

## THE UNCERTAINTY OF THE U.S. AND JAPANESE INTEREST RATES AND ITS EFFECT ON MONEY DEMAND IN MALAYSIA

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### ABSTRACT

*This paper examines the effect of the volatility of the U.S. and Japanese interest rates on the money demand in Malaysia. The volatility of the U.S. and Japanese interest rates measured as a conditional variance are estimated from the GARCH(1,1) model. The long-term relationship between real money demand in Malaysia and the volatility of the U.S., and between real money demand in Malaysia and Japanese interest rates are investigated by applying the Johansen multivariate cointegration test. Results show that the volatility of the U.S. and Japanese interest rates impose a significant influence in money demand in Malaysia. However, the opportunity cost of holding money remains to impose a larger effect on the money demand function.*

**Keywords:** money demand, GARCH, conditional variance, volatility, user cost, unit root, VAR, cointegration.

### ABSTRAK

*Kajian ini memeriksa kesan akibat daripada volatiliti kadar faedah bagi negara Amerika Syarikat dan Jepun ke atas permintaan wang di Malaysia. Volatiliti dalam kadar faedah bagi negara Amerika Syarikat dan Jepun ini diukur sebagai varian bersyarat yang di anggarkan daripada model GARCH(1,1). Hubungan jangka panjang antara permintaan wang sebenar di Malaysia dengan volatiliti dalam kadar faedah di Amerika Syarikat, dan di antara permintaan wang sebenar di Malaysia dengan kadar faedah di negara Jepun dikaji dengan menggunakan kaedah ujian kointegrasi 'Johansen multivariate'. Hasil kajian ini menunjukkan volatiliti dalam kadar faedah di negara Amerika Syarikat dan Jepun mempunyai pengaruh yang mendalam dan ianya boleh mempengaruhi corak permintaan wang di Malaysia. Walau bagaimanapun, kos melepas bagi pegangan wang masih lagi merupakan pengaruh yang lebih besar dan memberi kesan ke atas fungsi permintaan wang di Malaysia.*

## INTRODUCTION AND LITERATURE REVIEW

This paper presents an empirical analysis of the effect of the U.S. and Japanese interest rates volatility on the stability of money demand in Malaysia. A major behavioural relationship in monetary theory and policy is the demand for money. The money demand function has been subjected to extensive theoretical and empirical research because of its crucial importance as a fundamental building block in macroeconomic theory and as a critical component in the formulation of monetary policy. The effectiveness of the monetary policy depends on the stability of the money demand equation as such changes in the money supply will have a predictable impact on real variables. The evolution in the financial system as a result of technological changes and financial innovations are believed to be the factors attributed to the instability of the demand for money (Ford, Peng, & Mullineux, (1992); Ford & Mullineux, (1996)).

The current empirical research on the effect of interest rate volatility on the money demand function is rather limited and presently only confined to U.S. data. Given the fact that there may be important effects on monetary policy caused by interest rate volatility, research in this area is rather important.

In his study on intertemporal paths for household's consumption and portfolio allocation of wealth, Marquis (1989) concluded that the volatility of the interest rate could alter the optimality of the household's consumption and portfolio decision. Consequently, changes in the portfolio holding will have an affect on household's demand for money. However, in a stochastic environment these shocks are quickly offset by the subsequent shocks that attenuate the household's consumption and portfolio allocation response. On the effect of interest rate volatility on the partial equilibrium household demand for money, Marquis (1989) demonstrated that the volatility of the short-term interest rate does not necessarily imply an increase in money demand. Greater short-term or long-term interest volatility according to him has an ambiguous net effect on the household's quantity of money demanded due to cross-correlations of interest rates with each other and between interest rates and inflation rates. Garner (1990) argued that the economic experience in the U.S. in the early 1980's is difficult to interpret because of unusual circumstances that could obscure an interest rate volatility effect. He added that deposit deregulation and technological changes may have altered permanently the behaviour of money demand, and relative volatility measures may not represent accurately all movements of interest rate and inflation

rate uncertainty. Thus, an empirical study on interest rate volatility in the U.S. using a sample period of 1959-1984 provides little evidence to support the hypothesis that interest rate volatility raises demand for money. However, he found interest rate variability to have a negative impact upon money demand over the period 1959 to 1973 which he argues might be due to the inflation uncertainty dominating the relatively constant real interest rate. Garner (1990) concluded that interest rate volatility may affect real economic variables through such channels as bond risk premiums and direct effects on business investment spending. As such, a significant presence of interest rate volatility in the money demand function could have important effects on economic performance and monetary policy.

Subsequently, Arize and Darrat (1994) in their empirical study used U.S. quarterly data of 1963Q1-1991Q4 and included money-growth volatility and interest rate volatility as additional regressors in the U.S. M2 demand equation. Their study showed that there is little evidence that interest rate variability has significant influence on M2 demand for the U.S. Payne (1995) applied a Granger-causality framework to investigate the effect of the variability of the interest rate on the velocity of money. He found evidence that variability in the short-term interest rate, and in some cases, the long-term interest rate affects velocity. He concluded that the variability of interest rate measures Granger-cause velocity.

