The stability of money demand function in Japan: Evidence from rolling cointegration approach

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ABSTRACT

The main purpose of this study is to re-investigate the stability of Japanese M2 money demand function over the period of 1960:Q1 to 2007:Q2. This study propose to incorporate the rolling regression approach into the bounds testing procedure for cointegration within the autoregressive distributed lag (ARDL) framework to search for the stability of money demand function in Japan. This study, in general, confirms that real M2 money demand and its determinants, real income and interest rates are cointegrated within the entire sample period. In line to that, the CUSUM and CUSUM of Squares tests show that the money demand function is stable over the analysis period. However, the evidence of rolling ARDL cointegration test implies that Japanese M2 money demand is not stable due to a series of changes in the Japanese monetary policy environment. The finding of this study is vital for policymakers in formulating an appropriate macroeconomic policy. Owing to the low power of CUSUM and CUSUM of Squares tests in the presence of lagged dependent variable(s), this study propose to use the rolling cointegration test to re-investigate the stability of money demand function in Japan.

Keywords: Money Demand; Rolling Cointegration Test; Japan; Stability
JEL Classification Codes: C22; E41

1. INTRODUCTION

The stability of money demand function has long been the central issue in a growing body of research in the macroeconomics literature. Why stable money demand function is of concern? The stability of money demand function is crucial because it has important implications for how monetary policy should be conducted. According to Hamori and Tokihisa (2001) if money demand function is stable, the monetary policy is matters that is the money supply will have a certain amount of expected influence on real variables and that money supply controlled by the central bank is an effective macroeconomic policy. Caporale and Gil-Alana (2005) added that stability of money demand function is a pre-requisite for effective formulation of monetary targeting policy in an economy. If the money demand function is not stable, the policymakers would lose at least one of the fundamental pre-conditions for effective implementation of its anti-inflationary monetary policy (see also Dekle and Pradhan, 1999; Bahmani-Oskooee and Bohl, 2000). Therefore, the monetary policy has very little role to play when the money demand function is not stable.

With regards to the question of stability, cointegration techniques (e.g., Engle and Granger, 1987; Johansen, 1988; Johansen and Juselius, 1990; Pesaran et al., 2001) are the most widely applied method so far. The rationale is that if money demand and its determinants are cointegrated, this implies that the money demand function is stable since the cointegrated variables will never move too far apart, and will be attracted to their long run equilibrium relationship. However, Wagner (1981) argued that a stable money demand function may not imply a stable monetary multiplier. Then, Bahmani-Oskooee and Bohl (2000) demonstrates that although M3 money demand and its determinants (i.e. income and interest rate) are cointegrated, the CUSUM of Squares test showed that M3 money demand in Germany experienced structural break. In addition to that, Bahmani-Oskooee and Barry (2000) in the case of Russia, and Bahmani-Oskooee and Economidou (2005) in the case of Greece also discovered similar outcomes with regard to the M2 monetary aggregate. Following this, they concluded that the presence of cointegration may not interpret as a sign of stable money demand function. In contrast, some existing studies found that when cointegration exists, the CUSUM and CUSUM of Squares statistics shows that the money demand function is stable (e.g. Obben, 1998 in the case Brunei; Bahmani-

Oskooee and Ng, 2002 in the case of Hong Kong; Tang, 2004 in the case of Japan). Therefore, the argument of cointegration does not imply stability seems to be vague.

As far as Japan is concerned, many studies have empirically investigated the money demand function and its stability from different angles. Among them are Miyao (1996), Bahmani-Oskooee and Shabsigh (1996), Amano and Wirjanto (2000), Bahmani-Oskooee (2001), Bahmani-Oskooee and Chomsisengphet (2002), Hamori and Tokihisa (2001) and Tang (2004). Two themes have emerged from these studies. First, the previous studies used the presence of cointegration as an indicator for stable money demand function in Japan. Overall, these studies found that money demand function in Japan is fairly stable, except Miyao (1996) who found that real M2 money demand is not cointegrated with real output and nominal interest rates.

