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Abstract

How well does the monetary exchange rate model explain exchange rate behaviour in Nigeria? Using the Johansen (1991) and Johansen and Juselius (1990) cointegration technique, this paper examines the long-run validity of the monetary exchange rate model in Nigeria for the flexible exchange rate regime with quarterly data covering the period 1987 to 2008. We found a unique long-run relationship between the nominal exchange rate and the traditional monetary fundamentals (money supply, output and interest rate differentials). The estimated cointegrating coefficients were theoretically consistent with the monetary model and statistically significant exception of the output differential. In particular, this evidence supports strongly the monetary exchange rate model in Nigeria which could be used to model the naira-US dollar exchange rate movement.

Keywords: Exchange rate; Monetary fundamentals; Monetary exchange rate model; Cointegration; Nigeria.

JEL Classification: C22, C32, E4, F31, F41.

1. Introduction

Exchange rate determination remains an important issue both for the economists and policy analysts alike. As a key price variable in an economy, an exchange rate performs the role of a nominal anchor for domestic prices and maintains international competitiveness. Since the collapse of the Bretton Woods system, exchange rates have become volatile and intractable. The difficulty in tracking the exchange rate movement not only harms trade but also disrupts economic growth and development.

For decades, modelling the exchange rate has been an important issue in international finance. Several models explaining exchange rate behaviour have been developed mainly within the monetary approach to exchange rate determination with two variants: the flexible-price monetary model (Frankel 1976; Bilson, 1978) and the sticky-price monetary model (Dornbush, 1976). The monetary exchange rate model posits a relationship between the nominal exchange rate and a set of monetary fundamentals. Intuitively, the monetary model assumes that a country's exchange rate is determined by its money supply and demand through the purchasing power parity (PPP) relationship. Hence, it does not only provide a long-run benchmark for the nominal exchange rate between two currencies but also a criterion for determining whether a currency is significantly "overvalued" or "undervalued" (Rapach and Wohar, 2002).

The standard approach to testing the monetary exchange rate model has been through the cointegration techniques of Johansen-Juselius (1990) and Johansen (1991). Examples include Macdonald and Taylor (1991, 1994), Kouretas (1997), Dutt and Ghosh (2000),Groen (2002), Cusham (2000), Mark and Sul (2001), Rapach and Wohar (2002), Chin *et al*. (2007), Lee *et al*. (2007), Long and Samareth (2008), Liew *et al*. (2009), and for Nigeria, Jimoh (2004) and Nwafor (2006)[2]. However, the most important issue is not the existence of cointegrating relationship between the exchange rate and the traditional fundamentals, but the theoretical consistency of the cointegrating coefficient estimates. In the presence of cointegration, if the cointegrating coefficient estimates maintains the *a prior* assumptions then the monetary exchange rate model is deemed valid and capable of explaining exchange rate behaviour.

This paper's objective is to re-examine the validity of the monetary exchange rate model in Nigeria for the period 1987 to 2008 covering the era of floating exchange rate regime. This study is significant because evidence of the monetary model in Nigeria is scanty with few studies testing for only the existence of a long-run relationship without providing parameter estimates that links the impact of the monetary fundamentals on the exchange rate. The questions that this paper seeks to answer include: (1) how well does the monetary model explain the fluctuations in nominal exchange rates? (2) Is there any cointegration relationship between the exchange rate and monetary variables? (3) Are the cointegrating coefficient estimates theoretically consistent?

[2] See the section on Literature review

The paper is structured as follows: section 2 provides a review of the empirical literature on the monetary exchange rate model. Section 3 presents the theoretical framework for the monetary exchange rate model. Section 4 describes the methodology and data used in the research. Section 5 reports the empirical results, while section 6 gives the concluding remarks for the study.

2. Review of Related Literature

The monetary exchange rate model literature has grown exponentially since the post-Bretton Woods float. The interest of researchers has been to determine a reliable set of fundamental economic variables influencing the exchange rate behaviour in the wake of its increasing volatility and intractability. Emphasis has been on testing the predictability performance and long-run validity of the monetary model using standard cointegration techniques.

