Abstract

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Structural Breaks, Cointegration and the Demand for
Money in Greece

Abstract

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1. Introduction

The demand for money Md refers to the quantity of money that someone holds on average during a time period in order to finance his transactions. We assume that as long as real GDP(Y) increases, demand for money also increases, since real GDP measures the volume of goods and services circulated in the economy for a given time period. We also assume that as price level (P) increases, then the real money
demand for transactions increases respectively, so as the demand for money in real terms remains the same. This is the so-called “absence of money illusion” hypothesis. Our final assumption is that the demand for money is negatively related to nominal interest rate \((r)\) which in turn, alternative savings like government bonds, pay. More specifically, the higher the nominal interest rate, the higher the opportunity cost of holding money and hence the smaller the demand for money.

Since the late 1980’s, demand for money in industrial economies was in general unstable due to market freedom. That led central banks of these industrial economies to seize bank interest rates as the main mechanism of their monetary policy. Such an inappropriate choice of monetary policy, could easily lead to growing instability. On the contrary, there is no evidence that demand for money in developing countries is not stable (Oskooee-Bahmani and Rehman 2005). Nevertheless, in many developing countries, central banks, switched to bank interest rates as a mechanism for their monetary policy. Hence, it’s of great importance in research to apply contemporary techniques of developing time series in order to capture and test stability of demand for money.

So far numerous empirical findings have estimated the demand for money in many countries and have also tested its stability. Demand for money and in particular its seasonality has great consequences in choosing the mechanisms of monetary policy. Poole (1970) showed that when LM curve is not stable then central banks should use bank interest rate as means of monetary policy. When IS curve is not stable then the most appropriate mechanism of monetary politics is the supply for money. Since a huge degree if instability of LM curve is due to instability in demand for money, it is of great importance to understand the degree of stability in the demand for money.
The current paper aims at presenting an empirical work of the stability of the demand for money in the case of developing countries such as Greece, taking into consideration the structural changes in the cointegration relationships by applying Gregory and Hansen (1996a) techniques. To achieve this aim, the paper is organised as follows. Section 2 reviews some previous empirical studies on demand for money in Greece. Section 3 presents the model specification and econometric methodology. Section 4 presents empirical results and conclusions are in section 5.

2. **Empirical Studies on Greece**

The specification of long-run relationship between demand for money, real income, inflation, nominal interest rate and exchange rate, remains a popular application of many researches in economics. In the case of Greek economy, the specification of money demand function was the fundamental issue of the empirical work of many researchers such as Arestis (1988), Karfakis (1991), Ericsson and Sharma (1996), Apergis (1999), Karfakis and Sidiropoulos (2000) and Economidou and Oskooee (2005).

Psaradakis (1993) investigates the relationship between money demand and its determinants in the case of Greece. For this relationship he creates a small system comprised of money, prices, income and interest rates by applying a recently proposed modelling strategy based on sequential reduction of a congruent vector autoregression.

Papadopoulos and Zis (1997) investigate the determinants and the stability of the demand for broad and narrow definitions of money in Greece. The findings of the empirical work suggest that the demand for M1 is unstable whereas the results for M2 are not sufficiently ambiguous.
Brissimis et al. (2003) examines the behaviour of the demand for money in Greece during 1976Q1 to 2000Q4. In order to estimate money demand, authors apply two empirical methodologies; the vector error correction modelling (VECM) as well as the generation random coefficient (RC) modelling. The results estimated by both VECM methodology and RC methodology support that money demand in Greece became more responsive to both the own rate of return on money balances and the opportunity cost of holding money because of financial deregulation.

Karpetis (2008) investigates the linear long-run relationship between money demand, income and opportunity cost of holding money by using annual data covering the historic period between 1858 and 1938. The results of the analysis reveal a long-run equilibrium relationship and stability in the cointegration coefficients under examination.

In all these previous studies an important issue that was not addressed is that the cointegration relationship may have a structural break during the sample period. This issue was briefly discussed in Brissimis et al. (2003). Therefore, we address the stability of money demand, taking into account the unknown structural breaks, using the Gregory and Hansen techniques.