Choudhry (1999) explained that volatility in the nominal interest rate is due to the volatility in the real interest rate or in the expected rate of inflation. This explanation coincides with the suggestion by Garner (1990) that much of the actual nominal interest rate volatility may be due to inflation rate volatility which reflects the inverse relationship between money demand and interest rate volatility. Choudhry (1999) indicated that both interest rate and inflation rate volatility play a significant role in the M1 demand function in the U.S., although the size and direction of the effect is not identical in every relationship. He concluded that interest rate volatility imposes a significant effect on real M1 demand if the long-term interest rate is included in the money demand function. Furthermore, in an increasingly interdependent global economy among countries, monetary developments in one country could affect both the supply and demand for money in other countries. One implication of the increased interdependence is that the aggregate demand for money in a country could be sensitive to foreign monetary developments, such as a change in foreign interest rates (Bahmani-Oskooee, 1991). A monetary policy which is formulated to counteract foreign monetary and financial developments will require

knowledge of the sensitivity of the money supply to those events as well as knowledge of the response to the demand for money.

The literature on money demand is quite abundant but there are not many studies that link the U.S. and Japanese interest rates volatility on the stability of money demand for developing countries. Note that U.S. and Japan are the two major trading partners of many emerging economies including Malaysia. The Increasing globalisation of the financial system and interdependent of global economy among countries today may have significant implication towards formulating the effective monetary policy in Malaysia. Thus, it is imperative to understand how these external factors, particularly the volatility of the U.S. and Japanese interest rates (the two major trading partners for Malaysia) could influence the money demand function of this country. This study is important in its contribution to a better understanding of the effect of foreign interest rate volatility in the money demand function particularly for a small open economy such as Malaysia.

The remainder of this paper is organised as follows. Section II discusses the model to be estimated and methodological issues on the volatility of the interest rates. Data used in this study is also discussed in section II. The theoretical framework that underpins the empirical analysis and the discussion of the results of the analysis are presented in Section III. Finally, Section IV presents a brief summary of the major results and conclusions.

## **DATA AND METHODOLOGY**

The empirical work outlined in subsequent sections employs quarterly data. The series used in this study are the M1, M2, quasi money, consumption, base lending rate, interest rates (such as fixed deposits rates, savings rates, lending rates, money market rates, treasury bills rates, and rates for government securities), and consumer price index. These data are extracted from various issues of Bank Negara Quarterly Statistical Bulletin. In addition, the U.S. 3-month treasury bill and Japanese call money rates are obtained from International Financial Statistics of the International Monetary Fund database CD-ROM. Other data series such as claims on the banking sector, claims on government, net foreign assets, claims of the monetary authorities and the banking sector on the private sector are also obtained from International Financial Statistics of the International Monetary Fund database CD-ROM. The period of the data for this study is 1976Q1 to 2001Q4.

## Model

For the purpose of this study, the estimated model is based on the general functional form for the money demand function which is specified as follows:

$$M/P = \alpha Y^\beta R^\theta \quad (1)$$

Taking logarithms:

$$\ln(M/P)_t = \ln \alpha + \beta \ln(Y/P)_t + \theta \ln R_t + u_t \quad (2)$$

where  $M$  is the quantity of money balances i.e.  $M2$ ,  $P$  is the general price level,  $Y$  is income,  $R$  is the nominal interest rate,  $\alpha$ ,  $\beta$ ,  $\theta$ , are parameters,  $t$  is the time period, and  $u$  is a random error term. In this study, the financial wealth is also included in the model. This variable is considered relevant because with the increased development of the financial sector in Malaysia, more financial products are made available to the public as alternative to money. Fase and Winder (1996a) pointed out that the role of wealth is unarticulated and almost ignored in empirical research on money demand. Since then, the inclusion of income or wealth or both in the money demand function has remained an issue. Following Fase and Winder (1996b), the net financial wealth of the non-monetary private sector is used as the relevant wealth variable. This is defined as the difference between total assets – the sum of  $M1$ , quasi money, claims on the banking sector and on the government and net foreign assets – and the claims of the monetary authorities and the banking sector on the private sector. The estimated final model is determined as follows:

$$\ln(M/P)_t = \ln \alpha + \beta_1 \ln(C/P)_t + \beta_2 \ln R_t + \beta_3 \ln(FW/P)_t + \beta \ln V_t + u_t \quad (3)$$

where  $C$  represents the scale variable. The real consumption is used instead of income as the scale variable.  $FW$  is the financial wealth, and  $V$  is the variability of the U.S. and Japanese interest rates. Finally,  $R$  is the opportunity cost of holding money that is the user cost<sup>1</sup>. This user cost is derived by Barnett (1978) and given as:

$$R_{it} = P_t \frac{(r_t^b - r_{it})}{(1 + r_t^b)} \quad (4)$$

where

$R_{it}$  represents the user cost of asset  $i$  at time  $t$ ,

$P_t$  represents the consumer price index,

$r_t^b$  represents the benchmark rate, and

$r_{it}$  represents the rate of return from the  $i$ th monetary asset at time  $t$ .