Second, the CUSUM and CUSUM of Squares tests were extensively used to affirm the stability of the estimations. It is well noted in the literatures, the CUSUM and CUSUM of Squares tests are not valid when the estimated model contained a lagged dependent variable(s) (see Otto, 1994, pp. 181; Choong et al., 2005; Tang and Lean, 2007). Besides, Andrews (1993) pointed out that if a break point is determined by a search over the sample period, then the standard critical values would be smaller than the appropriate values and as such the statistical inference may be biased against the null hypothesis of stability. Furthermore, Amano and Wirjanto (2000) noted that any change point determined in an ad hoc manner may adversely affect the power of the test as the chosen point may be mis-specified. Due to these caveats, the results of the earlier studies should be accepted with caution. Apart from methodological flaws, the incidence of several shocks to the Japanese monetary system (e.g. the introduction of the floating exchange rate system in 1973, interest rate liberalisation and the initialling of the Plaza Accord in the mid-1980s, and the Asian financial crisis in 1997) also cast doubts on the premise that Japanese money demand function has remained stable.

In light to these problems, the present study attempts to re-investigate the Japanese M2 money demand function and its stability by incorporating the rolling regression approach into the bounds testing procedure for cointegration (see Pesaran et al., 2001) within the autoregressive distributed lag (ARDL) framework to search for the time period of which money demand and its determinants are cointegrated or stable. We are aware of the fact that there is a rolling cointegration test based on Johansen's procedure (e.g. Kutan and Zhou, 2003; Crowder and Phengpis, 2007), however, the bounds testing procedure is superior to the conventional tests because it is applicable irrespective of whether the underlying regressors are purely *I*(0), purely *I*(1) or mutually cointegrated. In addition to that, Narayan and Narayan (2005), and Narayan and Smyth (2006) noted that the bounds testing procedure is not plagued by the small sample bias problem. Moreover, the bounds testing procedure is likely to have better statistical properties because it does not push the short run dynamics into the residuals term as in the Engle and Granger two-step cointegration approach (see Pattichis, 1999; Mah, 2000).

The remainder of this study is organised as follows. Section 2 will briefly discuss the model specification, econometric techniques and data used in this study. The empirical results will be reported in Section 3. Finally, the conclusions and policy implications are presented in Section 4.

2. MODEL SPECIFICATION, ECONOMETRIC TECHNIQUES AND DATA

In order to analyse the money demand function in Japan, this study follows the standard money demand specification informed by Miyao (1996) and Bahmani-Oskooee (2001). The M2 money demand function can be expressed as equation (1).

$$\ln M2_t = \alpha_0 + \alpha_1 \ln Y_t + \alpha_2 R_t + \mu_t \qquad (1)$$

where ln denotes the natural logarithm, M2 is the real money demand for M2, Y is the real Gross Domestic Products (GDP) with the expected positive elasticity and R is the interest rate with the expected negative elasticity.

As noted in the earlier section, we use the ARDL bounds testing procedure for cointegration to test for the existence of any long run equilibrium relationship between real money demand and its determinants viz. real income and interest rate. To implement the bounds testing approach, the following ARDL equation (2) is estimated.

$$\Delta \ln M2_t = a_0 + a_1 \ln M2_{t-1} + a_2 \ln Y_{t-1} + a_3 R_{t-1} + \sum_{i=1}^{p} b_{1i} \Delta \ln M2_{t-i} + \sum_{i=0}^{p} b_{2i} \Delta \ln Y_{t-i} + \sum_{i=0}^{p} b_{3i} \Delta R_{t-i} + \varepsilon_t \qquad (2)$$

where Δ is the first difference operator and the residuals ε_t are assumed to be spherically distributed and white noise. The bounds testing for cointegration approach is based on the standard Wald or F-statistics and the presence of long run equilibrium relationship is tested by restricting the lagged levels variables, $\ln M2_{t-1}$, $\ln Y_{t-1}$ and R_{t-1} in the equation (2). Therefore, it is a joint significance F-test for the null hypothesis of no cointegrating relation $\left(H_0 : a_1 = a_2 = a_3 = 0\right)$ against the alternative hypothesis of a cointegrating relation $\left(H_1 : a_1 \neq a_2 \neq a_3 \neq 0\right)$. If the calculated F-statistics exceeds the respective upper critical bounds value tabulated in Pesaran et al. (2001, pp. 300), we suggest that the variables are cointegrated. Otherwise, the variables are not cointegrated.