3. Model and Econometric Methodology

In this analysis the monetary aggregate the real M1, (currency in circulation plus demand deposits), is taken as a proxy for the relevant measures of money. We use M1 as a proxy for the demand for money because the central bank is able to control this aggregate more accurately than broader aggregates such as M2 and M3. We also use real income is measured by GNP, the rate of inflation is the consumer price index, and three month t-bill rates are used as the nominal interest rate.
Logarithm values were used for money demand, consumer price index, real GNP, and nominal interest rate. All the data we use are from IMF (International Monetary Fund) over the period 2001:Q1 to 2010:Q4.

Following Hamori, and Hamori (2008) the model includes nominal money supply, the consumer price index, real GNP, and the nominal interest rate, which can be written as:

\[
\frac{M_t}{P_t} = L(Y_t, R_t) \quad L_y > 0 \quad L_R < 0
\]  

(1)

where

\( M_t \) represents nominal money supply for period \( t \);
\( P_t \) represents the consumer price index for period \( t \);
\( Y_t \) represents real GNP for period \( t \); and
\( R_t \) represents the nominal interest rate for period \( t \).

Increases in real GNP bring increases in money demand \( (L_y > 0) \) and increases in interest rates bring decreases in money demand \( (L_R < 0) \).

Getting the log of Equation (1) we get the following function:

\[
\ln(M_t) - \ln(P_t) = \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(R_t) + u_t \quad \beta_1 > 0 \quad \beta_2 < 0
\]  

(2)

Many macroeconomic time series contain unit roots dominated by stochastic trends as developed by Nelson and Plosser (1982). Unit roots are important in examining the stationarity of a time series, because a non-stationary regressor invalidates many standard empirical results. In this study, Augmented Dickey– Fuller (ADF) (1979, 1981) and Phillips-Perron (1988) tests were used to determine the presence of unit roots in the data sets. Also, we use the HEGY test (Hylleberg, Engle, Granger and Yoo, 1990) to examine the existence of seasonal unit roots in quarterly data.
3.1. **HEGY Seasonal Unit Root Tests**

In this section, we use the HEGY test (1990) to examine the existence of seasonal unit roots in quarterly data. A time series contains a seasonal unit root if its level series is nonstationary, but its fourth difference is stationary. The first order autoregressive process of a time series with seasonal unit root will be \( Y_t = Y_{t-4} + \varepsilon_t \).

HEGY (1990) is a test for seasonal and nonseasonal unit roots in a quarterly series. The HEGY test is based on the following regressions

\[
y_{4t} = \sum_{i=0}^{4} \mu_i D_{it} + \gamma T_t + \pi_1 y_{1t-4} + \pi_2 y_{2t-4} + \pi_3 y_{3t-2} + \pi_4 y_{4t-1} + \varepsilon_t
\]

where

\( D_{it} \) are seasonal dummies

\( T_t \) is the trend

\( y_{1t} = (1+\B^2+\B^3)y_t \)

\( y_{2t} = -(1-\B^2-\B^3)y_t \)

\( y_{3t} = -(1-\B^3)y_t \)

\( y_{4t} = \Delta_4 y_t = y_{t} - y_{t-4} \)

\( \Delta_4 = (1-\B^4) \)

\( \B \) denoting the usual lag operator

\( \varepsilon_t \) is assumed to be a white noise process.

The null and alternative hypotheses which are examined are the following:

\( H_0: \pi_1 = 0, \ H_1: \pi_1 < 0 \). The test for a unit root at zero frequency will be a t-test if \( \pi_1 = 0 \), hence the series contains a nonseasonal stochastic trend.

\( H_0: \pi_2 = 0, \ H_1: \pi_2 < 0 \). A t-test on \( \pi_2 = 0 \), will determine the presence of a bi-annual unit root frequency.
$H_0: \pi_3 = \pi_4 = 0$, $H_1: \pi_3 \neq 0 \& \pi_4 \neq 0$. A joint F-test of the null hypothesis ($\pi_3 = 0$ and $\pi_4 = 0$), will be the test for an annual unit root.

Seasonal unit root will not be present if both the tests ($\pi_2 = 0$, t-test and $\pi_3 = \pi_4 = 0$, joint F-test) reject the null hypothesis.

### 3.2. Cointegration Tests

When all variables under consideration are non-stationary and become stationary in their first differences, we perform a cointegration test to find out whether a linear combination of these series converge to an equilibrium or not. Johansen and Juselius’s (1990) cointegration method was used for cointegration analysis. Also, the Gregory and Hansen (1996a) tests are applied to examine the possible structural breaks in money demand functions.

