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How Stable is the Money Demand in Taiwan?

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Abstract: Empirical literature on money demand is mainly based on the estimation of a long run relation by means of time-invariant cointergration approach. Taiwan has experienced the economic and financial regime change since 1979. The purpose of this paper is to test structural breaks in Taiwan long run money demand equation. We examine six of the most influential specifications proposed in the literature. The classical set of explanatory variables (e.g. income and interest rates) is extended on the base of a number underlying economic reasons related to financial, labor and international portfolio characteristics. The results suggest that international financial market variables and the classical specifications are the key determinants of structural instability observed in Taiwan broad money.
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1. Introduction

Money plays a central role in policy making of monetary authority around the world. This is based on the observation that inflation is always and everywhere a monetary phenomenon. Price rises when central bank prints too much money. For this scope, aiming to achieve price stability is the statutory objective of most central banks. For example, the European Central Bank established an annual growth rate of M3 at a reference value of 4.5% to keep the inflation target below 2% since 1999. Although the monetary aggregate M3 diverged for its target value since the end of 2001, policymakers have increasingly taken macro-prudential view of regulation after the financial crisis. The goal of macro-prudential is to reduce the risk of system-wide distress, thereby protecting the economy against the decline of income and employment. Monitoring the monetary aggregates could help to achieve the goal of macro-prudential control of financial risk. As indicated by Calza *et al.* (2001), the existence of the stable relation between the money stock and the price level as well as some other important variables is perceived as a necessary prerequisite for the use of monetary aggregates in conducting the monetary policy by central banks.

Several recent studies utilize the cointegration analysis, which is proposed by Engle and Granger (1987) and Johansen (1998), to find the evidence of stable relationship relating the money stock to income and some explanatory variables. Examples include Calza *et al.* (2001) for Euro area, McNown and Wallace (1992) for the US, Johansen (1992) for the UK, Bahmani-Oskooee (2001) for Japan, Wu *et al.* (2005) for Taiwan, Zuo and Park (2011) for China, among many others. A general conclusion for the studies mentioned above, the money stock (M1 or M2), income, interest rates and some other explanatory variables are cointegrated, no matter which model are chosen. However, the traditional time-invariant approach of stable money demand is challenging if a country experiences an economic transition or structural change. Gregory and Hansen (1996) allow the possibility of regime shift in the sense that a linear combination (cointegrating vector) of non-stationary variables is stationary, but that the cointegrating vector is allowed to change at a single unknown time in the sample. By examining the annual and quarterly data of United States, Gregory and Hansen (1996) find some evidence of structural break of long run cointegrating relationship between the money stock and explanatory variables. China economic reform began in the late 1970s and the 16-point financial reform in 1993 raised the possibility of unstable money demand in China. Lee and Chien (2008) apply Gregory and Hansen (1996) methodology to investigate the regime shifts of China's money demand. They concluded that the structural break years, based on the three alternative models – a level shift, a level shift with trend, and the regime shift, are mainly in 1980 and 1993. This tended to suggest that the issue of structural break needs to be careful examined in formulating the money stock and income as well as some explanatory variables in China. Zuo and Park (2011) argued that economic condition and policy regime in China are changing over time. It is inappropriate to apply time-invariant cointegrating regression to analyze money demand in China. The evidence of unstable relation between money demand and income is also found in the Euro Area. Recognizing

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the presence of a structural break leads to time varying cointegrating approach to model the dynamics of money demand. Barrigozzi and Conti (2010) adopt the smooth time-varying cointegration likelihood-ratio test for parameter stability developed in Bieren and Martins (2010).

The purpose of this paper is to present cointegration based method with regime shift to model Taiwan money demand. Specifically, this paper starts with the cointegration analysis with the augmented Dickey-Fuller (ADF) test. However, if the model is indeed presented with structural break, the usual ADF tests may fall significantly and the researchers conclude that there is no long-run relationship among variables. To avoid the breakpoint determined by simple visual time series plot, Zivot and Andrews (1992) and Perron (1997) proposed the breakpoint determining "endogenously" from the data. I deliberately take issue with unit root testing procedure with structure change. In particular, Zivot and Andrews (1992) and Perron (1997) tests will be applied in Taiwan money demand specification. After the univariate tests of Zivot and Andrews (1992) and Perron (1997), the multivariate extension of cointegration analysis proposed by Gregory and Hansen (1996) is employed to examine the model of dynamic money demand in Taiwan. Gregory and Hansen (1996) allow for a regime shift with the intercept alone or the entire coefficient vector with unknown time of the regime shift.

During 1960s, banks in Taiwan had to rely upon foreign exchange control and interest rate control to allocate scarce resources to fuel national economic development. Following the establishment of the Taipei Foreign Exchange Market in February 1979, a flexible exchange rate system was formally implemented. Since then, the NT dollar exchange rate has been determined by the market. All foreign exchange controls on current account transaction were removed in 1987. Since 1990, all the restrictions on exchange rate movement have been removed and exchange rate is market determined. In addition, deregulation of capital movement took place in July 1987. Central Bank of Taiwan lifted restrictions on capital flows not involving NT dollars as well as involving NT dollars. Beginning in October 2003, foreign investors might invest stock market up to $5 million US dollars and foreign institutional investors were not subject to any ceiling. Moreover, money market was established in 1976 and interest rate controls were completely abolished by revised banking law in 1989. The introduction of Central Government Security System (CGSS) in 1997 and the Book-Entry Treasury Bill Program in 2001 enhanced the efficiency of government bond trading.[i] At June 27 1991, Ministry of Finance, under the objective of financial liberation policy, agreed the setup of 16 newly private banks, which in turn speed up the process of money creation. The transition from regulated financial market to less regulated financial market might be responsible for the unstable relationship between the money balances and income as well as other explanatory variables.

