THE LONG RUN DEMAND FOR BROAD MONEY IN AUSTRALIA SUBJECT TO REGIME SHIFTS

by

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Abstract

The goal is to determine if there is a stable Broad Money Demand relationship for Australia. Previous studies have not reached a consensus on this important issue, partly because the time series techniques used do not accommodate structural breaks. A standard multivariate cointegration analysis is conducted on monthly data over the period 1976(3) to 1998(4). It reveals some evidence for the presence of cointegration since one cointegrating vector is found. This involves broad money, the spread between interest on broad money and on non-money assets and real GDP. The evidence of cointegration is again present when a structural break is found in the relationship using Gregory and Hansen (GH) methodology. This occurs in 1991 coinciding with a deep recession and policy induced, interest rate reductions. The income elasticity of demand exceeds one, reacts positively to the interest spread and negatively to inflation.

1. Introduction

Why do we need any further study of the stability of money demand in Australia? A superficial and unsatisfactory answer to this question is that six years have elapsed since the last words on the issue were written by de Brouwer, Ng and Subbaraman (1993) and by Hossain et al (1994).

The quest here is for the existence of a long run Broad Money demand equilibrium relationship in the presence of structural breaks. There may be temporary (short run) departures from a long run steady state, but these are not analysed here.

The significant motivations for a further analysis of Broad Money are first, the importance of a predictable, long run relationship between monetary aggregates such as broad money, and other jointly determined economic variables in a general macroeconomic equilibrium; second, the significance of the connection between this monetary aggregate and monetary policy and third the opportunity created by recent developments in time series techniques for the resolution of outstanding items on the research agenda about Australian money demand, in particular for analysing structural instability.

In regards to the first motivation, once it is agreed that long run money demand relationships are endogenous being determined in an overall structure along with output, inflation, interest rates and other variables, then the stability and predicability of money demand influences the stability of any general macro equilibrium. So the quest for a well determined, stable money demand relationship is a pragmatic consideration for those using macroeconomic structures for forecasting purposes.

The second motive for studying the long term stability of money demand is its significance for monetary policy. The policy/stability nexus was clear during the Australian era of monetary targeting, an era described succinctly by McFarlane (1999). The basis of the switch in policy from discretion to rules in April 1976 was manifest in the Reserve Bank of Australia's

(RBA) target for M_3 as a device for controlling inflation. Monetary targeting was based on the monetarist perception of a strong and persistent correlation involving the growth of money demand and inflation. The success of targeting depended on the existence of a stable money demand relationship. It is tempting to think that the imperative for monetary stability lessened when targeting was abandoned in January 1985, becoming a victim of the rapid deregulation of the Australian financial system in the 1980s. However, as Grenville (1996) suggests, a stable money demand function remains an imperative in the new policy era of inflation targeting. Monetary aggregates such as Broad money are key policy indicators and the stability of the relation between money demand and its customary predictors, influences the reliability of measures such as Broad money and M_3 as policy indicators.

The switch in policy emphasis from money to inflation targets does not alter the prospect of policy induced changes of the cash rate causing money demand instability. This effect of monetary policy on money demand is an example of the Lucas (1976) critique of economic policy generally. Instability in the present context is reflected in the non constancy of parameter estimates in the money demand function[1]. Conventional money demand structures invariably contain interest rates and often include commodity prices or inflation all of which may be influenced by monetary policy actions. In summary, the nexus between monetary policy and the stability of money demand has not been removed by the switch to inflation targeting and the debate about the stability of the Australian money demand remains relevant.

The third significant motivation for additional study of Broad money demand in Australia is the improvements in time series techniques which accommodate structural breaks in underlying relationships. This is of particular significance for the analysis of money demand which is particularly susceptible to episodes of structural instability. The range of new

[1] Ericsson (1998, p.311), for example, interprets the non constancy of money demand parameter estimates as evidence for the relevance of the Lucas critique.

techniques available for researchers analysing money demand stability are comprehensively applied in a special issue of *Empirical Economics* (1998, 23.3).

Australian research on the stability of money demand tapers off in 1994 leaving a number of questions unresolved. Among the more recent studies Karfakis and Parikh (1994) find that M_3 does constitute a useful monetary target because M_3 is cointegrated with output, interest rates and the exchange rate noting that the relationship breaks at 1984(4). Two extensions of this study are suggested. First the Karfakis and Parikh's analysis of breakpoints is based on standard cointegration techniques which assume the absence of breaks in cointegrating vectors when these may subject to structural breaks. Second, the Karfakis and Parikh study is based on a data set truncating in 1990(3) just as the economy enters a deep recession and yet the long run stability of money demand may be affected by the financial turbulence evident in the mid 90s. There is justification for an updated study.

