryless, would converge in the ninth month and that Box Jenkins is best model at predicting exchange rate in Nigeria. The model was recommended for the policy makers to control the volatility of exchange rate in Nigeria.

Key words: Exchange rate, Naira – dollar, Markov chain, Post SAP, Volatility

Introduction

Naira – dollar exchange rate dynamism has affected most business activities in Nigeria. The uncertainty in the value of the rate of naira to dollar at a particular time has serious effect on international businesses. Exchange rate dictate the direction of growth and development in Nigeria because fluctuations in the exchange rate brings about either a positive or a negative effect on both consumer prices and the economy at large. The exchange rate regime in Nigeria has in the past and even in the present experienced sharp and volatile changes and these changes or disruptions have in one way or the other hindered the growth and development of the economy (Mba, 2014). Aside from January 1999 which had naira to dollar exchange rate of below ₦100 to one dollar, other years have witnessed sharp and volatile movements ranging from a major drop in the naira-dollar exchange rate in November 2008, which had a value for naira to one dollar at ₦117.79. A sharp rise also occurred in January 2009 (₦145.78) and the rise continued through August 2009 (₦151.85) and had a little drop in October 2009 with

₦149.35 as the exchange rate value for that period and the rise picked up again through to December 2011 with its value at ₦158.20 to ₦ 230.3 in March 2015 and the recent slight drop observed to ₦199.5 as at October 2015 due to the government policy of de-dollarization of the economy by the present administration where Nigerians were mandated to transact business activities in the country via Naira only with exception of serious evidence and approval of financial institutions to trade in dollars.

The significance of naira – dollar exchange rates cannot be overemphasised. Many researchers have attempted the prediction of exchange rate in Nigeria with the view that business activities can be stable if exchange rate behaviour can be predicted but most of them failed to see if exchange rate follows the purchasing power parity or follows the one price theory while some failed to predict inability in predicting its movements and its behaviour at large, this requires further intensive research (Mba, Mba, Aneke & Ogbuabor, 2013). The ability to understand exchange rate movements and volatility is necessary and important to monetary policy. Trying to control exchange rate volatility in Nigeria and also predict exchange rate is a problem that needs a lasting solution. In view of the foregoing, this paper is designed to predict exchange rate in Nigeria using a Markov transition model with emphasis on Naira – dollar exchange rate.

Literature review

Concept of Exchange Rate System

Conceptually, an exchange rate implies the price of one currency in terms of another; in the Nigerian context, it is the units of naira needed to purchase one unit of another country's currency e.g the United States dollar (Campbell, 2010). The management of any country's foreign exchange market is carried out within the ambit of a foreign exchange policy, which according to Obaseki (2001) is the sum total of the institutional framework and measures put in place to gravitate the exchange rate towards desired levels in order to stimulate the productive sectors, curtail inflation, ensure internal balance, improve the level of exports and attract direct foreign investment and other capital inflows. Exchange rate policy also determines the mechanism for channelling foreign exchange to end-users and therefore, reflects the institutional framework, system of exchange rate determination and allocation of foreign exchange as well as the policy options for managing the exchange rate (Oladapo & Oloyede, 2014).

There are three main categories of exchange rate regimes; ***Flexible Exchange Rate Systems :***In a flexible exchange rate system also known as the floating exchange rate system, the value of the currency is determined by the market, i.e. by the interactions of thousands of banks, firms and other institutions seeking to buy and sell currency for purposes of transactions clearing, hedging, arbitrage and speculation. So the higher the demand for a currency, every other things being equal, would lead to an appreciation of the currency (Mba, 2014). Lower demand, all else equal, would lead to a depreciation of the currency. An increase in the supply of a currency, all else equal, will lead to depreciation of that currency while a decrease in supply, all else equal will lead to an appreciation (Weerapana, 2004).