**Johansen and Juselius’s Cointegration Method**

The tests of co-integration between two variables are based on a VAR approach initiated by Johansen (1988). Suppose for that, that we have a general VAR model with $k$ lags:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_k Y_{t-k} + BX_t + e_t$$

(4)

where

$Y_t$ is a non-stationary vector I (1).

$A_k$ are different matrices of coefficients.

$X_t$ is a vector of deterministic terms and finally

$e_t$ is the vector of innovations.

This VAR specification can be rewritten in first differences as follows:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + BX_t + e_t$$

(5)

where
\[ \Pi = \sum_{i=1}^{p} A_i - I, \text{ and } \Gamma_i = - \sum_{j=i+1}^{k} A_j \]

The matrix \( \Pi \) has a reduced rank \( r < k \), it can be expressed then as \( \Pi = CB' \), where \( C \) and \( B \) are \( n \times r \) matrices and \( r \) is the distinct co-integrating vectors or the number of co-integrating relations (Granger 1986). Also, each column of \( B \) gives an estimate of the co-integrating vector.

**Gregory and Hansen Methodology**

Gregory and Hansen (1996a and 1996b) performed a cointegration test that allows for possible structural breaks. The four models of Gregory and Hansen with assumptions about structural breaks and their specifications with two variables, for simplicity, are as follows:

**Model 1: Standard Cointegration**

\[ Y_t = \mu_1 + \alpha_1 X_t + e_t \] (6)

**Model 2: Cointegration with Level Shift (CC)**

\[ Y_t = \mu_1 + \mu_2 \phi_{tk} + \alpha_1 X_t + e_t \] (7)

**Model 3: Cointegration with Level Shift and Trend (CT)**

\[ Y_t = \mu_1 + \mu_2 \phi_{tk} + \beta_1 t + \alpha_1 X_t + e_t \] (8)

**Model 4: Cointegration with Regime Shift (CS)**

\[ Y_t = \mu_1 + \mu_2 \phi_{tk} + \alpha_1 X_t + \alpha_2 X_t \phi_{tk} + e_t \] (9)

where:

- \( Y \) is the dependent variable
- \( X \) is the independent variable
- \( t \) is time subscript
- \( e \) is the error term
- \( k \) is the break date and
φ is a dummy variable such that:

\[
\varphi_{kt} = \begin{cases} 
0, & \alpha \leq t \leq k \text{ (is the breaking point)} \\
1, & t > k 
\end{cases}
\]

Gregory and Hansen (1996b) constructed three statistics for those test: ADF*, \(Z_a^*\) and \(Z_t^*\). They are corresponding to the traditional ADF test and Phillips type test of unit root on the residuals. The null hypothesis of no cointegration with structural breaks is tested against the alternative of cointegration by Gregory and Hansen approach. The single break date in these models is endogenously determined. Gregory and Hansen have tabulated critical values by modifying the Mackinnon (1991) procedure. The null hypothesis is rejected if the statistic ADF*, \(Z_a^*\) and \(Z_t^*\) is smaller than the corresponding critical value. Alternatively, these can be written as:

\[
ADF^{*} = \inf_{\tau \in T} ADF(\tau) 
\]

(10)

\[
Z_a^* = \inf_{\tau \in T} Z_a(\tau) 
\]

(11)

\[
Z_t^* = \inf_{\tau \in T} Z_t(\tau) 
\]

(12)

In all the previous studies on demand for money in Greece that was not addressed is that the cointegration relationship may have a structural break during the sample period. Therefore, we explore the stability of the demand for money with the Gregory and Hansen techniques. The Gregory and Hansen demand for money specifications for the aforesaid three models with structural breaks, are as follows:

The equations above could also be applied to more than one independent variables.

Our specification of demand for money is:

\[
\ln(MP_t) = \mu + \beta_1 \ln Y_t - \beta_2 \ln r_t + e_t 
\]

(13)

where

\[
\ln(MP_t) = \ln(M_t) - \ln(P_t)
\]
M is real narrow money

Y is real GNP

r is the nominal rate of interest

e is the error term.