In this study  $i$  is the Malaysian 3-month treasury bill rate. In theory, the benchmark rate of return,  $r_t^b$  is defined as the maximum expected holding period yield of a pure store-of-value asset. The benchmark asset is specifically assumed to provide no liquidity or other monetary services and is held solely to transfer wealth intertemporally. The predominant approach to measuring the benchmark rate is to view  $r_t^b$  as the maximum-available holding-period yield at each point in time. In this context, it is possible that different assets will occupy the role of the benchmark asset at different moments in time (Belongia, 2000). An arbitrary constant is added to  $r_t^b$  so that user costs are always positive. According to Mullineux (1996), the pragmatic solution to the benchmark problem is usually to include a (medium to long-term) local authority or government bond rate set along with the own rates of the monetary component assets and then to form the benchmark series by taking the highest rate in the set period by period. This will ensure that  $R_i \geq 0$ . A constant is added to avoid zero weight in the highest-yielding monetary component in a particular period.

In the case of Malaysia where data on corporate bonds is not readily available, the other viable alternative assets, i.e. the treasury bills and the government securities, are included to compute the benchmark rate<sup>2</sup>. Thus, the maximum among own rates at each point in time is chosen as the benchmark rate, i.e.

$$R_t = \max\{RDD_t, RSVD_t, RFXD_t, RNCD_t, RREPOS_t, YGS_{it}\} \quad (5)$$

where RDD is the own rate of return on demand deposits, RSVD is the own rate of return on savings deposits, RFXD is the own rate of return on fixed deposits, RNCD is the own rate of return on negotiable certificates of deposit, and RREPOS is the own rate of return on repurchase agreements, and YGS represents the return on the treasury bills and yield on government securities.

### Interest Rate Volatility

The volatility of the interest rate in this study is represented as the conditional variance of the  $GARCH(p,q)$  model. For modeling changing volatility under deviations from linearity, Engle (1982) introduced the autoregressive conditional heteroskedasticity or  $ARCH$  models. Following Enders (1995), the model is expressed as follows:

$$v_t = a_0 + a_1 v_{t-1} + \varepsilon_t \quad (6)$$

where  $v_t$  in this study is  $\log(i_t/i_{t-1})$ , and  $i_t$  is the opportunity cost.

Accordingly, the conditional variance can be modeled by estimating an  $AR(p)$  process using the squared residuals:

$$\hat{\varepsilon}_t^2 = \alpha_0 + \alpha_1 \hat{\varepsilon}_{t-1}^2 + \alpha_2 \hat{\varepsilon}_{t-2}^2 + \dots + \alpha_p \hat{\varepsilon}_{t-p}^2 + \mu_t \quad (7)$$

where  $\mu_t$  is a white noise such that  $\{\mu_t\} \sim iid N(0, \sigma^2)$ . In the  $ARCH$  model, the error structure is such that the conditional and unconditional means of  $\varepsilon_t$  are equal to zero.

As a way to model persistent movements in volatility, Bollerslev (1986) suggested the a Generalised Autoregressive Conditionally Heteroskedastic, or  $GARCH$  model allows the conditional variance to be an  $ARMA$  process. The error process is given here as:

$$\varepsilon_t = \mu_t \sqrt{h_t} \quad (8)$$

and

$$h_t = \alpha_0 + \sum_{i=1}^p \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^q \beta_i h_{t-i} \quad (9)$$

where  $\mu_t$  is a white noise process such that  $\{\mu_t\} \sim iid N(0,1)$  so  $\sigma_\mu^2 = 1$ . By analogy with  $ARMA$  models, this is called a  $GARCH(p,q)$  model.

The volatility of the U.S. and Japanese interest rates is measured using a  $GARCH$  model (Choudhry, 1999). The first difference of the interest rate,  $v_t$  can be represented in the  $GARCH(p,q)$  model as:

$$v_t = \mu_t + \varepsilon_t \quad (10)$$

where  $\{\varepsilon_t\} \sim N(0, h_t)$ .  $v_t$  is given as  $\log(i_t / i_{t-1})$  where  $i_t$  is the U.S. or Japanese interest rate and  $\mu_t$  is the mean of  $v_t$  conditional on past information.

Table 1 presents results from the  $GARCH(1,1)$  model for the U.S. and Japanese interest rates. The U.S. interest rate is represented by the three-month treasury bill and the Japanese interest rate is represented by the call money rate. The results show a significant  $ARCH$  effect. Also, the shocks to volatility are not explosive since the coefficient on the lagged error term is less than unity. The persistence measure ( $\alpha_1 + \beta_1$ ) is high in all tests, implying permanent shocks to volatility. In addition, Ljung-Box statistics fail to indicate any serial correlation in the standard residuals squared at 5% level using eight lags.