Table-1. A selective survey of recent studies on money demand in Taiwan

Author(s)	Sample Period	Monetary aggregates	Scale variable	Interest rate	Other variables	Method
Huang *et al.* (2001)	62.1-05.4(Q)	Real M2	Real GNP	3-month time deposit rate	e_t	*STECM*
Wu (2006)	91.1-04.4(Q)	*M2/CPI*	*Real GDP*	*(st-ot), (lt-ot)*	E_t	*Johansen, ECM*
Wu and Hu (2007)	62.1-96.4(Q)	*M1B/CPI, M2/CPI*	*Real GDP*	1-month time deposit rate	no	*ECM*
Wu and Hu (2007)	62.1-03.4(Q)	*M2/CPI*	*Real GNP*	1-month time deposit rate	no	*Johansen, ECM*
Wu *et al.* (2005)	78.1-99.4(Q)	*M1B/CPI*	*Real GDP*	1-month time deposit rate	no	*Johansen, ARMAX*

Note: Both monetary aggregates and scale variables arre in logarithm forms. Sample period (Q) denotes quarterly data. Interest rate variable: st is average lending rate for five major banks, lt is yield of ten year government bond, and ot is one year time deposit rate. Et and et are nominal and real exchange rate, respectively.

Previous empirical investigations of the relation between the money stock and income in Taiwan have focused on the time-invariant cointegration or linear ECM model. Table 1 provides a selective survey of recent studies on money demand in Taiwan. Wu (2006) propose a model which is considered as the workhorse M2 equation used in the monetary policy decisions of the board meeting by Central bank of Taiwan and it is taken as starting point of this research.[ii] Following the specification proposed by Calza *et al.* (2001), Wu (2006) estimates the equation relating real balances to real GDP and short term spread. The empirical results by using Johansen cointegration analysis and linear ECM model support the notion of stable money demand function during the period 1992-2004. When using recursive estimation approach, the long run income elasticity is ranging between 1 and 2. Recognizing the fact that Taiwan is a small open economy, Lin and Chen (2012) show that currency substitution effect is important for the long run stable relationship of real money demand in Taiwan. The long run income elasticity for M2 is significantly greater than 1 and the exchange rate is negatively related to the real money balances. Adding the stock market transaction volume into the money demand specification, Wu *et al.* (2005) conclude that the long run income elasticity for M1B is less than one and the money demand in Taiwan is stable. Wu and Hu (2007) argues that the error correction model is no better than partial adjustment model in terms of the accuracy of forecasting ability.

A few notable exceptions are the paper by Huang *et al.* (2001), and Wu and Hu (2007) in which money demand function in Taiwan characterized by the nonlinear specification. Huang *et al.* (2001) argue that the variation of

money demand is asymmetric during the economic downturn and upswing. They specify the smooth transition error-correction model (STECM) in short run adjustment toward long run equilibrium to investigate the issue of instability of money demand in Taiwan. The statistically significant transition coefficient seems to suggest that the logistic transition error-correction model outperforms the linear error-correction model in explaining the short run dynamic of Taiwan money demand. Unlike of previous finding of Lin and Chen (2012), Wu and Hu (2007) show that the assumption of constant speed adjustment in the linear error correction model is inappropriate. Inconsistent finding for a stable money demand function in Taiwan may be attributable to the application of econometric method.

This paper contributes to the existing literature by proposing standard economic framework for relating the money stock to income and other explanatory variables that takes into account the structural break of the aforementioned building block. That is, the standard model captures both the money demand and the regime shift of the economy, thereby circumventing some of the potential pitfalls associated with time-invariant cointegration approach.

The structure of this paper is organized as follows. Section II presents the standard economic framework for modelling long run money demand. Section III outlines the econometric methodology by Zivot and Andrews (1992), Perron (1997) and Gregory and Hansen (1996). Section IV outlines the results which provide empirical evidence on money demand instability. Finally, section V concludes.

2. Money Demand Specification

The Keynesian liquidity preference theory and Friedman's modern theory of money offer the main building block for empirical model. Keynes argues that there are three motives for holding money: transaction motive, speculative motive, and precautionary motive. While income captures the transaction and precautionary motives for money holding, long term interest rate captures speculative motive. Friedman considers money as one of many alternative assets within the spectrum of wealth. A set of interest rates are used to explain the demand for money. The empirical implications of both theories are quite similar. A standard money specification postulates that the quantity of real money balances is explained by two sets of explanatory variables: (1) scale variables; and (2) opportunity cost measures.[iii] Empirically, the choice of scale variables (the amount of transaction in the economy) is straightforward. Transaction motive chooses the income and the portfolio approach support the use of wealth as the proxy of scale variables. By contrast, the choice of opportunity cost measures (the difference between the returns on money and on its alternative assets) is relatively controversial. According the proposition of Friedman's monetary theory, based on the portfolio choice, people treat a large variety of assets (such as stock, bond, or house) as alternative to money. Thus, a wide spectrum of returns of alternative assets should be considered in the money demand specification.

A. Classical Speciifications

As mentioned by Barrigozzi and Conti (2010), the money demand specification proposed by Calza *et al.* (2001) has been considered as the workhorse M3 equation used by ECB during the period 2001-2006. Due to the imperfect capital market and heterogeneity of financial instruments, Calza *et al.* (2001) model the euro area money demand explicitly including the short term spread (the spread between the short term interest rate and the own rate of money) and long term spread (the difference of long government bond yield and the own rate of money). Specifically, the long run relationship is specified in the following (semi-) log linear form:

$$(m_t - p_t) = ß_0 + ß_1 y_t + ß_2(s_t - o_t) + ß_3(l_t - o_t) \quad (1)$$

where m_t , p_t and y_t denote the log of nominal monetary aggregate M3, the log of GDP deflator, and the log of the real GDP respectively. s_t and l_t represent the short and long term interest rates, and o_t is the own rate of M3 and t is time index. The anticipated signs in equation (1). $ß_1 > 0$, $ß_2 < 0$, *and* $ß_3 < 0$, with some theories giving more precise coefficient of long run income elasticity (for instance, $ß_1 = 1$ for quantity theory of money or $ß_1 = 0.5$ for Baumol-Tobins' transaction demand for money). Wu (2006) modelling Taiwan's money demand specification is exactly the same as the one proposed by Calza *et al.* (2001).