Next, a battery of diagnostic tests will be conducted to ensure that the classical assumptions are complied to. Besides that, this study will also test the stability of money demand function using the proposed rolling ARDL cointegration test to compare with the result of CUSUM and CUSUM of Squares tests.

In view of data sources, the present study uses quarterly data of real M2 money demand, real GDP and money market interest rates from 1960:Q1 to 2007:Q2 in Japan. The data are obtained from International Monetary Funds, *International Financial Statistics* (IFS). The GDP deflator (2000 = 100) was used to derive the real term.

Although Pesaran et al. (2001) stated that the bounds testing procedure is applicable irrespective of whether the regressors belong to $I(0)$ or $I(1)$ process, it is nevertheless important to ensure that the regressors are not integrated into an order higher than one. This is because the inclusion of $I(2)$ regressors may lead to spurious cointegration results as there is no critical values for bounds test with $I(2)$ regressors. To determine the order of integration, this study employed the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwaitkowski et al. (1992) – KPSS stationarity tests. The results for unit roots tests are reported in Table 1. The results for ADF and PP tests suggests that all the variables are integrated of order one, $I(1)$, except interest rate is stationary at level, $I(0)$. However, the evidence from KPSS test indicates that all the variables included interest rates are non-stationary at level, but they are stationary after first differencing. These results lead us to the conclusion that the order of integration of estimated variables are mixture (i.e. $I(0)$ and $I(1)$ process). Therefore, the bounds testing for cointegration is very suitable to the present formulation of the demand for money in Japan as the order of integration of the variables is different.

Table 1: The results of stationarity tests

Variables	ADF	PP	KPSS
$\ln M2_t$	–1.128 (5)	–1.172 (9)	0.421 (11)***
$\Delta \ln M2_t$	–3.658 (4)**	–7.262 (5)***	0.082 (9)
$\ln Y_t$	–2.208 (4)	–3.143 (14)	0.388 (11)***
$\Delta \ln Y_t$	–4.763 (3)***	–42.314 (15)***	0.084 (16)
R_t	–4.427 (1)***	–3.463 (5)**	0.216 (10)**
ΔR_t	–5.924 (8)***	–7.573 (1)***	0.021 (5)

Note: The asterisks ***, ** and * denotes the significance level at 1, 5 and 10 per cent. ADF, PP and KPSS refer to Augmented Dickey-Fuller, Phillips-Perron and Kwiatkowski et al. (1992) unit root tests. The optimal lag length for ADF test is selected using the AIC while the bandwidth for PP and KPSS tests are selected using the Newey-West Bartlett kernel. Figure in parentheses denotes the optimal lag length and bandwidth. The critical values for ADF and PP tests are obtained from MacKinnon (1996) while the asymptotic critical values for KPSS test are obtained from Kwiatkowski et al. (1992).

3. EMPIRICAL RESULTS

3.1 Cointegration test results

In applying the bounds testing procedure for cointegration, we have to decide the optimal lags order for ARDL model. With the assistance from Akaike's Information Criterion (AIC), we found that ARDL(5, 0, 1) is the best. This information criterion was used owing to its superior's properties in small sample (see Liew, 2004; Lütkepohl, 2005, pp. 151). The results of bounds test for cointegration, together with the critical bounds values for $k = 2$, are reported in Table 2, Panel A. Batteries of diagnostic tests were conducted on the final ARDL model. The Ramsey RESET test indicates that the final ARDL model is free from the specification error problem. The Breusch-Godfrey LM test for serial correlation does not reject the null hypothesis of no serial correlation at the 5 per cent significance level. This implied that the estimated residuals are not serially correlated. Moreover, the Jarque-Bera normality test shows that the estimated residuals are normally distributed. Therefore, the statistical inferences based on the conventional tests statistics such as t-ratio, R^2 and F-statistics are valid.