**Table 1**  
Test Results of GARCH(1,1)

U.S. Interest Rate	Japanese Interest Rate
$v_t = 0.009 + \varepsilon_t$ (1.065)	$v_t = 0.044 + \varepsilon_t$ (2.113*)
$h_t = 0.001 + 0.392\varepsilon_{t-1}^2 + 0.596h_{t-1}^2$ (1.451) (2.515*) (4.054*)	$h_t = 0.009 + 0.383\varepsilon_t^2 + 0.359h_{t-1}^2$ (2.699*) (1.718**) (1.683**)
$L = 88.601, \alpha + \beta = 0.989, LB(8)$ $SRS = 3.403$	$L = 49.413, \alpha + \beta = 0.742, LB(8)$ $SRS = 5.898$

Note:  $t$  – statistics in parentheses. L represents log likelihood, LB is Ljung-Box, SRS is standardised residuals squared.

\*/\*\* indicates significance at 5% and 10% levels.

## EMPIRICAL ANALYSIS

### Unit Root Test

The order of integration of monetary aggregate M2, the scale variable, financial wealth, the opportunity cost, and volatility of the U.S. and Japan interest rates is determined first before the long-term relationship of money demand and the volatility of the U.S. and Japan interest rates are to be examined. The test is to determine whether the variables in the money demand function are stationary or non-stationary in levels and it is to be performed by conducting a unit root test on the level and first difference of the series. Standard tests for the presence of a unit root are based on the work of Dickey and Fuller (1979; 1981), Perron (1988), and Phillip and Perron (1988) for testing the degree of integration of the variables. The augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests for a unit root are performed here.

The augmented Dickey-Fuller (ADF) test is based on the following regressions:

$$\Delta y_t = \alpha + \delta t + \gamma y_{t-1} + \sum_{i=1}^k \beta_i \Delta y_{t-i} + \varepsilon_t \quad (11)$$

where  $\Delta$  is the difference operator,  $t$  is a time trend,  $y$  is the time series variable being tested,  $\varepsilon$  is the error term, and  $\alpha$ ,  $\delta$ ,  $\gamma$ , and  $\beta$  are the parameters to be estimated.

Under the Phillip-Peron (PP) test for a unit root, the following estimated models are tested for  $\alpha$  equal to unity:

$$y_t = \hat{\mu} + \hat{\alpha}y_{t-1} + \hat{\varepsilon}_t \quad (12)$$

$$y_t = \tilde{\mu} + \tilde{\alpha}y_{t-1} + \tilde{\varepsilon}_t \quad (13)$$

$$y_t = \mu^* + \beta^*(t-T/2)_t + \alpha^*y_{t-1} + \varepsilon_t^* \quad (14)$$

where  $y_t$  is the time series variable at time  $t$ , and  $\varepsilon_t$ ,  $\tilde{\varepsilon}_t$  and  $\varepsilon_t^*$  are error terms. These error terms are of the normal distribution with zero mean. Under the PP unit root test, the estimated model in (14) is first tested for a unit root using the test statistics of  $Z(\alpha^*)$ ,  $Z(t_{\alpha})$ , and  $Z(\Phi_3)$ . If the null hypothesis is accepted, then the drift,  $\mu^*$ , is equal to zero. Then the null hypothesis  $H_0 : (\mu^*, \beta^*, \alpha^*) = (0, 0, 1)$  is tested using  $Z(\Phi_2)$ . If the null hypothesis is accepted then the next null hypothesis of  $H_0 : (\tilde{\mu}, \tilde{\alpha}) = (0, 1)$  is tested using  $Z(\alpha)$ ,  $Z(t_{\alpha})$  and  $Z(\Phi_1)$  to determine if a series has zero mean. If the null hypothesis is accepted, then the series has a zero mean. Therefore, the appropriate model will be one without the intercept or trend.

Tables 2 and 3 present the results from the various forms of the ADF and PP tests on log levels and log first difference series respectively, based on a standard regression with a constant, and with a constant time trend. The null hypothesis of the existence of a unit root for the log first difference of all series is overwhelmingly rejected. Therefore, we can conclude that all the series in our sample are stationary in the log first difference.

### Cointegration test with Johansen Maximum Likelihood

Even if all the macroeconomic time series are nonstationary, there may exist some linear combination of these variables that converge to a long-term relationship. Individually, if the series are stationary after differentiation, and a linear combination of their levels are also stationary, then the series are said to be cointegrated. The long-term equilibrium relationship in the money demand function is determined by using the maximum likelihood approach by Johansen (1988) and Johansen and Juselius (1990) in a multivariate setting. The Johansen-Juselius estimation method is based on the error-correction representation of the vector autoregressive (VAR) model with Gaussian errors. The method provides tests for identifying the number of cointegrating vectors between variables. These tests are based on the trace statistic test and the maximum eigenvalue test. It treats all variables as endogenous thus avoiding an arbitrary choice of a dependent variable. It also provides a unified framework of a vector error-correction model. Evidence of cointegration diminishes the possibility of the estimated relationship being spurious.