B. Dreger and Wolters (2013)

Sriram (2001) claims that the yield on real assets is usually proxied by the expected inflation. The expected inflation generally affects demand for money negatively as people prefer to hold real asset as hedges during the period of rising inflation. Dreger and Wolters (2013) argue that inflation is usually explained as the opportunity costs of holding money rather than holding other real assets. Inflation entering the money demand function can help to discriminate whether the portfolio adjustment process is in nominal or real term. In a low inflation environment, the opportunity costs of holding money have decreased and thus inflation is crucial in the money demand specification.

$$(m_t - p_t) = ß_0 + ß_1 y_t + ß_2 s_t + ß_3 l_t + ß_4 \pi_t \quad (2)$$

where π_t is the annualized inflation rate, i.e. $\pi_t = 4\Delta P$ and $ß_4 < 0$.

C. Carstensen (2006) and Baharumshah *et al.* (2009)

Justified by Friedman (1988) argument, Baharumshah *et al.* (2009) decompose the impact of increase in the real stock price on real monetary balances into two effects: a substitution effect and an income effect. Money is a part of total wealth held by the public and wealth is believed to be related by agent's money holding. The substitution effect

is the change in monetary holding that results from the change in the relative price of equity. In particular, people tend to hold less money when the real price of stock rises.

The income effect is the change in monetary holding that results from the change in nonhuman wealth. Money is held as a part of nonhuman wealth, which is believed to be related to the quantity demanded. A rise in stock prices tends to increase in nominal wealth. If the monetary holding and the equity holding are both normal goods, the public will want to spread this improvement over these two goods. Moreover, Friedman (1988) argues that the increase in share prices means the increase in the expected return in risky assets relative to safe assets. People can increase the weight of relative safe assets (such as money and money market instruments) to offset the risk associate with the long term bonds. This income effect tends to make people want more money. Thus, it is important to include stock price in the long run money demand function. The long run relationship is specified as:

$$(m_t - p_t) = ß_0 + ß_1 y_t + ß_2(s_t - o_t) + ß_3 sp_t \quad (3)$$

where sp_t represents the real stock prices. Carstensen (2006) adds the influence of stock market volatility $v_{t.}$ into the eq. (3) and obtains significant parameter estimates for Euro area money demand function.

D. De Santis *et al.* (2009)

De Santis *et al.* (2009) builds up a simple Tobin portfolio model of asset choice in an open economy to account for the missing link between classical money demand specifications and international portfolio approach. They assume the wealth portfolio consisting of money and domestic and foreign risky assets (stocks and bonds). This portfolio approach suggests that portfolio weights for all assets, including money, depend on Sharpe ratios of domestic and foreign assets. The proxy of Sharpe ratio, according the "FED model", are the price-earnings ratios and bond yields in the US and Euro area. If the attractiveness of foreign non-monetary assets increase, domestic residents are more willing to held more foreign assets. The resulting purchases of assets from foreigners by domestic residents imply a decrease in domestic money demanded. The classical specification augmented with international portfolio flows is:

$$(m_t - p_t) = ß_0 + ß_1 y_t + ß_2 pe_t + ß_3 pe_t^* + ß_4 l_t + ß_5 l_t^* \quad (4)$$

where *pe and pe** stand for the price-earnings ratio on two markets. l_t and l_t^* represent the long term interest rates for two markets.

E. Wu and Hu (2007)

Multinational corporations, foreign traders, tourists, and border residents all have transactions or precautionary or even speculative incentives to diversify their currency balances. The composition of the real cash balance portfolio will vary with the relevant opportunity costs of holding real balances of the various types of currencies. If the opportunity cost of real cash balances denominated in domestic currency rises relative to the opportunity cost of holding those denominated in foreign currency, all of these individuals will reduce their real balances denominated in domestic currency and to increase their holdings denominated in foreign currency. This will decrease the demand for domestic currency and increase the demand for foreign currency (currency substitution effect).

Another force of relating foreign exchange rate to demand for real cash balances is the portfolio adjustment effect. If there is increase in the foreign exchange rate, the value of foreign securities held by domestic residents increases and the value of domestic securities held by foreigners decreases. Given the assumption that wealth holders evaluate their portfolios in terms of their home currencies, this will push the demand for domestic currency in an upward direction. Justified by the argument of Mundell (1963), the demand for money is likely to depend on the foreign exchange rate in addition to the level of income and the interest rate. The modified money demand specification proposed by Wu *et al.* (2005) is given as follows:

$$(m_t - p_t) = ß_0 + ß_1 y_t + ß_2 s_t + ß_3 fx_t \quad (5)$$

where *fx* is the real exchange rate and $ß_3$ is the real exchange rate elasticity of money demand. The anticipated sign of $ß_3$ can be either negative or positive.

F. De Bondt (2010)

De Bondt (2010) examines the role of the equity and labor markets for the motives for holding money in the euro area money demand. Equity positively affects money through a transaction motive as equities are a significant store of household wealth that consists of housing and financial wealth. The expected equity returns negatively affect money through speculative motive as equities and money are substituted each other. The higher the expected equity returns, the more attractive are equities as a component of the wealth portfolio. The third effect is the precautionary motive of holding money, which is introduced by the annual changed in the unemployment. The deterioration in the labor market conditions, normally associated with lower GDP and with a lower demand for real cash balances, raises the long-run precautionary motive demand for money.