According to Samarasiri, (2005), floating exchange rate system allows the market forces to determine the exchange rate without direct intervention of the Central Bank, given any prevailing control on foreign exchange transactions. Accordingly, the exchange rate is free to fluctuate in response to changes in demand and supply factors. Since the central bank does not have to intervene in the foreign exchange market and it can conduct the monetary policy independently from the balance of payments as long as the exchange rate is free to fluctuate to clear the imbalances in the foreign exchange market. However, if the exchange rate volatility at any time is considered high, the central bank will intervene in the market by buying or selling foreign exchange to maintain greater stability in the exchange rate. Hanke, (1999) stressed that the floating rates unlike fixed rates do not perform well in developing countries because those countries usually have weak monetary authorities and histories of monetary instability. Currencies in developing countries rarely float on a sea of tranquility.

Managed Floating Exchange Rate Systems: A managed floating exchange rate system is a hybrid of a fixed exchange rate and a flexible exchange rate system. In a country with a managed floating exchange rate system, the central bank becomes a key participant in the foreign exchange market (Weerapana, 2004). The managed floating exchange rate system allows the market forces to operate within a band of exchange rates. The band is the rate at which the central bank is prepared to buy the foreign currency from the authorized dealers and the rate at which the central bank is prepared to sell the foreign currency to the authorized dealers. The band width, that is, the difference between the central bank's buying rate and selling rate, depends on the level of freedom given to the market to determine the exchange rate. Since the central bank is prepared to buy and sell the foreign currency at those rates, the exchange rate in the market may not move

outside the band. However, since destabilizing speculation on exchange rate may cause the pressure on the market exchange rate to move beyond the band, the central bank should be prepared to have sufficient intervention at such times (Samarasiri, 2005)

Unlike in a fixed exchange rate regime, the central bank does not have an explicit set value for currency: however, unlike in a flexible exchange rate regime, it doesn't allow the market to freely determine the value of the currency. Instead, the central bank has either an explicit range of target values for their currency; it intervenes in the foreign exchange market by buying and selling domestic and foreign currency to keep the exchange rate close to this desired explicit value or within the desired target values (Weerapana, 2004). So under a managed floating regime, the central bank holds stocks of foreign currency: these holdings are known as foreign exchange reserves. It is important to realize that a managed float can only work when the implicit target is close to the equilibrium rate that would prevail in the absence of central bank intervention. Otherwise, the central bank will deplete its foreign exchange reserves and the country will be in a flexible exchange rate system because they can no longer intervene (Weerapana, 2004).

Fixed (Pegged) Exchange Rate Systems: According to Hanke (2002), fixed and pegged rates appear to be the same. However, they are fundamentally different. Pegged rates are not free-market mechanisms for international payments. With a pegged rate, the monetary base contains both domestic and foreign components. He went further in emphasizing that unlike floating and fixed rates, pegged rates invariably result in conflicts between exchange rate and monetary policies. He buttressed his points by an example that when capital flows become "excessive" under a pegged system, a monetary authority often attempts to sterilize the ensuing increase in the foreign component of the monetary base and when outflows become "excessive" an authority attempts to offset the decrease in the foreign component of the base with an increase in the domestic component of the monetary base. Balance of payments crises erupt as a monetary authority begins to offset more and more of the reduction in the foreign component of the monetary base with domestically created base money. When this occurs, it is only a matter of time before currency speculators spot the contradictions between exchange rate and monetary policies and force devaluation.

According to Samarasiri (2005), under the fixed exchange rate system, a central bank fixes the exchange rates of the currency against the foreign