The  $k$ th order vector autoregressive (VAR) of  $Y_t$  is given as:

$$Y_t = \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \dots + \Pi_{t-k} Y_{t-k} + C + \Phi t + \xi_t,$$

where  $t = 1, 2, \dots, T$  (15)

$$Y_t = C + \sum_{i=1}^k \Pi_i Y_{t-i} + \Phi t + \xi_t \quad (16)$$

where  $Y_t$  is a  $p \times 1$  vector of I(1) processes.  $Y_t$  is a sequence of random vectors with components  $(Y_{1t}, Y_{2t}, \dots, Y_{pt})$ . The residuals of this process,  $\xi_t$ s, are drawn independently and identically from a  $p$ -dimensional Gaussian distribution with covariance  $\Lambda$  and  $Y_{-k+1}, Y_{-k+2}, \dots, Y_0$  fixed. Thus  $\{\xi_t\} \sim iid N(0, \sigma^2_\xi)$ .  $C$  is a constant term and  $t$  is time trend.

The first difference form of the VAR model is:

$$\Delta Y_t = \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + \dots + \Gamma_{k-1} \Delta Y_{t-k+1} + \Pi Y_{t-k} + \Phi_t + \xi_t \quad (17)$$

where  $\Gamma_i = -(I - \Pi_1 - \dots - \Pi_i)$  and  $\Pi = -(I - \Pi_1 - \dots - \Pi_k)$ .

Since  $Y_{t-k}$  is I(1), but  $\Delta Y_t$  and  $\Delta Y_{t-i}$  are I(0), it is the  $\Pi$  matrix that conveys the information about the long-term relationship between the  $Y$  variables in the model.  $\Pi_t$  is a  $p \times p$  matrix which is called a long-term impact matrix and the test procedure will examine this  $\Pi$  matrix. In this procedure two likelihood ratio test statistics will be employed.

First, the null hypothesis of at most  $r$  cointegrating vectors against a general alternative will be tested by:

$$\text{Trace statistics} = T \sum_{i=r+1}^p \ln(i - \lambda_i)$$

Secondly, the null hypothesis of  $r$  cointegrating vector against the alternative of  $r+1$  will be tested by:

$$\text{Maximum eigenvalue statistics} (\lambda\text{-max}) = T \ln(1 - \lambda_{r+1}) \quad (18)$$

where  $\lambda$  are the estimated eigenvalues.

Using the multivariate method of cointegrating, we examined if there is any long-term relationship between money demand with the volatility of the U.S. interest rate, and between money demand with the volatility of the Japanese interest rate.

To proceed with the long-term cointegration analysis, the order of the VAR system needs to be determined. The various likelihood ratio (LR)

**Table 2**  
Unit Root Tests - Log Level

Variables	Lags	ADF Test		Philip-Perron Test						
		Model 1		Model 2		Model 1		Model 2		
		$t_{\alpha^*}$	$t_{\alpha}$	$Z(\alpha^*)$	$Z(t_{\alpha})$	$Z(\tilde{\alpha})$	$Z(t_{\tilde{\alpha}})$	$Z(\Phi_2)$	$Z(\Phi_3)$	
RCONS	5	-0.73	-3.02	-0.63	-0.88	9.51**	-16.72	-2.95	7.75**	4.41
RM2	8	-1.39	-1.61	-0.43	-1.19	49.15**	-7.04	-1.89	33.13**	2.35
RFINW	5	-1.02	-3.35	-1.73	-1.16	2.77	-20.16	-3.36	5.06	5.68
R	1	-2.34	-2.28	12.82	-2.17	3.31	-14.00	-2.49	2.19	3.23
VUS	1	-1.01	-1.83	-5.52	-0.78	1.28	-11.82	-2.39	2.76	4.09
VJP	4	-3.12	-4.62	-16.49*	-3.12	4.66	-36.48**	-4.66**	7.28**	10.93**
Critical Value for T=100		1%	-3.51	-4.04	-19.80	-3.51	6.70	-27.40	-4.04	6.50
		5%	-2.89	-3.45	-13.70	-2.89	4.71	-20.70	-3.45	4.88

Note: Model 1 includes non-zero mean. Model 2 includes non-zero mean and linear trend. The optimal lag length for each of autoregressive process of ADF test is determined by Schwarz Information Criterion (SIC).

The adjusted Z test statistics are given in detail in Perron (1988, p. 308-309).

The Critical Value of  $Z(\alpha^*)$ ,  $Z(\tilde{\alpha})$ ,  $Z(t_{\alpha^*})$ , and  $Z(t_{\tilde{\alpha}})$  are given in Fuller (1976, p. 371 and 373).

The Critical Value of  $Z(\Phi_1)$ ,  $Z(\Phi_2)$ , and  $Z(\Phi_3)$  are given in Dickey and Fuller (1981, p. 1063),

\* and \*\* indicate rejection of the null hypothesis at 1 and 5% significance level respectively.