A standard money demand specification augmented with equity-related and labour market variables is specified as:

$$(m_t - p_t) = ß_0 + ß_1 y_t + ß_2 w_t + ß_3 o_t + ß_4 e_t + ß_5(ur_t - ur_{t-4}) \quad (6)$$

where *w, e and ur* denote the real wealth, expected return on equity and the unemployment rate. Real variables are computed by using the GDP deflator and are transformed to logarithms.

3. Some Econometric Issues

3.1. Unit Root Test and Structural Break

Conventional Dickey-Fuller test and Augmented Dickey-Fuller test have been employed to test for order for integration. A structural break essentially corresponds to an intermittent shock with a permanent effect on the series. The failure to take account of the possibility of break in the series, unit root tests will have low power. In order to test for a possibility for a break, two of the univariate tests were proposed: Zivot and Andrews (1992) and Perron (1997).

A. Zivot and Andrews (1992)

Zivot and Andrews (1992) endogenous structural break test is a sequential test which utilizes the full sample and uses a different dummy variable for each possible break date. The breakpoint is selected where the t-statistic from the ADF test of unit root is at a minimum (most negative). Consequently, a breakpoint will be chosen where the evidence is least favorable for the null hypothesis of unit root. Zivot and Andrews (1992) proceed with three models to test for a unit root: (1) model A, which permits a one-time change in the level of the series; (2) model B, which allows for a one-time change in the slope of the trend function, and (3) model C, which combines one-time changes in the level and the slope of the trend function of the series. The regression equations corresponding to the above three models are as follows:

Model A: $y_t = \hat{\mu}^A + \hat{\theta}^A DU_t(\hat{\lambda}) + \hat{\beta}^A t + \hat{\alpha}^A y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^A \Delta y_{t-j} + \hat{e}_t$,

Model B: $y_t = \hat{\mu}^B + \hat{\gamma}^B DT_t^*(\hat{\lambda}) + \hat{\beta}^B t + \hat{\alpha}^B y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^B \Delta y_{t-j} + \hat{e}_t$,

Model C: $y_t = \hat{\mu}^C + \hat{\theta}^C DU_t(\hat{\lambda}) + \hat{\gamma}^C DT_t^*(\hat{\lambda}) + \hat{\beta}^C t + \hat{\alpha}^C y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^C \Delta y_{t-j} + \hat{e}_t$

and

$DU_t(\lambda) = 1$ *if* $t > T\lambda$

$= 0$ *otherwise*

$DT^*(\lambda) = t - T\lambda$ *if* $t > T\lambda$

$= 0$ *otherwise*[iv]

where the break fraction $\lambda = T_B/T$. The null hypothesis stipulated by Zivot and Andrews (1992) is that the series $\{y_t\}$ is integrated without any structural break. The alternative hypothesis is that $\{y_t\}$ can be represented by a trend-stationary process with a onetime break occurring at an unknown point in time. Zivot and Andrews (1992) suggest the 'trimming region' be specified as (0.15T, 0.85T) and the breakpoint is searched over the trimming region.

B. Perron (1997)

Perron (1997) proposes a unit root test allowing for the presence of a change in the trend function occurring at most once. The model is the complement of Zivot and Andrews (1992) in that similar procedures and series are analyzed. The breakpoint T_b is searched over the range without any trimming at the end points. The three different models considered by Perron (1997) are as follows. Model A allows only a change in the intercept under both the null and alternative hypotheses. Under model B, only a change in the slope without any sudden change in the level is allowed at time T_B. Model C allows for both effects to take place simultaneously, i.e., a sudden change in the level followed by a different growth path.

The following regressions corresponding to Models A, B, and C are constructed by nesting the corresponding models under the null and alternative hypotheses.

Model A: $y_t = \hat{\mu}^A + \hat{\theta}^A DU_t + \hat{\beta}^A t + \hat{d}^A D(TB)_t + \hat{\alpha}^A y_{t-1} + \sum_{j=1}^{k} \hat{c}_j \Delta y_{t-j} + \hat{e}_t$,

Model B: $y_t = \hat{\mu}^B + \hat{\theta}^B DU_t + \hat{\gamma}^B DT_t^* + \hat{\beta}^B t + \hat{\alpha}^B y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^B \Delta y_{t-j} + \hat{e}_t$,

Model C: $y_t = \hat{\mu}^C + \hat{\theta}^C DU_t + \hat{\gamma}^C DT_t + \hat{\beta}^C t + \hat{d}^C D(TB)_t + \hat{\alpha}^C y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^C \Delta y_{t-j} + \hat{e}_t$

where $DU_t = 1$ $(t > T_B)$, $D(TB)_t = 1$ $(t = T_B+1)$, $DT_t = 1$ $(t > T_B)t$, and $DT_t^* = 1\,(t > T_B)(t - T_B)$. Under the alternative hypothesis of a "trend stationary" process, the anticipated signs of $\alpha^A, \alpha^B, \alpha^c < 1$; $\beta^A, \beta^B, \beta^c \neq 0$; $\theta^A, \theta^C \gamma^c, \gamma^c \neq 0$. Finally, under the alternative hypothesis, d^A, d^C, and θ^B should be close to zero while under the null hypothesis they are expected to be significantly different from zero.

3.2. Cointegration Analysis and Structural Break Test

The extensive reforms in the financial sector during the sample period highlight the transition from one regime to other. It is necessary to account for regime shifts in the long run demand for money estimation. In this paper, the residual-based tests for cointegration in models with regime shifts proposed by Gregory and Hansen (1996) are employed to investigate the stability of long run demand for money in Taiwan. The main advantage of single equation over the full system approach is the increased dimensionality of the system due to unconditional use of information.