The implied specification for the three Gregory and Hansen equations with structural breaks are as follows:

\[
\ln MP_t = \mu_1 + \beta_1 \ln Y_t - \beta_2 \ln r_t + e_t \tag{14}
\]

\[
\ln MP_t = \mu_1 + \mu_2 \varphi_{dt} + \beta_1 \ln Y_t - \beta_2 \ln r_t + e_t \tag{CC}
\]

\[
\ln MP_t = \mu_1 + \mu_2 \varphi_{dt} + \alpha_1 t + \beta_1 \ln Y_t - \beta_2 \ln r_t + e_t \tag{CT}
\]

\[
\ln MP_t = \mu_1 + \mu_2 \varphi_{dt} + \beta_1 \ln Y_t + \beta_{11} \ln Y_t \varphi_{dt} - \beta_2 \ln r_t - \beta_{22} \ln r_t \varphi_{dt} + e_t \tag{CS}
\]

The Gregory and Hansen method is essentially an extension of similar tests for unit root tests with structural breaks, Zivot and Andrews (1992). However, it should be noted that unit roots and cointegration with structural breaks are conceptually different and they have different critical values.

The break date is found by estimating the cointegration equations for all possible break dates in the sample. We select a break date where the test statistic is the minimum or in other words the absolute ADF test statistic is at its maximum. Gregory and Hansen have tabulated the critical values by modifying the MacKinnon (1991) procedure for testing cointegration in the Engle-Granger method for unknown breaks.

3.3. Vector Error Correction Models

In order to be able to formulate the Vector Error Correction Model (VECM), we should first ensure that the variables are cointegrated. If in the estimates there in
more than one cointegrating vector, then we would have more than one error correction term.

The dynamic relationship includes the lagged value of the residual from the cointegrating regression, besides the first difference of variables appear as regressors of the long-run relationship. The inclusion of the variables from the long-run relationship can capture short run dynamics. It is essential to test if the long-term relationship established in the model gives the short-run disturbances. Thus, a dynamic error correction model, forecasting the short-run behavior, is estimated on the basis of cointegration relationship. For this purpose the lagged residual-error derived from the cointegrating vector is incorporated into a highly general error correction model. This leads to the specification of a general error correction model (ECM) (Jayasooriya 2010).

4. Empirical results

4.1. ADF and PP unit root tests

We first tested for the presence of unit roots in our variables. The Augmented Dickey – Fuller test (ADF) (1979, 1981) and Phillips – Perron (PP) (1988) are used for testing for the order of the variables. The time trend is included because it is significant in the levels and first differences (Δ) of the variables. The computed test statistics for the levels and first differences (Δ) of the variables are given in table 1.

<table>
<thead>
<tr>
<th>Table 1</th>
</tr>
</thead>
</table>

From the results of table 1 we observe that the null hypothesis of unit root cannot be rejected in all variables in their levels, but can be rejected in their first differences as seen in both tests we apply. Hence, we could say that the variables we examine are stationary in their first differences.
4.2. HEGY Seasonal Unit Root Tests

Table 2 presents the results of HEGY tests for our quarterly time series. From the table, we can see that t statistics of $\pi_1$ for all series are not significant at the 5% level. We fail to reject the null hypothesis that $\pi_1$ equals to zero. Hence we conclude that all series contain unit root at zero frequency. Furthermore, we can see that all the t values of $\pi_2$, $\pi_3$, $\pi_4$ and joint F statistics of $\pi_3$ and $\pi_4$ are significant at 5% levels. Therefore, we reject the null hypotheses for these series that $\pi_2$, $\pi_3$, $\pi_4$ and joint of $\pi_3$ and $\pi_4$ are equal to zero. Hence we draw the conclusion that lnM, lnY, and lnR do not have seasonal unit roots. HEGY(1990) contain the critical values for these unit root and seasonal unit root tests.

Table 2

4.3. Johansen's Cointegration Procedure

Johansen and Juselius’s (1990) cointegration method was used for cointegration analysis. The order of lag-length was determined by Schwarz Information Criterion (SIC) and Akaike Information Criterion (AIC). Johansen and Juselius, procedure test results are presented in table 3.

Table 3

The test statistics do not reject the null hypothesis of no cointegrating relation at 5 per cent significance level. Therefore, there is not cointegration vector (see the trace test and the maximal-eigenvalue statistics for cointegration test in table 3). This indicates that there is no long run relationship between money demand, real GNP, and interest rate over the sample period.