Several studies have estimated various versions of the monetary model with mixed evidence. Meese and Rogoff (1983) in their seminal contribution finds that the out-of-sample forecasting performance of these models fails to outperform a simple random walk model at short horizons. However, studies by Mark (1995), Chinn and Meese (1995), MacDonald and Taylor (1994) have shown that for a small set of monetary fundamentals, the out-of-sample forecast improves upon the random walk model. The robustness of these results has been questioned by Berben and van Dijk (1998) and Berkowitz and Giorgianni (2001) based on the assumption of a stable cointegrating relationship. Recent studies admit the possibility albeit difficulty in beating the random walk forecast (see for example, Mark and Sul, 2001; Rapach and Wohar, 2002).

On the other hand, researchers have examined the long-run relationship of the monetary exchange rate model using cointegration approach[3]. Groen (1999) emphasized the importance of cointegration in establishing a long-run link between nominal exchange rate and monetary fundamentals. In the absence of cointegration, the long-run predictability of the monetary model breaks down (Mark, 1995; Chinn and Meese, 1995; Groen, 1999). MacDonald and Taylor (1991) examined the long-run validity of the monetary model of exchange rate by employing the Johansen's multivariate cointegration technique and provide supportive evidence for both the US dollar and British pound. Choudhry and Lawler (1997) applied both Johansen-Juselius and Engle-Granger cointegration tests for Canada and found the existence of a long-run relationship for Canadian dollar-US dollar. This evidence is further supported by Kouretas (1997). Dutt and Ghosh (2000) found evidence in favour the monetary model for the nominal Japanese yen-US dollar exchange rates. Miyakoshi (2000) examined the flexible-price monetary model in the case of Korea during the period 1980M1 to 1996M12. Using Johansen-Juselius cointegration technique, they found the Korean Won exchange rates to be cointegrated with money supplies, incomes and interest with the US dollar, German mark and Japanese yen as numeraires. Liew *et al*. (2009) reports a long-run relationship for Thailand's exchange rate based on the flexible-price monetary model. Lee *et al*. (2007) and Long and Samareth (2008) using different cointegration approaches found evidence in support of the monetary model for the Philippines; while same conclusion is reached for Malaysia by Chin *et al*. (2007). Shylajan *et al*. (2011) applied the Johansen-Juselius cointegration technique to investigate the link between the Indian rupee-US dollar exchange rates and a set of macroeconomic fundamentals using the flexible-price monetary model (FPMM). They found the existence of long-run relationship between exchange and the macroeconomic variables implying the validity of the FPMM model in the Indian context

[3] Macdonald and Talylor (1991) argue that the multivariate cointegration technique is more appropriate than the two-step cointegration methodology in testing the monetary model. This has become widely used in the literature.

although the vector error-correction model (VECM) analysis did not show any short-run casual relationship.

Another strand of the literature finds little evidence in favour of the monetary exchange rate model (e.g. Meese, 1986; McNown and Wallace, 1989; Sarantis, 1994; Cusham, 2000). Sarantis (1994) applied the Johansen cointegration framework to investigate three variants of the long-run monetary approach to exchange rate determination and found no statistical evidence in support long-run equilibrium relationship consistent with the flexible-price monetary model. Cusham (2000) found cointegration relationship for the monetary model using Canadian – US dollar exchange rate but since the estimated cointegrating coefficients were inconsistent with those predicted by the monetary model, he concluded that the data does not support the monetary model.

The long-run relationship for the monetary exchange rate model has also been examined using panel data framework and long historical data with supportive evidence (e.g. Groen, 2000; Mark and Sul, 2001; Crespo-Cuaresma et al., 2004; Uz and Ketenci, 2007; Rapach and Wohar, 2002). Groen (2000) and Mark and Sul (2001) follow the first approach and tested for a stable long-run relationship between nominal exchange rate and monetary fundamentals using panel cointegration tests for the post-Bretton Woods. Both found strong evidence of cointegration among nominal exchange rates, relative money supplies, and real output levels. Uz and Ketenci (2007) tested the monetary model using panel data for ten new members of the European Union and Turkey over 1993:1 and 2005:4 and finds strong evidence of cointegration between exchange rates and monetary model. Crespo-Cuaresma *et al*. (2004) used the panel cointegration techniques for six Central and Eastern European countries[4] to estimate the monetary exchange rate model supplemented with the Balassa-Samuelson effect and found that the monetary model provides a good explanation of the fluctuations in nominal exchange rates. Rapach and Wohar (2002) follows the second

[4] This includes Czech Republic, Hungary, Poland, Romania, Slovakia and Slovenia.

approach using long span of data with results supporting a simple long-run monetary model of the U.S. dollar exchange rate determination for France, Italy, the Netherlands and Spain; moderate support Belgium, Finland and Portugal; and weaker support for Switzerland.