As indicated by Gregory and Hansen (1996), the tests are multivariate extensions of univariate tests of Zivot and Andrews (1992), Perron (1989), and Perron (1997). The test statistics ADF^*,Z_α^* ,and Z_t^* are designed to test the null hypothesis of no cointegration against the alternative of cointegration in the presence of a possible structural break. Structural change can take several forms. They consider three cases in which the intercept and/or slope coefficients have a single break with unknown timing. Model A allows a level shift in the cointegrating relationships (level shift model). Model B allows the slope coefficients to shift (regime shit model). Model C allows both the level and the cointegrating slope coefficients to shift.

Model A: $y_{1t} = \mu^A + \theta^A DU_t(\lambda) + \alpha^A y_{2t} + e_t$,

Model B: $y_{1t} = \mu^B + \theta^B DU_t(\lambda) + \beta^B t + \alpha^B y_{2t} + e_t$,

Model C: $y_{1t} = \mu^C + \theta^C DU_t(\lambda) + \beta^C t + \alpha^C y_{2t} + \gamma^C DU_t(\lambda) + e_t$,

and the dummy variable to represent the structural change is:

$DU_t(\lambda) = 1$ *if* $t > T_B$

$=0$ *otherwise*

where y_{1t} and y_{2t} are real-valued and a vector of observed data. The break fraction $\lambda = T_B/T$ (the point in the sample where the smallest value of the test statistics is obtained) and T_B represents a possible break. In the parameterization, μdenotes the intercept before change, θdenotes the change in the intercept at the time of shift, α denotes the cointegrating slope coefficients before the regime shift, andγdenotes the change in the slope coefficients. The test statistics is computed for each breakpoint in the interval (*0.15T*, *0.85T*).

4. Data and Empirical Results

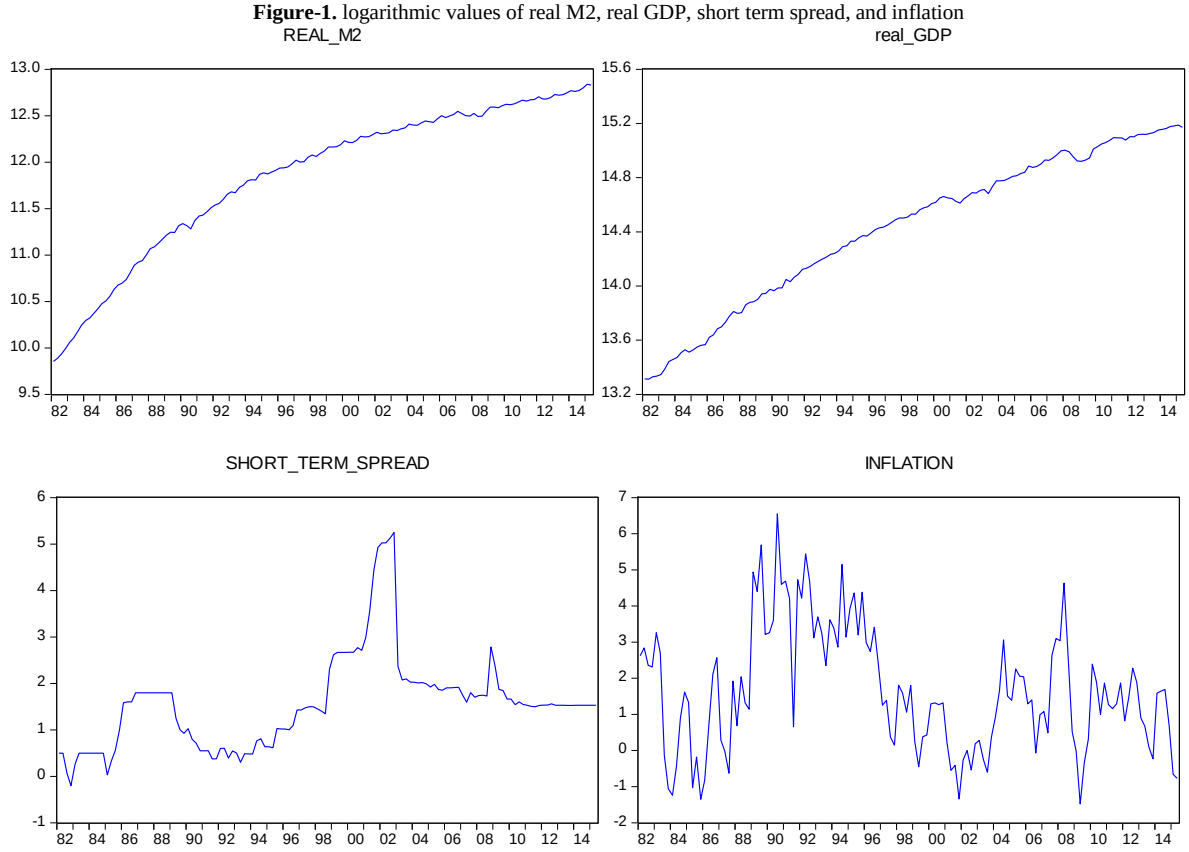
Our model estimates the demand for the broad money M2 definition of the money supply (*M*), using quarterly data for the period 1981:1-2015:2. Our scale variable is real GDP (*Y*), and we have taken into account the latest statistical revisions to Taiwan GDP post-World War II. Our price variable (*P*) is the consumer price index. I prefer this to using the GDP deflator as it is likely to be a more important determinant of transactions balances. The short term and long term interest rate are captured by the average of 5 major banks prime rate (s_t) and the yield on long-term government debt (l_t) respectively. In addition, the one year time deposit rate is taken as a measure of the own rate for M2 (o_t). Nominal exchange rate between New Taiwan dollars and US dollars isbtained from the Central bank of Taiwan. Taiwan stock exchange capitalization weighted stock index (TAIEX) and its associated price-earnings ratio are provided by the Taiwan Stock Exchange Corporation. The unemployment rate is obtained from Directorate-General of Budget, Accounting and Statistics, Executive Yuan. The data for the US consumer price index is obtained from IMF's international financial statistics. The data of S&P 500 is obtained from Thompson Reuters Financial Datastream.