currencies and market participants have to use these exchange rates for transactions. In some instances, the currency is linked or pegged to a particular foreign currency and the exchange rate is fixed for that currency. The exchange rates for other foreign currencies will be fixed as cross-rates taking the exchange rates between the pegged currency and other foreign currencies. The fixed exchange rate for the pegged currency will be revised by the central bank from time to time in response to changes in demand and supply conditions and other economic policy priorities. Moreover, the fundamental problem in this system is the central banks' tendency to fix the value of its currency below the market clearing value, partly because of their inability to figure out the market clearing exchange rate (that is, the rate that should prevail to make the demand and supply equal), in a flexible exchange rate system, this is the spot rate. In a fixed exchange rate system, the pre-announced rate may not coincide with the market equilibrium exchange rate (Samarasiri, 2005; Weerapana, 2004; Hanke, 2002; Mba, 2014). Furthermore, given the current demand and supply conditions, such a low value is tantamount to over-valued currency (or artificially appreciated value) encouraging more imports. Consequently, in any market, there would be situations of excess demand and excess supply. Under a flexible exchange rate system, these changes cause appreciation or depreciation of the currency respectively. Under a fixed exchange rate system, the central bank remains prepared to absorb the excess demand or supply. In other to achieve this, the central bank must hold stocks of both foreign and domestic currency. Since the central bank prints domestic currency, holding stocks of domestic currency poses no problems. The difficulty comes in holding an adequate stock of foreign currency known as foreign exchange reserves (Samarasiri, 2005; Weerapana, 2004; Mba, 2014).

It is important to note that, balance of payment deficit arises when there is an excess demand for foreign currency and in such circumstance; the central bank is expected to supply foreign currency to meet the excess demand so as to maintain the fixed exchange rate. if the foreign currency is sold in exchange for domestic currency by the central bank, there will be contraction of money available in the economy but if the central bank lacks sufficient foreign currency reserves at hand, it will result to imposition of exchange controls in other to restrict the demand for foreign currency so as to match the current level of supply at low exchange rate (that is, overvalued domestic currency). The above scenario will give rise to the black market business for foreign currency, the problem at hand becomes a practical one since it evolves around the central bank being able to maintain exchange controls and fight the black market mayhem.

Exchange Rate in Nigeria: It's Management

The exchange rate is a useful macroeconomic indicator which aid policy makers to take informed actions to stimulate or sustain the economy on a long run path (Tule & Duke, 2007). It is interesting to note that exchange rates has come to stay and also exist amongst countries since there must be exchange of their national currencies with foreign currencies for trade and financial transactions to take place thus exchange rate can be defined as the price of a country's currency stated in units of another currency. For a developing country like Nigeria, the price of foreign exchange plays a highly significant role in the ability of the economy to attain optimal productive capacity (Genevesi, 1996; Mba, 2014). Genevesi in 1996 also said that before the dramatic change in exchange rate management policy in the wake of the economic reform programme that began in July 1986, the supply of foreign exchange to the economy was heavily subsidized through the overvaluation of the domestic currency (the naira). In the years of abundant foreign exchange earnings, for example 1974-1980, the impact of this subsidy was felt mainly on the consumption side. The manufacturing sector also benefitted but agriculture suffered inadvertently. When the economic crisis started in January 1981, efforts to preserve the subsidy became futile; the subsidy went as economic rent to a handful of opportunists, and the expected benefits of a fixed rate at less than market price were lost to the economy (Genevesi, 1996; Mba, 2014).

Prior to the introduction of structural adjustment programme in Nigeria in 1986, the country adopted a fixed exchange rate regime supported by exchange control regulations that engendered significant distortions in the economy (Olowe, 2009). During the pre-SAP period, precisely (1970- June 1986), the exchange rate of the naira was administratively managed and backed up by control measures (Ifionu & Ogbuagu, 2007).

Theoretical framework

In contemporary analytical discourse, three theories on which these research adventures anchor are: Mint parity theory; Purchasing power parity theory; and Balance of payments parity.

The mint parity theory is associated with international gold standards, where the currency in use was made of gold or converted into gold at a fixed rate. Thus, the value of the currency unit was defined in terms of certain weight of gold, and the apex bank of the country bought and sold gold at the specified

price. The rate at which the standard money of the country was converted into gold was the mint price of gold. The actual rate of exchange, therefore, prevailed around mint parity relative to the cost of shipping gold between two countries.