4.4. Gregory and Hansen Tests
Table 4 presents the cointegration results for the case of three models of Gregory-Hansen with structural variables. All three models were estimated by OLS and after obtaining the residuals we proceeded with ADF test. The estimation was conducted for every t within the interval \([0.15\eta, 0.85\eta]\), where \(\eta\) is the sample size minus the number of lags used in the ADF test\(^1\). Hence, the estimation is conducted for the period 2001Q1 – 2010Q4, where we get the minimum t – statistic from the ADF test and test the null hypothesis\(^2\).

Table 4

These results in table 4 which are self-explanatory, imply that irrespective of which of the three models with structural breaks is used, there is a cointegrating relationship between real money, real GNP, and the nominal rate in interest in Greece. The brake date is 2008:Q3 in model CC, 2010:Q1 in model CT, and 2009Q1 in model CSI. The null hypothesis of no cointegration is rejected in all the three models.

In table 5 we estimate the cointegration equations for the three models by applying the Ordinary Least Squares (OLS) method.

Table 5

From the results of table 5 we observe that the estimates of these three models seem to imply that model CC is the most plausible model for the following reasons. In model CC all the estimated coefficients are significant with expected signs and magnitudes. The real GNP elasticity of demand for money is 0.572 at the 1% level, and rate of interest elasticity of demand for money is 0.121 at the 1% level. Wald test

---

\(1\) In our analysis we start with 10 time lags and then we decide to use only the ones statistical significant.

\(2\)Critical values for ADF tests came from Gregory and Hansen (1996a)
statistic for the null of unit elasticity of the coefficient of real GNP of demand for money failed to reject it in model CC\(^3\).

In the CT and CS models the estimate of real GNP and interest rate have incorrect signs. Therefore, we shall use the residuals from CC model to estimate the short run dynamic equation for the demand for money with the error correction adjustment model.

4.5. Error Correction Model

The short run ECM model is developed by using the LSE-Hendry General to Specific (GETS) framework in the second stage. \(\Delta \ln MP_t\) is regressed on the lagged values, the current and lagged values of the \(\Delta \ln Y_t\) and \(\Delta \ln R_t\) and the one period lagged residuals from the cointegrating vector from model CC. We have used lags to 4 periods and using the variable deletion tests in EViews 7.0 arrived at the following parsimonious equation:

Table 6

From the results of table 4 we conclude that:

All coefficients from equation (18) are statistically significant in the 5% significant level. The coefficient of the lagged error correction term is significant at the 11.3 per cent level with the correct negative sign, and serves as the expected negative feedback function. This implies that if there are departures from equilibrium in the previous period, the departure is reduced by 0.7% in the current period. Furthermore, all diagnostic tests have no problem in this dynamic equation.

\(^3\) The Wald test statistic is \(X^2(1) = 0.835\) with p-value of 0.360.
Taking into account the long-term equilibrium and the respective dynamic model, we could move on to the stability of the function of demand for money in the case of Greece.

4.6. Testing Stability of the Demand for Money

This section presents the test for the stability of the demand for money estimate. Test for stability of demand for money is important as supply of money is one of the key instruments of monetary policy conducted by Bank of Greece. If the demand for money is stable then money supply is the most suitable monetary policy instrument but if the money demand function is not stable central bank should use interest rate as the more appropriate instrument for the conduct of monetary policy. After estimating the demand for money function, we have used the conventional methods for the test of stability of the demand for money function, these test include CUSUM, CUSUMSQ and recursive estimation technique. The plots of the CUSUM CUSUMSQ and Recursive Residuals are given in figures 1, 2 and 3 below.

**Figure 1**

**Figure 2**

**Figure 3**

Figure 1, 2 and 3 presents the plots of CUSUM, Cumulative sum of squares and Recursive Residuals with 5% level of significance, plot of the CUMUM, CUSUMSQ and Recursive Residuals show instability of the demand for money function during the period 2001Q1 – 2010Q4.
5. Conclusion

In this paper we have attempted to empirically determine whether there exist any long-run equilibrium money demand functions for narrow money in Greece for the period 2001:Q1 to 2010:Q4. To achieve this objective, we employ the Johansen maximum likelihood procedure as well as the Gregory and Hansen tests, to test for possible structural breaks but also to estimate the cointegration vectors between demand for money and its determinants. Furthermore, with the error correction mechanism, we investigate the stability of money demand in the case of Greece for the period under investigation.