An informal examination of the data and the graphs, shown in Figure 1, may be useful to give a preliminary idea about the properties of relevant variables. While the real M2 and the real GDP show steady growth over the last three decades, the downturn of both series has been observed at the onset of 2008-2009 financial crises. As can be seen, there is a dramatic break in the short term spread as the interest rate control has been lifted since 1991. Moreover, the inflation rate shows a large fluctuation after the second oil crisis.

4.1. The Results for Unit Root Test

Table 2 reports the test statistics for the conventional ADF test and Zivot and Andrews (1992) and Perron (1997) tests for unit root. From the conventional ADF statistics, there is strong evidence supporting the presence of unit root in all variables except for real M2.

Figure-1. logarithmic values of real M2, real GDP, short term spread, and inflation



The same conclusion is also found for the Zivot and Andrews (1992) test, but not for the Perron (1997) test. The null hypothesis of nonstationarity for real M2 is also rejected at the 10% level using Model A (level shift) and at the 1% level using Model B (level shift with trend) formulations, but not using Model C (regime shift) formulation. Since the conventional ADF test rejects the same null, it would be inappropriate to conclude form this piece of information alone that there is a structural break.

On the contrary, the conventional ADF fails to reject the null hypothesis of unit root for the real stock price for constant and trend formulations. The tests which allows for only a level shift (Model A in Zivot and Andrews and Perrons' formulation) also fails to reject the null. I found, however, that the null is rejected at the 10% significant level for Zivot and Andrews (1992) and Perron (1997) tests. There is strong evidence to reject the null hypothesis of allowing for both the intercept and the slope coefficient to shift for Zivot and Andrews (1992) test, but little evidence against the null for Perron (1997) test. Figure 2 shows the results of structural break by Zivot and Andrews (1992) and Perron (1997) tests for real stock price. The Zivot and Andrews (1992) estimated results indicate that the breakpoint occurs in 1988Q4 for allowing the level shift with trend and in 1990Q2 for allowing the regime shift. The Perron (1997) test results indicate that the breakpoint occurs in 1987Q1 for allowing the level shift with trend.

Table-2. Results for unit root test

	Constant	**Constant and trend**	**Model A**		**Model B**		**Model C**	
Variables	*ADF*	*ADF*	*Zivot and Andrews*	*Perron*	*Zivot and Andrews*	*Perron*	*Zivot and Andrews*	*Perron*
Real M2	-4.54*** (4)	-4.14*** (4)	-4.84*(1990Q4)	-4.65 (1990Q3)	-5.21*** (1996Q4)	-4.18 (1990Q3)	-3.67 (1991Q2)	-2.74 (1996Q3)
Real GDP	-3.30** (0)	-0.96 (0)	-2.10 (2008Q1)	-2.10 (2008Q1)	-3.48 (1995Q1)	-3.50 (1994Q3)	-3.44 (1994Q4)	-3.47 (1996Q1)
Short term spread	-2.07 (0)	-2.04 (0)	-3.57 (2003Q1)	-3.65 (2002Q4)	-3.14 (2001Q4)	-4.12 (1998Q3)	-4.14 (1998Q4)	-2.98 (2003Q3)
inflation	-2.18 (4)	-2.26 (4)	-3.74 (1988Q4)	-3.72 (1988Q3)	-3.77 (1989Q4)	-4.36 (1996Q3)	-4.37 (1994Q1)	-2.76 (1990Q1)
real stock price	-2.54 (0)	-2.37 (0)	-4.53 (1987Q2)	-5.14* (1987Q1)	-4.19* (1988Q4)	-5.36* (1987Q1)	-5.57*** (1990Q2)	-3.93 (1989Q2)
real exchange rate	-1.69 (4)	-1.54 (0)	-3.26 (1987Q2)	-3.29 (1987Q1)	-3.35 (1988Q1)	-3.70 (1997Q3)	-3.70 (1997Q3)	-2.72 (1989Q2)

Note: *ADF* is by the Augmented Dicky–Fuller test statistics for the null hypothesis that the series are nonstationary. The numbers in parentheses in *ADF* represent the selected lag lengths. *Zivot and Andrews* and *Perron* are, respectively, the tests proposed by Zivot and Andrews (1992) and Perron (1997). The numbers in parentheses in *Zivot and Andrews* and LP represent the timing of breakpoint. Model A denotes for allowing structural breaks in intercept term, Model B allows for structural breaks in trend term, and Model C allows for the regime shift. An *, **, and *** indicates significance at the 10%, 5%, and 1% levels, respectively.

Table-3. Testing for Regime shifts in Taiwan money demand: Classical specifications

A. Classical specifications

	Model A	**Model B**	**Model C**
ADF^*	-5.86***(2006Q3)	-5.93**(2000Q3)	-6.29**(2006Q3)
Z_t^*	-40.72(2006Q4)	-49.29(2006Q4)	-55.48(2007Q1)
Z_α^*	-4.81(2006Q4)	-5.68**(2007Q3)	-6.10**(2007Q1)
ADF	-5.28***	-2.67	

B. Dreger and Wolters (2013)

	Model A	**Model B**	**Model C**
ADF^*	-6.12***(2008Q4)	-5.77*(2009Q1)	-7.05***(2008Q4)
Z_t^*	-53.26(2008Q4)	-67.12**(2008Q3)	-63.55**(2008Q4)
Z_α^*	-6.13***(2008Q4)	-7.57***(2008Q3)	-7.09***(2008Q4)
ADF	-2.35	-3.21	

There are statistics where an * and ** indicate significance at 10% and 5% level, respectively. Beside these in parentheses are the estimated timing of changing point. Z_t^*, Z_α^*, ADF* are the test statistics defined in Gregory and Hansen (1996). Rejection frequencies the critical values are referred from Table 1 of Gregory and Hansen (1996).