For Nigeria, the literature on exchange rate determination based on the monetary exchange rate model is increasing. Jimoh (2004) tested the monetary model of exchange rate determination in Nigeria during the floating regime between 1987 and 2001 (quarterly series) using the two-step cointegration methodology. He finds that the monetary approach fits the Nigerian exchange rate behaviour. Nwafor (2006) applied the Johansen's multivariate cointegration procedure to the naira-dollar exchange rates for the period 1986 and 2002 (quarterly series) and finds at least one cointegrating vector which suggests the existence of a long-run monetary model of exchange rate in Nigeria. Alao *et al*. (2011) examined the flexible price monetary model for the naira-US dollar exchange rates using time series data for the period 1986-2008. Applying Johansen cointegration test, they found that one cointegrating vector and concluded that the variability of the nominal naira-dollar exchange rate was consistent with flexible price model.

Although, most studies have focused on the existence of a long-run relationship within the monetary model framework, very few have tested its validity in terms of the estimated cointegrating coefficients being theoretically consistent with the monetary exchange rate model. To our knowledge, no study has examined this for Nigeria. Hence, it is imperative to re-examine the monetary model of exchange rate in Nigeria.

3. Monetary Exchange Rate Model Framework

The monetary approach to exchange rate has been the standard instrument of analysis in international finance. The main features of the monetary approach to exchange rate determination start with the flexible-price formulation (Frankel, 1976; Bilson, 1978). The standard monetary model contains three basic building blocks: monetary market equilibrium, purchasing power parity (PPP) and uncovered interest rate parity (UIP)[5].

The starting point of the monetary approach is the definition of exchange rate as the relative price of two monies in terms of the relative supply and demand for money. The money demand relationships between the domestic and foreign country can be expressed as a monetary equilibria as follows:

$$m_t = p_t + ky_t - \lambda i_t \tag{1}$$

$$m_t^* = p_t^* + ky_t^* - \lambda i_t^* \tag{2}$$

where m_t, p_t, y_t and i_t denote the log-levels of the domestic money supply, price level, income level and interest rate level respectively at time *t*; k and λ are positive constants; asterisks denote foreign variables. In the monetary model, the real interest rate is assumed to be exogenous in the long-run and determined in the world markets because of the assumption of perfect mobility of capital and goods.

Another building block of the monetary approach is the absolute power purchasing parity (PPP) which holds that goods market arbitrage will tend to move the exchange rate until prices in both domestic and foreign countries are equalized. Therefore, the monetary approach assumes that PPP holds continuously so that:

$$e_t = p_t - p_t^* \tag{3}$$

where e_t is the log-level of the nominal bilateral exchange rate (the domestic price of the foreign currency). The domestic money supply determines the domestic price level and hence the exchange rate is determined by the relative money supplies. Solving for $(p_t - p_t^*)$ by subtracting (2) from (1), the nominal exchange rate becomes as follows:

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[5] The UIP asserts that with open markets, expected changes in the nominal exchange rate are equal to the interest rate differential. This is expressed as $E_t(\Delta s_{t+1}) = (i_t - i_t^*)$, where $E_t(\Delta s_{t+1})$ denotes the market expectation of the change in the exchange rate.

$$e_t = (m_t - m_t^*) + (ky_t - ky_t^*) + (\lambda i_t - \lambda i_t^*) \quad (4)$$

which is the fundamental monetary model equation. For simplicity, the model assumes that the income elasticities and interest rate semi-elasticity of money demand are the same for domestic and foreign countries. Therefore, (4) reduces to the following:

$$e_t = (m_t - m_t^*) + k(y_t - y_t^*) + \lambda(i_t - i_t^*) \quad (5)$$

Based on equation (5), the monetary model postulates that exchange rate movement may be determined by the differentials of money supply, income and interest rate. Accordingly, the transmission mechanism maintains the monetary market equilibrium through changes in the nominal exchange rate as follows: an increase in the domestic money supply relative to the foreign counterpart produces an equiproportionate depreciation of the currency; income differential and interest rate differential have negative and positive impact on the exchange rate respectively. Therefore, income differential and interest rate differential will produce exchange rate appreciation and depreciation respectively. In addition, the elasticities for the domestic and foreign money supply are assumed to be identical although both variables have opposite effects on the exchange rate. The same assumption holds for the domestic and foreign interest rate variables.