The exchange rate under the gold standard was still subject to and operationally determined by the forces of demand and supply between the gold points. The purchasing power parity (PPP) theory seeks to determine the exchange rate between countries under inconvertible paper currency system. The purchasing power parity, thus, represents the quotients of purchasing power of the different currencies. Equilibrium exchange rate between two inconvertible paper currencies is attained where there is equality of purchasing power, anchored on relative price levels. In the balance of payments theory, favorable balance of payments is expected to raise exchange rate as driven by the demand and supply of foreign exchange. The rate of foreign exchange may also be associated with seasonal trade fluctuations in export and import commodities.

Consequently, foreign exchange dynamics continue to pose strategic challenges to economic management and administration in developing economies coupled with the intrigues of conducting trade within global policy infrastructure. It has equally been observed that the introduction of Dutch Auction System in Nigeria has not shown appreciable efficiency over the years as the market is highly characterized by exchange rate instability, insignificant premium and declining reserves (Ogbonna, 2010; Nnanna, 2004; Onoh, 2002). In the face of scarce foreign exchange resources, the apex bank of the nation closely monitors the use of periodic releases of foreign exchange to ensure that appropriation and application by various sectors are in line with strategic economic priorities. This foreign exchange management strategic template facilitates the realization and sustenance of favorable balance of payments position anchored on stability of the auspicious exchange rate of the nation's currency to other major currencies in the global arena. In Nigeria in particular, it is considered quintessential to accentuate efficient and effective management of foreign exchange dynamics in view of the macroeconomic connect with external reserves. Where the process runs smoothly, the economy stands to harness critical advantages such as: Availability of liquidity for settlement of international transactions especially in periods of temporary constraints on the balance of payments of the nation; Sustenance of reasonable import level in the face of high domestic propensity to import; Maintenance of high level of reserves required to create high level confidence in the nation's currency; Supply of

the desired quantum of foreign exchange for intervention in the market in order to keep the exchange rate stable; and Enhancement of the country's international credit worthiness rating, as balance of payments represents a veritable line of defense of a country's strategic credibility.

Methodology

The study adopts cross sectional survey. Secondary data was used which comprises of monthly exchange rate obtained from Federal office of statistics, Central Bank of Nigeria and daily financial publications. The periods cover was after 1986 which was regarded as post - SAP era, the period naira lost its value and when Nigeria experience volatility in exchange rate. Pre – SAP periods were not considered because exchange rate was relatively stable and naira still had its value. The variable of interest is the monthly exchange rate and the major currency under consideration is the Naira-Dollar exchange rates. The null hypotheses formulated for the study are;

H_{01}: the Nigerian exchange rate movement does not follow a markovian process and will not converge in the long run
H_{02}: no forecasting model is most suitable in predicting exchange rate dynamism in Nigeria.

Q^T has an asymptotic Chi-square distribution and predictive models were was used to test the formulated hypotheses. The model specification for the study is given as;

$$\hat{P}_{ij}^{k}=\begin{bmatrix} P_{11}^{k} & P_{12}^{k} \\ P_{21}^{k} & P_{22}^{k} \end{bmatrix}$$

Where
P_{11}^{k} = the transition probabilities that appreciation state of the exchange rate will be followed by the appreciation state of the exchange rate by a k^{th} order etc and

$$\hat{P}_{ij}^{k}=\begin{cases} \frac{f_{ij}^{k}}{\sum_{ij=1}^{n} f_{ij}^{k}} & \text{if } \sum_{ij=1}^{n} f_{ij}^{k} \neq 0 \\ 0 & otherwise \end{cases}$$

Discussion of findings

From the table 1 in the appendix, the transition probability table revealed that, there was a zero probability value for the exchange rate that switched from an appreciation to appreciation state and the years affected are; 2002, 2003 and 2009 which implies that Naira never moved from an appreciation

state to another appreciation state but rather depreciate against dollar. It can also be seen that, depreciation to depreciation state has a zero probability for 2005, 2006, 2007 and 2008 successively, which implies that instead of depreciating, it appreciates. A zero probability value for depreciation to appreciation also occurred in 1999. The pooled transition probability matrix ($PTPM_{1999\text{-}2011}$) is given as:

$$PTPM = \begin{bmatrix} 0.53 & 0.47 \\ 0.37 & 0.63 \end{bmatrix}$$

This means that, 0.53 is the pooled probability transition value for appreciation to appreciation from the year 1999 to the year 2011, 0.47 for exchange rate appreciation state to exchange rate depreciation state, 0.37 for depreciation to appreciation and 0.63 for depreciation to depreciation states.