Table 2: The results of bounds test for cointegration

Panel A: Calculated F-statistic		
$F_{M2}\left(M2 \mid Y, R\right)$	4.340*	
# Critical Values Bounds (F-test):		
Significance Level	Lower $I(0)$	Upper $I(1)$
1 per cent	5.15	6.36
5 per cent	3.79	4.85
10 per cent	3.17	4.14
Conclusion:	**Cointegrated**	

Panel B: Long run coefficients

Regressors	Coefficients
Constant	–9.942***
$\ln Y$	1.786***
R	–0.014

Note: ***, **, * denote significance at 1, 5 and 10 per cent level, respectively. # Case III: Unrestricted intercept and no trend (k = 2) critical values are obtained from Pesaran et al. (2001, pp. 300).
R-squared: 0.880; Adjusted R-squared: 0.873; F-Statistic: 115.157 (0.000); Jarque-Bera: 2.813 (0.245); Ramsey RESET [1]: 0.004 (0.952); Breusch-Godfrey LM test [1]: 2.273 (0.132), [2]: 2.293 (0.318);
ARCH test [1]: 1.450 (0.228).
[ ] refer to the diagnostics tests order; ( ) refer to the p-values.

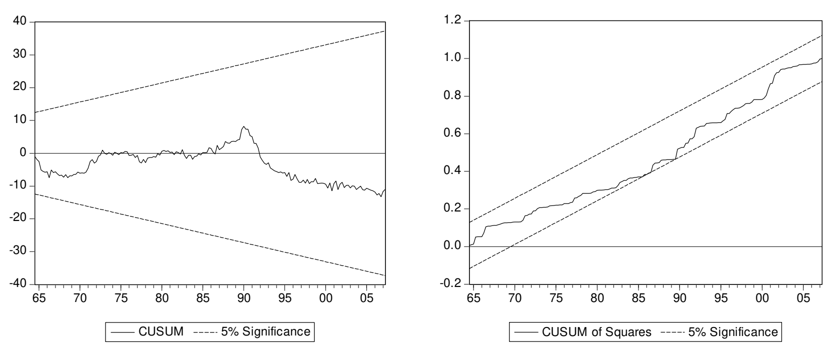

Figure 1: CUSUM and CUSUM of Squares Statistics

In order to ascertain the presence of a long run equilibrium relationship between M2 money demand and its determinants, a joint significance F-test for $\left(H_0 : a_1 = a_2 = a_3 = 0\right)$ was conducted. The calculated F-statistic for bounds test is 4.340 which is greater than the 10 per cent upper bounds critical values tabulated in Pesaran et al. (2001). This implied that real M2 money demand and its determinants, real income, interest rates are cointegrated. Next, we performed the CUSUM and CUSUM of Squares tests on the final ARDL model to test the stability of money demand function. The plots of CUSUM and CUSUM of Squares tests in Figure 1 are always stay inside the 5 per cent critical bounds. This implies that the estimated coefficients are stable over the analysis period.

Apart from that, this study employed the Bardsen (1989) procedure to calculate the long run elasticities from the ARDL model as the variable are cointegrated. The long run real income and interest rates elasticities are $-\left(a_2/a_1\right)$ and $-\left(a_3/a_1\right)$, respectively. The results of long run coefficients are presented in Table 2, Panel B. From the estimated results, we found that the sign of estimated coefficients are harmony to the economic theory, where real income (1.786) is positively related to real money demand while interest rate (–0.014) is negatively related to real money demand.

3.2 Rolling cointegration test results

In this section, this study propose to implement the rolling ARDL cointegration test to gains some further insights on the stability of money demand function in Japan. Over the past few decades, Japan has witnessed some major switch in its monetary policies environments such as the introduction of the floating exchange rate system in 1973, interest rate liberalisation and the initialling of the Plaza Accord in the mid-1980s, and the Asian financial crisis in 1997. Although the CUSUM and CUSUM of Squares tests show that the estimation is stable, these tests are low power in handling models with lagged dependent variable(s). Thus, it is interesting to implement a rolling cointegration test to re-examine whether the Japanese money demand function remains stable or not under the changing monetary policies environments. By using the rolling ARDL cointegration test, we may possibly detect the influences of the monetary policies innovations on the interactions between money demand and its determinants.