4. Methodology and Data

The conventional approach to validating the long-run relationship between exchange rate and the monetary variables follows from the multivariate cointegration framework of Johansen (1988; 1991) and Johansen-Juselius (1991). The technique is superior to the Engle and Granger (1987) two-step methodology because of the underlying time series properties of the data, and provides estimates of all cointegrating vectors existing within a vector of variables along with test statistics for the number of cointegrating vectors (Macdonald and Taylor, 1991). In order to apply the Johansen tests, two conditions must be met. First, the time series properties must be tested and all variables integrated at order one, *I* (1), such that the linear combination of the variables will be stationary. . Second, is the selection of the appropriate lag length for which the residuals in the system are white noise (i.e. absence of serial correlation). Consequently, we estimate a standard linear vector autoregression (VAR) framework by using the Johansen full-information maximum likelihood cointegration methodology represented as:

$$\Delta Z_t = \mu + \sum_{i=1}^{p} \Gamma_i \Delta Z_{t-i} + \prod Z_{t-1} + u_t \qquad (6)$$

Where Z_t = $[e_t, m_t - m_t^*, y_t - y_t^*, i_t - i_t^*]'$ is the column vector for the cointegrating relation based on the monetary exchange rate model, Γ_i's are the parameters, and $\prod = \alpha\beta'$ is an $m \times m$ matrix of unknown parameters, where α and β are $m \times r$ matrices representing the reversion rate and cointegrating parameters for the system. Johansen (1995) proposes two test statistics for determining the number of cointegration vectors: maximum-eigenvalue (λ-max) and trace statistics. The trace test is used to test the null hypothesis of at most *r* cointegrating vectors against the alternative of more than *r* cointegrating vectors, and is given as:

$$\lambda_{trace} = -T \sum_{i=r+1}^{k} \ln(1 - \lambda_i) \qquad (7)$$

On the other hand, the maximum eigenvalue statistic tests the null hypothesis of *r* cointegrating vectors against the alternative *r* + 1 cointegrating vectors and it is computed as:

$$\lambda_{max} = -T(1 - \lambda_{r+1}) \qquad (8)$$

Specifically, the Johansen's maximum likelihood procedure for testing the existence of a cointegration relationship is applied to the monetary model of exchange rate equation given as follows:

$$e_t = \beta_1(m_t - m_t^*) + \beta_2(y_t - y_t^*) + \beta_3(i_t - i_t^*) \qquad (9)$$

The expected coefficient signs for the long-run monetary model must be $\beta_1, \beta_3 > 0$ and $\beta_2 < 0$. If one of the cointegrating relationships is consistent with the expected coefficients in (9), then the monetary model of exchange rate holds in the long-run. Both test statistics are used in this paper for robust comparison of results.

The analysis is based on quarterly data for the period between 1987:1 and 2008:4 which spans both the fixed and floating exchange rate regimes periods in Nigeria. The reference country is the United States. Broad money supply (M2) proxies the monetary aggregates whereas Index of Industrial Production proxies the income level. Interest rates are short-term discount rates while nominal exchange rate is quarterly averages in terms of the naira-US dollar. The quarterly series of index of industrial production, nominal exchange rate and short-term discount rates are compiled from the International Monetary Fund (IMF) *International Financial Statistics* CD-ROM 2010. The annual broad monetary aggregates were retrieved from the *World Development Indicators* 2011 and subsequently transformed into quarterly series using the cubic spline technique (see Lisman and Sandee, 1964; Denton, 1971). All variables are measured in log-levels for accurate comparison of the relative effect of the three main building blocks contained in the simple monetary exchange rate model.

5. Monetary Model Results

5.1 Unit root test

The first step in testing the monetary model of exchange rate is to examine the integration properties of both the nominal exchange rate and the monetary fundamentals. The standard Augmented Dickey-Fuller (1979; ADF), Phillips-Perron (1988; PP) and the Kwiatkowski et al. (1992; KPSS) unit root tests are employed. Table 1 presents the unit root test results for the variables. For all four variables in levels, only the ADF test for the interest rate differential is the null hypothesis of unit roots rejected. The tests cannot be rejected for the nominal exchange rate, money supply differential and income differential. This indicates that those variables should therefore be integrated at order one, $I(1)$.