The results from the Johansen procedure show that there is no cointegration vector. On the other hand, based on Gregory and Hansen method, cointegration analysis proved there is a cointegration vector. Also, Gregory and Hansen tests reveal three structural breaks in the demand for money for the periods 2008Q3, 2009Q1 and 2010Q1. Finally, the stability results based on error correction model show that demand for money in Greece is not stable for the sample period.

One of the main goals of a nation’s monetary policy is to achieve price stability to promote economic growth. Monetary policy should be designed to ward off deflation as well as inflation. It is also imperative to maintain an appropriate increase in money supply in order to advance the sustained, rapid and sound development.

Our empirical results have important economic implications. Conducting monetary policy by targeting a monetary aggregate requires reliable quantitative estimates of money demand. The empirical results in this paper show the existence of an unstable long-run money demand for the case of Greece for the sample period. This instability is more obvious from 2008 onwards leading to Greece’s entrance into
the International Monetary Fund. Innovation in economic sector (hosting the Olympic Games 2004), economic reforms (predominantly tax reforms) and changes in the political environment (change of governments with different economic programs and above all economic scandals) are some of the factors responsible for instability of money demand in Greek economy.

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### Table 1: ADF and PP unit root tests

<table>
<thead>
<tr>
<th>Variables</th>
<th>ADF</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Constant</td>
<td>Constant and Linear Trend</td>
</tr>
<tr>
<td>lnY</td>
<td>F1.723(3)</td>
<td>F1.492(3)</td>
</tr>
<tr>
<td>ΔlnMP</td>
<td>F3.128(2)**</td>
<td>F3.677(2)**</td>
</tr>
<tr>
<td>ΔlnY</td>
<td>F11.111(4)***</td>
<td>F12.407(2)***</td>
</tr>
<tr>
<td>ΔlnR</td>
<td>F2.675(0)*</td>
<td>F3.554(0)*</td>
</tr>
</tbody>
</table>

Notes:
1. ***, **, * indicate significance at the 1, 5 and 10 percentage levels.
2. The numbers within parentheses followed by ADF statistics represents the lag length of the dependent variable used to obtain white noise residuals.
3. The lag lengths for ADF equation were selected using Akaike Information Criterion (AIC).
5. The numbers within brackets followed by PP statistics represent the bandwidth selected based on Newey West (1994) method using Bartlett Kernel.
6. Δ is the first differences
7. lnMP=ln(M1)-ln(P).

### Table 2: HEGY Tests

<table>
<thead>
<tr>
<th>Variables</th>
<th>π1</th>
<th>π2</th>
<th>π3</th>
<th>π4</th>
<th>π3 and π4</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnY</td>
<td>-1.589</td>
<td>-5.672***</td>
<td>-6.096***</td>
<td>-5.453***</td>
<td>12.893***</td>
</tr>
<tr>
<td>lnR</td>
<td>-0.609</td>
<td>-1.975**</td>
<td>-2.067**</td>
<td>-1.674*</td>
<td>7.546***</td>
</tr>
</tbody>
</table>

Notes:
1. ***, **, * indicate significance at the 1, 5 and 10 percentage levels.
Table 3: Johansen Cointegration Test Results

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Trace test</th>
<th>Max-Eigen</th>
<th>5% critical value</th>
<th>Trace test</th>
<th>Max-Eigen</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnMP, lnY, lnR (Order VAR = 1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r = 0</td>
<td>28.48981</td>
<td>19.72439</td>
<td>29.79707</td>
<td>21.13162</td>
<td></td>
</tr>
<tr>
<td>r ≤ 1</td>
<td>14.76542</td>
<td>13.15962</td>
<td>15.49471</td>
<td>14.26460</td>
<td></td>
</tr>
<tr>
<td>r ≤ 2</td>
<td>3.605801</td>
<td>3.605801</td>
<td>3.841466</td>
<td>3.841466</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
2. r denotes the number of cointegrated vectors
3. Akaike and Schwarz criterion are used for the order of VAR model

Table 4: Results of the test for Cointegration with Structural Breaks (2001Q1– 2010Q4)

<table>
<thead>
<tr>
<th>Cointegration models</th>
<th>Break point</th>
<th>ADF* Test Statistic</th>
<th>Critical Value</th>
<th>Reject H0 of no Cointegration</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC</td>
<td>2008:Q3</td>
<td>-5.75</td>
<td>-5.13</td>
<td>-4.61</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-4.34</td>
<td></td>
</tr>
<tr>
<td>CT</td>
<td>2010:Q1</td>
<td>-6.43</td>
<td>-5.45</td>
<td>-4.99</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-4.72</td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>2009:Q1</td>
<td>-6.56</td>
<td>-5.47</td>
<td>-4.95</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-4.68</td>
<td></td>
</tr>
</tbody>
</table>

Note: The critical values are from Gregory – Hansen (1996a).