From table 2 in the appendix, it can be seen that there is a disparity in the second regime and the first regime in terms of its variances and means which implies that the exchange rate in the second regime converges more, that is, the variations are lower in the second regime with 199.383 than in the first regime with 388.505 showing that there is a more steady and stable economy unlike in the first regime with a high variation indicating that there isn't a stable economic condition in the first regime. Exchange rate in the first and second regime considering the mean shows on average that both regimes one and two are in the neighbourhoods of 127 but regime two is with a better and low variability which gives a better economy.

The entire sample was divided into two sub-samples; 1999-2005 and 2006-2011. The decision rules is that if $X^2_{calculated}$ is greater than $X^2_{tabulated}$, H_0 should be rejected otherwise accept. The result from table 3 and 4 in the appendix shows that all the chi square values are greater than tabulated value. With this, the exchange rate follows a markovian process. The Chapman-Kolmogorov equation was applied to the monthly exchange rate data which already has been transformed to the pooled transition probability matrix to check for convergence and the iterations. From the iterations table in the appendix, it can be seen that convergence was almost attained at the eighth and at exactly the ninth iterations which could also be referred to as the eighth and ninth year after 2011 i.e. 2019 and 2020 with the convergence probability values of 0.4404762 (for the appreciation state) and 0.5595238 (for depreciation state) respectively. With this, at any chosen period after convergence, the probability values remain the same. This is

referred to as steady or stationary values of the exchange rate i.e. 44% and 56% are appreciation state and depreciation respectively of the naira via dollar exchange rate. A contrary value would not give the needed equilibrium in the long run.

The mean return time (MRT) on average takes the Naira-Dollar exchange rate two months to return to an appreciation state, that is, if it happens to be in a depreciation state at a particular time t, it would on an average take it two months (2.27) to return to an appreciation state which was the state it left.
From table 7 in the appendix, it can be seen that on an average the Naira-Dollar exchange rate remains on an appreciation (state 1) 1.86 which signifies a month and nine days; simply add 2.13 to 1.59 and take the average. It would also stay or remain in a depreciation state (state 2), that is 2.29, which implies two months and three days (add 1.89 to 2.70 then take the average). Whether the Naira-Dollar exchange rate is in state 1 or state 2, one can see that it remains longer on an average on the depreciating state than on the appreciating state. The difference between the values, 1.86 and 2.29 isn't much since to the nearest whole number; both states are approximately two months which can also be seen from table 6, still approximately two months (to the nearest whole number) . It implies that there are no noticeable difference between the time the Naira-Dollar exchange rate takes on an average to return to a state it left and the time it takes on an average to remain on a particular state which means that in the long run, there would be stability in the Naira-Dollar exchange rate.

From the analysis in the table 9 of the appendix, it can be seen that the forecasted values ranging from January 2012 to December 2014 had both upper confidence limits and lower confidence limits. The forecasted results from the SARIMA model and the observed values were verified and it was discovered that the observed values were actually within the confidence limits of the forecast and also there was no significant difference between the predicted/forecasted values and the observed/actual values. They were actually in the neighbourhood of 139.31 to 178.66 confidence limits.

Policy Formulation

Based on the findings, it was revealed that the model is adequate for controlling of fluctuations in the exchange rate movement and also that the convergence reached by the Markov analysis via the Chapman Kolmogorov iterations in the long run should be made a thing of the short run and policies

by Federal Ministry of Finance and Economic Planning should be put in place to further enhance the management of exchange rate in Nigeria.