**Table 3**  
Unit Root Tests - Log First Difference

Variables	ADF Test				Philip-Perron Test					
	Model 1		Model 2		Model 1		Model 2			
	Lags	$t_{\alpha}$	$t_{\alpha}$	$Z(\alpha^*)$	$Z(t_{\alpha})$	$Z(\Phi_1)$	$Z(\tilde{\alpha})$	$Z(t_{\alpha})$	$Z(\Phi_2)$	$Z(\Phi_3)$
RCONS	5	-4.84**	-4.83**	-290.12**	-14.08**	108.60**	-162.34**	-14.52**	70.37**	105.55**
RM2	8	-3.43**	-3.53**	-113.09**	-8.93**	44.71**	-109.21**	-9.49**	30.03**	45.04**
REINW	5	-4.90**	-4.88**	84.55**	-13.08**	85.15**	-135.02**	-12.69**	53.71**	80.57**
R	1	-11.02**	-11.01**	4245.32**	-10.99**	70.14**	-121.44**	-11.01**	40.41**	60.62**
VUS	1	-9.47**	-9.48**	-74.52**	-6.95**	23.46**	-74.97**	-6.95**	16.25**	24.26**
V/P	4	-6.88**	-6.84**	-84.35**	-12.74**	74.88**	-116.43**	-11.98**	147.88**	71.82**
Critical Value for T=100		1%	-3.51	-4.04	-19.80	-3.51	6.70	-27.40	-4.04	6.50
		5%	-2.89	-3.45	-13.70	-2.89	4.71	-20.70	-3.45	4.88
										6.49

Note: Model 1 includes non-zero mean. Model 2 includes non-zero mean and linear trend. The optimal lag length for each of autoregressive process of ADF test is determined by Shwarz Information Criterion (SIC).

The adjusted Z test statistics are given in detail in Perron (1988, p. 308-309).

The Critical Value of  $Z(\alpha^*)$ ,  $Z(\tilde{\alpha})$ ,  $Z(t_{\alpha})$ , and  $Z(\Phi_1)$  are given in Fuller (1976, p. 371 and 373).

The Critical Value of  $Z(\Phi_1)$ ,  $Z(\Phi_2)$ , and  $Z(\Phi_3)$  are given in Dickey and Fuller (1981, p. 1063).

\* and \*\* indicate rejection of the null hypothesis at 1 and 5% significance level respectively.

tests are performed and examined for the exclusion of the  $(p-1)th$  lag. In this study, the general to specific procedure yields the AR model of 8 for both models with the volatility of U.S. and Japanese interest rates. A systematic test procedure for the model specification is performed to examine both the rank order and the deterministic component for the cointegration system simultaneously<sup>3</sup>. Based on the  $\lambda$ -trace statistics at the 5% significance level, the procedure suggests a linear trend for the model with US and Japanese interest rates volatility.

The statistical tests regarding the number of cointegrating vector are presented in tables 4 and 5. Result from the test show that at 5% level of significance, money demand and other variables i.e. consumption, financial wealth, opportunity cost and volatility of the interest rates (U.S. and Japanese) are bound together in the long-term by one cointegrating vector. Normalising the coefficients of the money demand, the long-term relationships between the money demand in Malaysia with consumption, opportunity cost, volatility of the U.S. and Japanese interest rates, and financial wealth can be expressed as follows:

$$\log(M/P) = 1.695\log(C/P) - 0.439\log R + 0.117\log(VUS) + 0.021\log(FW/P) \quad (19)$$

(16.845)	(7.281)	(5.273)	(0.296)
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$$\log(M/P) = 0.968\log(C/P) - 0.121\log R + 0.095\log(VJP) + 0.685\log(FW/P) \quad (20)$$

(5.757)	(5.091)	(2.427)	(1.083)
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where  $VUS$  and  $VJP$  are the U.S. and Japanese interest rates volatility respectively. Residuals from the systems are tested for serial correlation and reported in Tables 3 and 4. The Ljung-Box and Lagrange Multiplier tests indicate no serial correlation among residuals.

The signs for scale variable,  $C$  and opportunity cost,  $R$  are as anticipated in accordance to standard money demand theory. The results indicate a positive relationship between the volatility of the U.S. and Japanese interest rates and real money demand in Malaysia. By means of the t-test, all variables except for the financial wealth ( $FW$ ), are found to be significantly different from zero at 5% significance level. The results also indicate a significant effect is imposed by the volatility of the U.S. and Japanese interest rates on the demand for real money in Malaysia. This could be due to the fact that U.S. and Japan are the two major trading partners for Malaysia and the influence could be felt directly. Therefore, any structural change in the interest rates in these two countries will bear some implications toward the demand for real money in Malaysia. The influence of the U.S. and Japanese interest rates volatility can also be explained by the portfolio theory of money

**Table 4**  
 Johansen Maximum Likelihood Test for the Number of Cointegrating Vectors for Log Real Money Demand, Real Consumption, Opportunity Cost and the U.S. Interest Rate Volatility