In running the rolling ARDL cointegration test, we need to set the size of rolling window. To the best of our knowledge, there is no statistical procedure to set the optimal window size. As a result, the choice of rolling window size seems arbitrary. Given that cointegration is a long run property and reasonably long time spans of data may be required to capture the presence of cointegrating relation (see Hakkio and Rush, 1991), thus we set the window size at 10 year. Following this, the rolling ARDL cointegration test is conducted with the sub-sample data of 40 quarters over the period of analysis. Another concern raised in this section is the small sample critical values. We noted that the critical values provided by Pesaran et al. (2001) are not suitable for our constant rolling windows size of 40 observations. Thus, we employed the response surface procedure developed by Turner (2006) to derive the exact critical values for 40 observations. Furthermore, the 10-year rolling F-statistics for bounds test is normalised by the 10 per cent critical values. If the ratio is above one then the null hypothesis of no cointegrating relation will be rejected. In other words, if the money demand function is stable, then a larger number of significant F-statistics should be observed as time goes on.

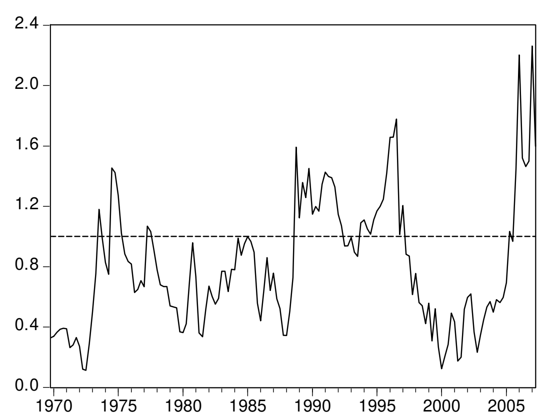

Figure 2: The normalized F-statistics for rolling cointegration test

Figure 2 presents the normalised F-statistics for bounds test for the rolling window size of 40 observations. Overall, the rolling ARDL cointegration test results are varies over the analysis period. On one hand, the test results indicate that the stable M2 money demand function emerged merely from the period of 1989 to approximately 1997. On the other hand, the test results shows that there are two potential structural breaks in the Japanese M2 money demand that is during the period of 1975 to approximately 1988 and late 1990s. Over the past decades, the money demand in Japan has experienced a large fluctuation due to a series of changes in the monetary policies environments; hence it was not a surprise to shows that the M2 money demand function in Japan is not stable.[1] This is consistent with our priori expectation and also the findings of Seo and Harada (2001) who found that M1 and M2 money demand in Japan are unstable after the Asian financial crisis in 1997. This additional exercise clearly indicate that the CUSUM and CUSUM of Squares tests may not be an appropriate tools for stability when the model contained lagged dependent variable(s).

4. CONCLUSIONS AND POLICY IMPLICATIONS

Using rolling approach to ARDL cointegration tests, this study empirically re-investigates the stability of Japanese M2 money demand function over the period of 1960:Q1 to 2007:Q2. Several remarkable evidences emerged from this study: First, the ARDL model is estimated for whole sample period (see Table 2). The result of the bounds test show that real money demand for M2 and its determinants are cointegrated and both CUSUM tests (see Figure 1) shows that the parameters are stable over the analysis period. Second, the Bardsen's (1989) estimation results suggest that the long run coefficients sign for real income and interest rates are consistent with the economic theory. Finally, this study proposed to use rolling regression-based ARDL cointegration test to re-examine the stability of money demand function in Japan. With the assistance from this rolling cointegration test, we find that M2 money demand function in Japan is not stable due to a series of changes in the Japanese monetary policies environments. This result is not consistent with most of previous empirical studies in Japan (e.g., Bahmani-Oskooee, 2001; Tang, 2004; etc.).

The finding of unstable money demand function in Japan has offered a new piece of evidence supporting the needs of others macroeconomic policies such as fiscal policy and supply-side economy to stabilise the economy. However, the monetary policy should not be discarded as a useless policy instrument for curbing

[1] We are aware that the results of the rolling ARDL cointegration tests are sensitive to the number of years included in the rolling window; hence we have also conducted the test by using different rolling windows size such as 50 and 60 quarterly observations. To save space, the results for the rolling window size of 50 and 60 quarterly observations are not reported here, but it is available upon request from the author. The obtained results tend to show that the M2 money demand function is not stable.

inflation and others economic issue in Japan as the inelasticity of interest rate may shed some light that the monetary policies are effective (see Moghaddam, 1997). Therefore, this study suggests that policymakers should employ both monetary policy and fiscal policy in its efforts either to combat inflation or to stimulate economic growth in Japan.

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