Conclusion and Recommendations

This study concluded that, exchange rate convergence occurred in the long run via the Chapman Kolmogorov equations and iterations which were basically achieved exactly at the ninth iteration that is the ninth year (2020). This suggests that, appreciation and depreciation of the naira via dollar rate would be stable as indicated by the probability values of 44% and 56% respectively. However, the Nigerian exchange rate movement follows a markovian process i.e. memoryless (current value does not depend on the immediate past period).

Besides, a time series Box-Jenkins model specification was established, which was actually best in predicting exchange rate dynamics in Nigeria both in the in-sample and out-of-sample periods. Three parameters estimated via the Yule-Walker estimation was discovered and each of the parameters estimated were significant. A diagnostic check was carried out so as to enhance the credibility of the model identified and from the residual ACF, it was seen that the model was actually adequate and fit since the values all fall within the upper and lower confidence level. The exchange rate dynamics were also classified into states and thus the mean return time and mean sojourn time were also identified. A time series model was specified that actually showed that both the observed, fitted and forecasted values follow same trend without deviations each been superimposed on the other which also enhanced the predictive power and gave more credence to the SARIMA(0,1,1)(1,0,1) model identified. The model is recommended for the Federal Ministry of Finance and Economic Planning of Nigeria to predict and control volatility in the exchange rate.

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APPENDIX

Table 1: TRANSITION PROABILITY MATRICES

YEAR	SWITCHING REGIMES	TRANSITION FREQUENCY MATRICES AND TRANSITION PROBABILITY MATRICES (TPM)	YEAR	SWITCHING REGIMES	TRANSITION FREQUENCY MATRICES AND TRANSITION PROBABILITY MATRICES (TPM)
1999	$\begin{bmatrix} aa & ad \\ da & dd \end{bmatrix}$	$\begin{bmatrix} 2 & 1 \\ 0 & 9 \end{bmatrix}$ $\begin{bmatrix} 0.67 & 0.33 \\ 0 & 1 \end{bmatrix}$	2006	$\begin{bmatrix} aa & ad \\ da & dd \end{bmatrix}$	$\begin{bmatrix} 6 & 3 \\ 3 & 0 \end{bmatrix}$ $\begin{bmatrix} 0.67 & 0.33 \\ 1 & 0 \end{bmatrix}$
2000	$\begin{bmatrix} aa & ad \\ da & dd \end{bmatrix}$	$\begin{bmatrix} 1 & 3 \\ 3 & 5 \end{bmatrix}$ $\begin{bmatrix} 0.25 & 0.75 \\ 0.375 & 0.625 \end{bmatrix}$	2007	$\begin{bmatrix} aa & ad \\ da & dd \end{bmatrix}$	$\begin{bmatrix} 7 & 3 \\ 2 & 0 \end{bmatrix}$ $\begin{bmatrix} 0.7 & 0.3 \\ 1 & 0 \end{bmatrix}$
2001	$\begin{bmatrix} aa & ad \\ da & dd \end{bmatrix}$	$\begin{bmatrix} 5 & 2 \\ 2 & 3 \end{bmatrix}$ $\begin{bmatrix} 0.71 & 0.29 \\ 0.4 & 0.6 \end{bmatrix}$	2008	$\begin{bmatrix} aa & ad \\ da & dd \end{bmatrix}$	$\begin{bmatrix} 7 & 3 \\ 2 & 0 \end{bmatrix}$ $\begin{bmatrix} 0.7 & 0.3 \\ 1 & 0 \end{bmatrix}$
2002	$\begin{bmatrix} aa & ad \\ da & dd \end{bmatrix}$	$\begin{bmatrix} 0 & 1 \\ 3 & 8 \end{bmatrix}$ $\begin{bmatrix} 0 & 1 \\ 0.27 & 0.73 \end{bmatrix}$	2009	$\begin{bmatrix} aa & ad \\ da & dd \end{bmatrix}$	$\begin{bmatrix} 0 & 2 \\ 3 & 7 \end{bmatrix}$ $\begin{bmatrix} 0 & 1 \\ 0.3 & 0.7 \end{bmatrix}$