H <sub>0</sub>	H <sub>1</sub>	Eigenvalue	Test Statistics			5% Critical Value
			$\lambda$ - max	$\lambda$ - trace	$\lambda$ - max	
r=0	r>1	0.3062	43.1495**	95.1157**	39.97	94.15
r≤1	r>2	0.1534	19.5074	41.9661	33.46	68.52
r≤2	r>3	0.1285	16.2324	22.4587	27.07	47.21
r≤3	r>4	0.042	5.0675	6.2263	20.97	29.68
r≤4	r=5	0.0097	1.1589	1.1589	14.07	15.41

  

Residual Analysis: Test for Serial Correlation						
	L-B(25)	$\chi^2(25)$	LM(1)	LM(4)		
	618.69	52.39	36.55			
p-value	0.06	p-value	0.11	0.16		

**Notes:** The cointegration model is based on the vector autoregressive model (VAR) with 8 lags using likelihood ratio (LR) test. The critical values for  $\lambda$ -Trace and  $\lambda$ -Max statistics are from Osterwald-Lenum (1992). The asterisks indicate significance at the 95% (\*\*) level. Ljung-Box Q statistics or L-B(k) and Langrange Multiplier or LM(k) tests are used to test the null hypothesis of no serial correlation up to order k in the residuals. See Ljung and Box (1978), Breusch (1978), and Godfrey (1978) for detailed discussions on these tests.

**Table 5**

Johansen Maximum Likelihood Test for the Number of Cointegrating Vectors for Log Real Money Demand, Real Consumption, Opportunity Cost and Japanese Interest Rate Volatility

$H_0$	$H_1$	Eigenvalue	Test Statistics			5% Critical Value
			$\lambda$ - max	$\lambda$ - trace	$\lambda$ - max	
$r = 0$	$r > 1$	0.2808	37.5748**	75.6788**	39.97	94.15
$r \leq 1$	$r > 2$	0.1531	18.9469	38.104	33.46	68.52
$r \leq 2$	$r > 3$	0.1285	12.016	19.157	27.07	47.21
$r \leq 3$	$r > 4$	0.0597	7.0128	7.1411	20.97	29.68
$r \leq 4$	$r = 5$	0.0011	0.1282	0.1283	14.07	15.41

#### Residual Analysis: Test for Serial Correlation

	L-B (25)	LM(1)	LM(4)
$\chi^2(525)$	673.83	$\chi^2(25)$	34.89
p-value	0.09	p-value	0.12

Notes: The cointegration model is based on the vector autoregressive model (VAR) with 8 lags using likelihood ratio (LR) test. The critical values for  $\lambda$ -Trace and  $\lambda$ -Max statistics are from Osterwald-Lenum (1992). The asterisks indicate significance at the 95% (\*\*) level. Ljung-Box Q statistics or L-B(k) and Langrange Multiplier or LM(k) tests are used to test the null hypothesis of no serial correlation up to order k in the residuals. See Ljung and Box (1978), Breusch (1978), and Godfrey (1978) for detailed discussions on these tests.

demand and transaction demand for money. According to the portfolio theory of money demand and transaction demand for money, an increase in the volatility of interest rates increases the risk, of holding fixed-term interest paying securities, and in order to reduce this risk, firms and households may wish to hold larger money balances (Garner, 1990). In addition, according Slovin and Sushka (1983), the interest rate volatility can be important because large changes in the interest rate may produce substantial variation in holding period returns for even short-term liquid assets that are sold prior to maturity in order to alter a cash position. This suggests that the risk-averse economic agents will increase their demand for money as the interest rate becomes more volatile.

The results in this study also show evidence that the size of the effect imposed by the opportunity cost, in absolute value, is larger than the effect due to the volatility of the U.S. and Japanese interest rates. Thus, the opportunity cost of holding money still imposes a larger effect on money demand function than the volatility of the U.S. and Japanese interest rates. Nevertheless, the results indicate that the U.S. and Japanese interest rates volatility could also play a significant role in influencing the demand for money in Malaysia, and as such it cannot be totally ignored by the policy makers in formulating an effective monetary policy for Malaysia.

## CONCLUDING REMARKS

This paper estimates the impact of the foreign interest rates volatility on the money demand in a Malaysia. The U.S. 3-month treasury bill and Japanese call money rates are used to represent the foreign interest rates. The conditional variance estimates of the U.S. and Japanese interest rates obtained from GARCH(1,1) model are applied as the U.S. and Japanese interest rates volatility. By applying the Johansen procedure of cointegration the long-term relationship between real M2, real consumption, the opportunity cost of holding money, and real financial wealth, firstly with the U.S. interest rate volatility, and secondly with Japanese interest rate volatility are determined.

The results show that there is a larger effect in money demand function in Malaysia imposed by opportunity cost, as compared to the effect imposed by the volatility of the U.S. and Japanese interest rates. However, the results indicate that the volatility of the U.S and Japanese interest rates have a significant role in money demand function in Malaysia, given the fact the U.S. and Japan are the main trading partners of Malaysia. As such, the role of the volatility of the foreign interest

rates (U.S. and Japanese) in formulating the effective monetary policy in Malaysia cannot be totally ignored.