Table 5: Cointegrating Equations

<table>
<thead>
<tr>
<th></th>
<th>Model CC (Dummy 2008Q3)</th>
<th>Model CT (Dummy 2010Q1)</th>
<th>Model CS (Dummy 2009Q1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-2.237*** (8.164)</td>
<td>10.228*** (2.895)</td>
<td>6.851 (2.356)**</td>
</tr>
<tr>
<td>Dummy</td>
<td>-0.214*** (-6.063)</td>
<td>-0.013 (-0.099)</td>
<td>0.101 (0.353)</td>
</tr>
<tr>
<td>Trend</td>
<td>0.164*** (13.92)</td>
<td>0.164*** (13.92)</td>
<td>0.164*** (13.92)</td>
</tr>
<tr>
<td>lnY</td>
<td>0.572*** (7.690)</td>
<td>-0.756** (-2.246)</td>
<td>-0.478* (-1.724)</td>
</tr>
<tr>
<td>Dummy X lnY</td>
<td>-0.121*** (-3.875)</td>
<td>0.064*** (5.942)</td>
<td>0.137*** (7.982)</td>
</tr>
<tr>
<td>lnR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dummy X lnR</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. T – ratios are in parentheses below the coefficients.
2. ***, **, * indicate significance at the 1, 5 and 10 percentage levels.

Table 6 - Error Correction Model

\[ \Delta \text{lnMP}_t = 0.016 -0.312 \Delta \text{lnMP}_{t-1} + 0.304 \Delta \text{lnMP}_{t-2} + 0.314 \Delta \text{lnMP}_{t-3} + 0.292 \Delta \text{lnMP}_{t-4} \]

\( (0.792) \quad (-2.111) \quad (2.377) \quad (2.413) \quad (2.311) \)
\[ 0.130 \Delta \ln Y_{t-4} - 0.102 \Delta \ln R_{t-1} + 0.103 \Delta \ln R_{t-4} - 0.076 \text{ECM}_{t-1} \quad (18) \]

\[
\begin{array}{cccc}
(2.330)^{**} & (-3.545)^{***} & (3.882)^{***} & (-1.458) \\
[0.027] & [0.001] & [0.000] & [0.113]
\end{array}
\]

\[ \bar{R}^2 = 0.624 \quad \text{F – Statistic} = 11.254 \quad \text{D-W} = 2.097 \]

| A: $X^2[1]$ | 1.451 | 0.228 | B: $X^2[1]$ | 0.590 | 0.442 |
| C: $X^2[2]$ | 1.098 | 0.577 | D: $X^2[16]$ | 14.75 | 0.542 |

Notes:
- $\Delta$: Denotes the first differences of the variables.
- $\bar{R}^2$: Coefficient of multiple determination adjusted for the degrees of freedom (d.f).
- DW = Durbin-Watson statistic.
- A: $X^2(n)$ Lagrange multiplier test of residual serial correlation, following $x^2$ distribution with n d.f.
- B: $X^2(n)$ Ramsey’s Reset test for the functional form of the model, following $x^2$ distribution with n d.f.
- C: Normality test based on a test of skewness and kurtosis of residuals, following $x^2$ distribution with n d.f. (Jarque-Bera).
- D: $X^2(n)$ Heteroscedasticity test, following $x^2$ distribution with n d.f.
- ( ) = We denote the t-ratio for the corresponding estimated regression coefficient.
- [ ] = We denote prob. Levels.
- ***, **, *, + indicate significance at the 1, 5, 10 and 12 percentage levels.

**Figure 1: CUSUM Test for Equation 18**

**Figure 2: CUSUMSQ Test for Equation 18**
Figure 3: Cumulative Sums of Squares of Recursive Residuals for Equation 18