2003	$\begin{bmatrix} aa & ad \\ da & dd \end{bmatrix}$	$\begin{bmatrix} 0 & 6 \\ 2 & 4 \end{bmatrix}$ $\begin{bmatrix} 0 & 1 \\ 0.33 & 0.67 \end{bmatrix}$	2010	$\begin{bmatrix} aa & ad \\ da & dd \end{bmatrix}$	$\begin{bmatrix} 2 & 4 \\ 3 & 3 \end{bmatrix}$ $\begin{bmatrix} 0.33 & 0.67 \\ 0.5 & 0.5 \end{bmatrix}$
2004	$\begin{bmatrix} aa & ad \\ da & dd \end{bmatrix}$	$\begin{bmatrix} 6 & 1 \\ 1 & 4 \end{bmatrix}$ $\begin{bmatrix} 0.86 & 0.14 \\ 0.2 & 0.8 \end{bmatrix}$	2011	$\begin{bmatrix} aa & ad \\ da & dd \end{bmatrix}$	$\begin{bmatrix} 1 & 2 \\ 2 & 7 \end{bmatrix}$ $\begin{bmatrix} 0.33 & 0.67 \\ 0.22 & 0.78 \end{bmatrix}$
2005	$\begin{bmatrix} aa & ad \\ da & dd \end{bmatrix}$	$\begin{bmatrix} 4 & 5 \\ 3 & 0 \end{bmatrix}$ $\begin{bmatrix} 0.44 & 0.56 \\ 1 & 0 \end{bmatrix}$			

Markov parameter estimates	Regime 1(appreciation state)	Regime 2(depreciation state)
η_1	0.5595238	
η_2		0.4404762
μ_1	127.3429	
μ_2		127.0152
σ_{u1}^2	388.505	
σ_{u2}^2		199.383
ρ_{11}	0.53	
ρ_{12}		0.47
ρ_{21}	0.37	
ρ_{22}		0.63

Table 2: MARKOV MODELPARAMETER ESTIMATES

Table 3: CHECK IF EXCHANGE RATE MOVEMENT FOLLOWS A MARKOVIAN PROCESS
(t-sub sample; from 1999-2005)

$Q^T=X^2_{Calculated}$	$X^2_{tabulated(0.05)}$	Decision
4.252	3.841	Accept H_1
4.286	3.841	Accept H_1
5.1088	3.841	Accept H_1
4.6552	3.841	Accept H_1

Table 4: CHECK IF EXCHANGE RATE MOVEMENT FOLLOWS A MARKOVIAN PROCESS
(t-sub sample; from 2006-2011)

$Q^T=X^2_{Calculated}$	$X^2_{tabulated(0.05)}$	Decision
.2751	3.841	Accept H_1
4.3102	3.841	Accept H_1
5.9072	3.841	Accept H_1
5.1201	3.841	Accept H_1