Table 3, Table 4 and Table 5 report the results of testing for regime shifts in Taiwan's money demand. As indicated by Gregory and Hansen (1996), the conventional ADF test statistics and proposed ADF* test statistics both test the null of nointegration between variables, so rejection of either test statistics implies that there is some sort of long run cointegrating relationship in the data. If the conventional ADF does not reject the null, but the ADF* does, this implies that structural break may be important. If both the ADF statistics and ADF* reject the null, no structural change has occurred from this test result.

Figure-2. Zivot and Andrews (1992) and Perron (1997) test for real stock price

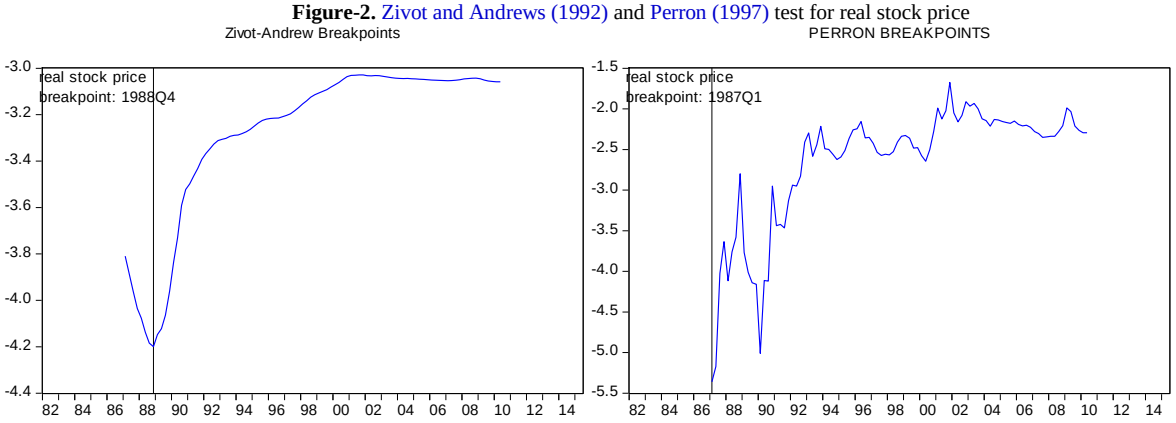


Table 3 is dedicated to the two specifications taken as the starting point of the analysis, respectively by Calza *et al.* (2001), Dreger and Wolters (2013). Model A allows for a change in the intercept at the time of shift. Model B allows for a change in the trend. Model C allows for the slope vector to shift as well. The parentheses beside the test statistics are the estimated timing of changing point. Examining first the result of Calza *et al.* (2001), the conventional *ADF* test strongly rejects the null hypothesis of no cointegration at the 1 % level for Model A and fails to reject the same null for Model B. It is difficult from these mixed results to conclude that there is a structural change in Taiwan money demand. Turning to results of the Dreger and Wolters (2013) money specification, the conventional ADF test statistics cannot reject the null of no cointegration for both Model A and Model B. However, the results of ADF^*, Z_t^*, and Z_α^* all reject the null of no integration with structural change. For this data and model, allowing the possibility of a structural break does raise the important question of long run stability of money demand in Taiwan.

Table-4. Testing for Regime shifts in Taiwan money demand: financial and labor market specifications

A. Carstensen (2006) and Baharumshah *et al.* (2009)

	Model A	**Model B**	**Model C**
ADF^*	-6.10***(1995Q3)	-5.79* (1997Q1)	-6.10(1995Q3)
Z_t^*	-58.83*(1995Q3)	-53.49(1997Q1)	-58.83(1995Q3)
Z_α^*	-6.12***(1995Q3)	-5.87** (1997Q1)	-6.12(1995Q3)
ADF	-4.66**	-4.63*	

B. De Bondt (2010)

	Model A	**Model B**	**Model C**
ADF^*	-5.16(1988Q4)	-5.62*(2004Q4)	-4.98(2001Q1)
Z_t^*	-35.56(1998Q4)	-43.90(1988Q4)	-53.62(1992Q1)
Z_α^*	-4.83(1988Q4)	-5.06(1988Q4)	-5.68(2000Q3)
ADF	-3.19	-4.16	

C. Zuo and Park (2011)

	Model A	**Model B**	**Model C**
ADF^*	-4.77 (2003Q1)	-5.09 (1997Q3)	-5.44 (1997Q1)
Z_t^*	-39.58(1990Q3)	-46.93(1996Q3)	-49.69(1996Q3)
Z_α^*	-4.98 (1990Q3)	-5.37*(1996Q3)	-5.51 (1997Q1)
ADF	-4.75**	-4.79**	

There are statistics where an * and ** indicate significance at 10% and 5% level, respectively. Besides these in parentheses are the estimated timing of changing point. Z_t^*, Z_α^*, ADF* are the test statistics defined in Gregory and Hansen (1996). Rejection frequencies The critical values are referred from Table 1 of Gregory and Hansen (1996).

Table 4 presents the same structure, but for papers extending the explanatory variables to new motives. The first specification show that Carstensen (2006) hypothesis of long run relationship between stock market downswing and euro area money demand. The conventional *ADF* tests reject the null of no cointegration at 5% level for Model A and reject the null of no cointegration at 10% level for Model B. The Gregory and Hansen (1996) test also rejects the null of no cointegration for both Model A and Model B, but not for Model C. As indicated by Gregory and Hansen (1996), it is hard to conclude that there is a structural change over the sample period. The second specification adds a novel precautionary motive, which is captured by the annual change in the unemployment rate, and a speculative motive approximated by the expected equity return by De Bondt (2010). The conventional ADF and Gregory and Hansen (1996) tests both fail to reject the null of on cointegration. The evidence seems to suggest that there is no long run cointegrating relationship between these variables. Finally, in Zuo and Park (2011) relying on financial market development as an additional determinant of demand for real money. The fact that the insignificance of conventional *ADF* tests and the Gregory and Hansen (1996) tests suggests that there is some sort of long run time-invariant relationship for including the stock price in the money demand specification.