Table 1. Unit Roots Test

Variables	ADF	PP	KPSS
Level			
e_t	-1.6415	-2.0829	1.1378
$(m_t - m_t^*)$	-1.0072	-0.2194	1.2016
$(y_t - y_t^*)$	-1.1144	-1.1477	0.7134
$(i_t - i_t^*)$	**-3.0391**	-2.5179	0.1272
First Difference			
Δe_t	**-3.7049**	**-3.6678**	**0.2481**
$\Delta(m_t - m_t^*)$	**-3.8109**	**-3.1007**	**0.0842**
$\Delta(y_t - y_t^*)$	**-3.7959**	**-3.0279**	**0.2148**
$\Delta(i_t - i_t^*)$	-2.3168	**-3.7178**	**0.0774**

Note: ADF - Augmented Dickey Fuller; PP - Phillips-Perron; KPSS - Kwiatkowski-Phillips-Schmidt-Shin. Critical values for ADF and PP are from MacKinnon (1996) one-sided p-values while that of KPSS is from Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1). Bold values indicate significance of the test statistic at 5% level.

For confirmation, the same testing procedure is applied to the variables after first differencing. Both the nominal exchange rate, money supply, income and interest rate differentials are stationary and thus integrated at order one, $I(1)$ except for the ADF test on the interest rate differential which is non-stationary. In the case of interest rate differential, we follow the majority rule based on the PP and KPSS tests for which the variable is stationary after first differencing. Therefore, a linear combination of both the nominal exchange rate and monetary fundamentals should be stationary (i.e. cointegrated). The findings of unit roots in the variables have implications on whether to model the structural VAR in levels (i.e. with non-stationary variables) or first difference (i.e. with stationary variables). As suggested in the literature, if the variables are cointegrated then modelling in levels is appropriate[6].

5.2 Cointegration test

Before applying the Johansen full-information maximum likelihood (JOH-FIML) cointegration methodology (see Johansen, 1988, 1991; Johansen and Juselius, 1990), an

[6] Sims et al. (1990) show that a VAR coefficient estimates is consistent with standard asymptotic distribution when variables have unit roots and some form a cointegration relationship.

optimal lag order must be chosen. The rationale is that the residuals in the system must be white noise, otherwise the relevant trace and maximum eigenvalue test statistics can be oversized (Cusham, 2000). For the VAR model estimated in levels for the four (4) variables, an optimal lag order of 5 is obtained, which is chosen by the sequential modified likelihood ratio statistic of Sims (1980), the Final Prediction Error (FPE) criterion, and the Akaike Information Criterion (AIC). The Breusch-Godfrey Lagrange multiplier (LM) test for serial correlation accepts the null hypothesis of no serial correlation at the optimal lag order of 5. The result for the lag order selection criteria and serial correlation is reported in the appendix.

With an optimal lag of 5, the JOH-FIML cointegration technique is applied to equation (9). The result is presented in Table 2 below. The trace and maximum eigenvalue test statistics which is statistically significant at 1% level suggest the existence of one cointegrating vector that implies cointegration between the nominal exchange rate and monetary fundamentals. In other words, there is a long-run equilibrium relationship between nominal exchange rate and monetary fundamentals for Nigeria. Hence, the Nigeria exchange rate behaviour in terms of the naira-US dollar rates in the long-run can be modelled appropriately using the traditional monetary fundamentals. The result is consistent with earlier studies by Jimoh (2004), Nwafor (2006) and, for Nigeria, with others such as Macdonald and Taylor (1991), Rapach and Wohar (2002), Loria et al. (2010) to mention a few.

Table 2. Johansen Cointegration Test

Null Hypotheses	Eigenvalue	Trace	Critical Value (5%)	Max-eigen	Critical Value (5%)
$r = 0$	0.387443	**66.34551**	47.85613	**40.18933**	27.58434
$r \leq 1$	0.206263	26.15618	29.79707	18.94224	21.13162
$r \leq 2$	0.053026	7.213940	15.49471	4.467621	14.26460
$r \leq 3$	0.032937	2.746319	3.841466	2.746319	3.841466

Notes: r indicates the number of cointegrating vector. Critical values are from MacKinnon-Haug-Michelis (1999) p-values. Bold values indicate significance of the test statistic at 1% level.

Although the preliminary evidence from the JOH-FIML cointegration test gives some support for the existence of one cointegrating vector, it does not necessarily imply support for the monetary model of exchange rate except the estimated relationships among the variables are theoretically consistent with those implied by the monetary model in equation (9). The estimated cointegrating equation is reported in Table 3 below.