## ENDNOTES

1. User cost is also referred to as rental prices of the monetary assets. It is the price of the transaction service of each monetary asset. See Dahalan (2004) for the detail discussion of the user cost.
2. The benchmark rate of return is defined as the maximum expected holding period yield of pure store-of-value asset. The benchmark asset is specifically assumed to provide no liquidity or other monetary service and held solely to transfer wealth intertemporally. See Dahalan (2004) for a detail discussion on benchmark rate for Malaysia.
3. A systematic test procedure for model specification is performed to examine both the rank order and deterministic component for the cointegration system simultaneously.

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## REFERENCES

Arize, A. C., & Darrat, A. F. (1994). Value of time and recent U.S. money demand instability. *Southern Economic Journal*, 60(3), 564-578.

Bahmani-Oskooee, M. (1991). The demand for money in an open economy: The United Kingdom. *Applied Economics*, 23, 1037-1042.

Barnett, W. A. (1978). The user cost of money. *Economics Letters*, 1, 145-149.

Belongia, M. T. (2000). Introductory comments, definitions, and research on indexes of monetary services. In M. T. Belongia & J. M. Binner (Eds). *Divisia Monetary Aggregate: Theory and Practice*. New York: Palgrave.

Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, 31, 307-327.

Breusch, T. S. (1978). Testing for autocorrelation in Dynamic Linear Models. *Australian Economics Papers*, 17, 334-355.

Choudhry, T. (1999). Does interest rate volatility affect the U.S. M1 demand function? Evidence from cointegration. *The Manchester School*, 67(6), 621-648.

Dahalan, J. (2004). Divisia index monetary aggregates and monetary policy in malaysia: Does it matter? *Malaysia Management Journal*, 8 (1), June.

Dickey, D. A., & Fuller, W. A. (1979). Likelihood ratio tests for autoregressive time series with a Unit Root. *Econometrica*, 49, 1057-1072.

Dickey, D. A., & Fuller, W. A. (1981). Distribution of the estimators for autoregressive time series with a Unit Root. *Journal of the American Statistical Association*, 74, 427-431.

Engle, F. R. (1982). Autoregressive conditional heteroskedasticity with estimates of the variance of U.K. Inflation. *Econometrica*, 50, 987-1008.

Enders, W. (1995). *Applied econometric time series*. New York: John Wiley & Sons.

Fase, M. M. G., & Winder, C. C. A. (1996a). Wealth and the demand for money: empirical evidence for the Netherlands and Belgium. *De Economist*, 144(4), 569-589.

Fase, M. M. G., & Winder, C. C. A. (1996b). Wealth and the demand for money in the European Union. *De Nederlandsche Bank - Staff Reports*.

Ford, J. L., Peng, W. S., & Mullineux, A. W. (1992). Financial innovation and divisia monetary aggregates. *Oxford Bulletin of Economics and Statistics*, 54(1), 87-102.

Ford, J. L., & Mullineux, A. (1996). Financial innovation and monetary aggregates In the U.K., 1977-1973. In A. Mullineux (Ed). *Financial Innovation, Banking and Monetary Aggregates*. Cheltenham: Edward Elgar.

Fuller, W. A. (1976). *Introduction to statistical time series*. New York: John Wiley & Sons.

Garner, A. C. (1990). Does interest rate volatility affect money demand? *Federal Reserve Bank of Kansas City*. 99-112.

Godfrey, L. G. (1978). Testing against general autoregressive and moving average error models when the regressors include lagged dependent variables. *Econometrica*. 46, 1293-1302.

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*. 12, 231-254.

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration with application to the demand for money. *Oxford Bulletin of Economics and Statistics*. 52, 169-209.

Ljung, G. M., & Box, G. E. P. (1978). On a measure of lack of fit in Time Series Models. *Biometrika*. 67, 297-203.

Marquis, M. H. (1989). Interest rate volatility in a Partial Equilibrium Model of household money demand. *Journal of Macroeconomics*. 11(1), 67-80.

Mullineux, A. (1996). Monetary aggregates and monetary policy: some introductory remarks. In A. Mullineux (Ed.), *Financial innovation, banking and monetary aggregates*. Cheltenham: Edward Elgar.

Osterwald-Lenum, M. (1992). A note with quantiles of the asymptotic distribution of the maximum likelihood cointegration rank test statistics: four cases. *Oxford Bulletin of Economics and Statistics*. 54, 461-472.

Payne, J. E. (1995). Velocity and the variability of yields of financial and other assets. *The American Economist*. 39(1), 89-94.

Perron, P. (1988). Trends and random walks in Macroeconomic Time Series: Further evidence from a new approach. *Journal of Economic Dynamics and Control*, 12, 297-332.

Phillip, P. C. B., & Perron, P. (1988). Testing for Unit Root in Time Series Regression. *Biometrika*. 75, 335-346.

Slovin, M., & Sushka, M. (1983). Money, interest rates, and risk. *Journal of Monetary Economics*. 12, 475-482.