The last case is the one considering the international portfolio allocation in De Santis *et al.* (2009) and Wu and Hu (2007). De Santis *et al.* (2009) specification presents an analogous results, though as not as significant, as did by Dreger and Wolters (2013), that is, the specification support the hypothesis of cointegration in the presence of possible regime shift. On the other hand, the inclusion of currency substitution effect in the money demand specification by Wu and Hu (2007) supports the hypothesis of time-invariant cointegration model. The overall testing results of regime shifts appear to support that some evidence of instability of long run relationship are found in Taiwan money demand. The structural break quarters associated with the money specification pproposed by De Santis *et al.* (2009) are 1997Q4 for regime shift and 2006Q3 for level shift, respectively. The structural break quarters associated with the money specification introduced by Dreger and Wolters (2013) are mainly around 2008Q4. The structural break year of 1997 is caused by the reforms of money market.

Table-5. Testing for Regime shifts in Taiwan money demand: international portfolio allocation specification

A. De Santis *et al.* (2009)

	Model A	**Model B**	**Model C**
ADF^*	-5.39*(2006Q3)	-4.62(1998Q2)	-5.28(2001Q3)
Z_t^*	-34.35 (2006Q4)	-56.85 (1997Q4)	-33.71(2002Q2)
Z_α^*	-4.30 (2006Q4)	-6.32**(1997Q4)	-4.30 (2009Q4)
ADF	-3.98	-2.20	

B. Wu and Hu (2007)

	Model A	**Model B**	**Model C**
ADF^*	-4.87(2006Q4)	-4.86(2005Q4)	-5.31(1991Q3)
Z_t^*	-36.05(2006Q4)	-42.89(2003Q4)	-52.32(1991Q3)
Z_α^*	-5.00(2006Q4)	-5.06(2005Q4)	-5.52(1991Q3)
ADF	-4.18*	-4.40*	

There are statistics where an * and ** indicate significance at 10% and 5% level, respectively. Besides these in parentheses are the estimated timing of changing point. Z_t^*, Z_α^*, ADF* are the test statistics defined in Gregory and Hansen (1996). Rejection frequencies The critical values are referred from Table 1 of Gregory and Hansen (1996).

The introduction of Central Government Security System (CGSS) in 1997 and the Book-Entry Treasury Bill Program in 2001 increased the role of monetary policy and promoted a substantial increase in the volume of open market operation. Moreover, the financial crisis of 2008-2009 leads to a sudden change in monetary policy, insolvencies at financial institutions, credit crunch and a vicious cycle. During the financial crises, firms are unable

to obtain funds financing new investment projects. Aggregate demand for goods and services declines. The economic downturn reduces the profitability of many companies and the value of firms. Some firms go bankruptcy and default their business loans. Firms begin to layoff works and unemployed workers cannot pay off their personal loans. Individuals with uninsured deposits withdraw their deposit. Facing a substantial volume of withdrawals, banks are unwilling to make new lending. The credit crunch and the insolvencies of financial institutions induce the large decline of the money multiplier. The fall in the money multiplier causes the money supply to fall dramatically. Thus, the financial crisis of 2008-2009 impedes the economy's ability to intermediate between savers and investors and causes a large and sudden fall in the money supply.

5. Concluding Remarks

Achieving and maintaining price-level stability in the medium and long term in Taiwan is one of the ultimate goal of the Taiwan's monetary policy. The existence of stable relationship between money and price has long been perceived as a prerequisite for the use of monetary aggregate in conducting the monetary policy. The stability of relating money and price is assessed in a money demand framework.

The purpose of this paper is to investigate the long run stability of money demand in Taiwan. In order to test the possibility of structural break, the univariate tests of Zivot and Andrews (1992) and Perron (1997) are proposed. The test results indicate that the null of unit root with drift are rejected for real M2 and real stock price. Gregory and Hansen (1996) propose the residual-based test for cointegration allowing for the possibility of regime shift and considered as a multivariate extension of the univariate test procedure mentioned above. A time-invariant relation explaining real money balances is rejected by data for some money demand specifications. As economic condition and policy regimes are changing over time, a stable relation of money, income as well as other explanatory variables no longer holds. This is especially true for a small open economy like Taiwan, where economy is transformed from highly regulated system to a market oriented one. In particular, an international portfolio approach is responsible for explaining a possible regime shift in Taiwan money demand. The instability of long run money demand becomes apparent during the 2008-2009 financial crisis. Conversely, when taking into account the role of financial and labor market characteristics, we find no evidence of regime shift.

A policy implication from our finding is that, to avoid the danger of instability, the central bank of Taiwan should not look at domestic economy alone but also at international financial developments.

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[i] The government bond outright transactions in over-the counter market rose significantly from NT $16,691 (billion) in 2000 to NT $60,660

[ii] The reference value of M2 growth target of Taiwan Central Bank has been followed the equation estimated by the partial adjustment model.

[iii] According to Sriram (2001). A Survey of Recent Empirical Money Demand Studies. *IMF Staff Papers,* 47(3): 334-65. the theories of money demand imply a long-run relationship of the form:

$M/P = f(S, OC)$

where M/P represents the real monetary balances held by the public. S denotes the scale variables. OC is a vector of opportunity costs of holding money.

[iv] The "hats" put on the λ parameters in Model A-Model C to emphasize that they correspond to estimated values of the break fraction.