Table 3. Johansen Estimates of Normalized Cointegrating Vector

	Variables and Expected signs			
	e_t	$(m_t - m_t^*)$ (+)	$(y_t - y_t^*)$ (-)	$(i_t - i_t^*)$ (+)
vector coefficients	1.0000	0.8484 (0.0352)	-0.5274 (0.3778)	0.0970 (0.0082)

Note: standard errors in parenthesis.

The coefficient values have been normalized with respect to the exchange rate so that the signs of the monetary fundamentals, if correct would match that implied by theory. With only one cointegrating vector, the interpretation of the estimated coefficients is straight forward because identification of the cointegrating space is not required as would be for several vectors. The result shows that the cointegrating vector estimates of the monetary model of exchange rate are theoretically consistent. The money supply differential is positive as expected and implies that an expansion in relative domestic money supply will induce the depreciation of the nominal naira-dollar exchange rate. The increase in domestic money supply triggers a rise in domestic price levels in relative terms, which in turn, reduces international competitiveness of domestic goods and hence deterioration in the trade balances. The estimated coefficient of the money supply differential is close to unity, which means that monetary policy is significant in determining Nigeria's exchange rate behaviour in the long-run. The interest rate differential assumes the expected positive sign and is statistically significant. One might infer that the domestic interest has declined in relative terms, inducing the depreciation of the nominal exchange rate and balance of payments deficits as a result of capital outflows. On the other hand, the income differential is negative as predicted by theory but it is insignificant. By assuming the theoretical sign, the result suggests that real sector variables such as productivity growth and economic growth may have non-transitory effects on the exchange rates. An increase in relative domestic output leads to an appreciation of the nominal exchange rate and an improvement in international competitiveness and trade balance following a reduction in the domestic price level. However, its insignificance means that relative domestic income has no impact on exchange rate movement in the long-run for Nigeria. This result is justifiable given the weak production base and low level of income in the Nigerian economy. Despite the insignificance of the income differential variable, the theoretical consistency of the estimates gives support for the monetary exchange rate model for Nigeria in the long-run. Therefore, in the long-run the naira-US dollar exchange rate is influenced most by the relative domestic money supply and interest rates than relative income level (output).

6. Conclusion

Following the application of Johansen cointegration technique as the standard approach in validating the monetary exchange rate model for both the existence of cointegrating vectors and values of their corresponding cointegrating coefficient estimates which should be consistent with the economic model, this paper tested the monetary exchange rate model for Nigeria over a long time span covering both fixed and floating exchange era (1987:1 and 2008:4).

The key findings and implications of this study are as follows. First, there exist one cointegrating vector indicating the presence of a long-run relationship between the exchange rate and the monetary fundamentals. Therefore, the fluctuations in the Nigeria naira-US dollar exchange rate depend and respond to the monetary fundamentals in the monetary exchange rate model. Second, the estimated cointegrating coefficients are theoretically consistent with the monetary exchange rate model. Specifically, all the estimated coefficients of the money supply, income and interest rate differentials support the monetary exchange rate model. As a result, market participants in the foreign exchange market may monitor and forecast future exchange rate movements using the money supplies, incomes and interest rates variables; whereas monetary authorities can strengthen the nominal exchange rate and reduce its fluctuations by following a tight monetary policy relative to the country under consideration.

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Appendix

Table A.1 VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-301.428	NA	0.020201	7.449463	7.566864	7.496598
1	349.5274	1222.526	3.80e-09	-8.03725	-7.45025	-7.80158
2	668.2945	567.5609	2.37e-12	-15.4218	-14.3652	-14.9976
3	839.1680	287.5676	5.45e-14	-19.1992	-17.67301*	-18.5865
4	872.9313	53.52720	3.58e-14	-19.6325	-17.6367	-18.83118*
5	892.8697	29.66449*	3.33e-14*	-19.72853*	-17.2631	-18.7387
6	908.4186	21.61678	3.48e-14	-19.7175	-16.7825	-18.5392

Notes: * indicates lag order selected by the criterion. LR (sequential modified LR test statistic), FPE (final prediction error), AIC (Akaike information criterion), SC (Schwarz information criterion), and HQ (Hannann-Quinn Information criterion). NA is not applicable.

Table A.2 Breusch-Godfrey Serial Correlation Test

Lags	LM-Stat	Prob
1	16.48394	0.4197
2	33.98477	0.0055
3	26.63684	0.0457
4	55.16637	0.0000
5	14.75044	0.5430
6	6.859766	0.9759

Notes: Probs from chi-square with 16 df.