Table 5: CHAPMAN KOLMOGOROV ITERATIONS FOR THE TRANSITION PROBABILITY MATRIX

C-K iterations	C-K transition matrices
n=1	$\begin{bmatrix} 0.53 & 0.47 \\ 0.37 & 0.63 \end{bmatrix}$
n=2	$\begin{bmatrix} 0.4548 & 0.5452 \\ 0.4292 & 0.5708 \end{bmatrix}$
n=3	$\begin{bmatrix} 0.442768 & 0.557232 \\ 0.438672 & 0.561328 \end{bmatrix}$
n=4	$\begin{bmatrix} 0.4408429 & 0.5591571 \\ 0.4401875 & 0.5598125 \end{bmatrix}$
n=5	$\begin{bmatrix} 0.4405349 & 0.5594651 \\ 0.44043 & 0.55957 \end{bmatrix}$
n=6	$\begin{bmatrix} 0.4404856 & 0.5595144 \\ 0.4404688 & 0.5595312 \end{bmatrix}$
n=7	$\begin{bmatrix} 0.4404777 & 0.5595223 \\ 0.4404750 & 0.5595250 \end{bmatrix}$
n=8	$\begin{bmatrix} 0.4404764 & 0.5595236 \\ 0.440476 & 0.559524 \end{bmatrix}$
n=9	$\begin{bmatrix} 0.4404762 & 0.5595238 \\ 0.4404762 & 0.5595238 \end{bmatrix}$
n=50	$\begin{bmatrix} 0.4404762 & 0.5595238 \\ 0.4404762 & 0.5595238 \end{bmatrix}$
n=100	$\begin{bmatrix} 0.4404762 & 0.5595238 \\ 0.4404762 & 0.5595238 \end{bmatrix}$
n=∞	$\begin{bmatrix} 0.4404762 & 0.5595238 \\ 0.4404762 & 0.5595238 \end{bmatrix}$

Table 6 Mean Return Time (MRT)

States	=steady state probability values	MRT(approximated values)
1=appreciation	0.4404762	2.27
2=depreciation	0.5595238	1.79

Table 7 Mean Sojourn Time (MST)

Switching Regimes under states	MST(approximated Values)
aa= appreciation to appreciation	2.13
ad=appreciation to depreciation	1.89
da= depreciation to appreciation	1.59
dd=depreciation to depreciation	2.70

Table 8 MODEL ESTIMATION

Parameters	Estimate	SE(standard error)	T	sig
MA	-0.294	0.079	-3.712	.000
AR, Seasonal	-0.994	0.205	-4.849	.000
MA Seasonal	-0.974	0.482	-2.022	0.002

* The order of non-seasonal differencing is 1

Table 9: BOX-JENKINS (IN-SAMPLE AND OUT OF SAMPLE FORECAST)

Year	Forecast	UCL	LCL	Observed values	Year	Forecast	UCL	LCL	Observed values
Jan 2012	158.42	162.88	153.95	158.4	Jul 2013	159.13	183.74	134.52	NA
Feb 2012	158.58	165.88	151.28	157.9	Aug 2013	159.42	184.66	134.18	NA
Mar 2012	158.35	167.67	149.04	157.6	Sep 2013	159.41	185.26	133.56	NA
Apr 2012	158.19	169.14	147.23	157.3	Oct 2013	159.26	185.70	132.81	NA
May 2012	158.08	170.46	145.69	157.3	Nov 2013	159.53	186.56	132.51	NA
Jun 2012	158.23	171.90	144.56	157.4	Dec 2013	158.87	186.46	131.27	NA
Jul 2012	158.72	173.56	143.88	157.4	Jan 2014	158.42	186.61	130.24	NA
Aug 2012	158.43	174.35	142.50	157.4	Feb 2014	158.58	187.36	129.81	NA
Sep 2012	158.44	175.38	141.50	155.3	Mar 2014	158.36	187.72	129.01	NA
Oct 2012	158.59	176.49	140.70	155.28	Apr 2014	158.20	188.11	128.28	NA
Nov 2012	158.32	177.12	139.51	155.25	May 2014	158.09	188.55	127.62	NA
Dec 2012	158.99	178.66	139.31	155.26	Jun 2014	158.24	189.25	127.23	NA
Jan 2013	159.43	179.90	138.97	NA	Jul 2014	158.72	190.26	127.18	NA
Feb 2013	159.27	180.48	138.06	NA	Aug 2014	158.43	190.50	126.37	NA
Mar 2013	159.49	181.43	137.56	NA	Sep 2014	158.45	191.03	125.87	NA
Apr 2013	159.66	182.29	137.03	NA	Oct 2014	158.60	191.69	125.51	NA
May 2013	159.77	183.08	136.46	NA	Nov 2014	158.32	191.91	124.74	NA
Jun 2013	159.62	183.59	135.65	NA	Dec 2014	158.99	193.07	124.91	NA