Hoque and Al-Mutairi (1996) study the stability of a relationship for M_1, taking into account a structural break occurring in 1980 coinciding with the beginning of a deregulatory phase in the Australian financial system. These researchers find that a stable M_1 relationship exists using Australia data. Hoque and Al-Mutairi apply a standard Chow test for stability whereas techniques which locate the date of break points are now available. It is important to determine if these later techniques improve our understanding of broad money demand.

These two Australian studies focus on M_1 and M_3, while our concern is to test for the stability of a long run relationship for Broad Money, the most comprehensive of financial indicators. The most recent test for the stability of Broad Money is conducted by de Brouwer (1993) et al, who fail to reach a definite conclusion about the stability of long run Broad money demand in Australia. The de Brouwer study is based on a data set ending in 1992 and is also reliant on the efficacy of standard cointegration tests which do not accommodate breaks in cointegrating vectors. An obvious extension of the de Brouwer et. al. study involves tests for the stability of Broad money demand accommodating breaks.

The methodology and data set required for this study are described in Section 2 of the paper, while results and conclusions appear in Section 3 and 4 respectively.

2. Methodology and Data

2.1: Modeling Regime

The following analysis is based on time series estimates of the following money demand relationship:

$$m_t^d = \alpha + \beta y_t + \gamma\left(r_t^d - r_t^0\right) + \lambda \dot{p}_t + \varepsilon_t \tag{1}$$

This interpretation of the long run money demand equation contains some conventional arguments, namely, that the logarithm of money demand is determined by the logarithm of real GDP (y_t); the spread between interest rates on the monetary aggregate (r_t^d) and those on alternatives to money (r_t^0) and the rate of inflation of the CPI $(\dot{p}_t)$. This is similar to the model applied by Vega (1998) in his quest for a long run money demand in Spain. The departure from Vega's formulation is that interest rate effects enter through the spread between rates on broad money and those on non money assets: $(r_t^d - r_t^0)$. Vega enters (r_t^d) and (r_t^0) separately, but we find that the spread is always significant in our model, but the individual rates (r_t^d, r_t^0) are not.

The a priori argument about the signs of estimates of the parameters in (1) are summarised briefly: money demand should rise with real income $(\beta > 0)$ and its value will exceed the value one if money is a luxury good; increases in the spread between monetary aggregate rates and other interest rates should stimulate money demand $(\gamma > 0)$, but any increase in inflation should reduce money demand $(\lambda < 0)$.

2.2: Estimation Regime

The first consideration is the stationarity or otherwise of the four time series employed in this analysis. Standard ADF and Phillips and Perron (PP) tests are conducted and the results indicated on Table 1. Once having determined that these four series are suitable candidates for cointegration analysis, a standard multivariate Johansen and Juselius (1990) test for the presence of multivariate cointegration is conducted.

The validity of these multivariate tests is questioned by Gregory and Hansen (GH) (1996a), when there are level and/or slope shifts affecting the cointegrating vectors. GH propose a cointegration test which accommodates a single, non predetermined break in an underlying cointegrating relationship. We propose three variations of the GH test in the Broad Money demand relationship (1). These allow for both changes in the intercept (level shift) and change in slopes (slope shifts) of (1) as follows:

Model 1: Change in Intercept Only

$$m_t^d = \alpha_1 + \alpha_2 \phi_{t\tau} + \beta y_t + \gamma\left(r_t^d - r_t^0\right) + \lambda \dot{p}_t + \varepsilon_t \qquad (2)$$

Model 2: Change in Intercept, Change in Slope (GDP)

$$m_t^d = \alpha_1 + \alpha_2 \phi_{t\tau} + \beta_1 y_t + \beta_2 \phi_{t\tau} y_t + \gamma\left(r_t^d - r_t^0\right) + \lambda \dot{p}_t + \varepsilon_t \qquad (3)$$

Model 3: Change in Intercept, Change in Slope $\left(r_t^d - r_t^0\right)$

$$m_t^d = \alpha_1 + \alpha_2 \phi_{t\tau} + \beta_1 y_t + \gamma_1\left(r_t^d - r_t^0\right) + \gamma_2 \phi_{t\tau}\left(r_t^d - r_1^0\right) + \lambda \dot{p}_t + \varepsilon_t \qquad (4)$$

where

$$\begin{aligned} \phi_{t\tau} &= 0 \text{ if } t \le T_\tau \\ \phi_{t\tau} &= 1 \text{ if } t > T_t \end{aligned} \qquad (5)$$

Model 1 (2) incorporates a potential break in the intercept of (1), while Model 2 (3) incorporates both the intercept and slope coefficient associated with y_t and Model 3 (4) allows for a shift in the relationship between money demand and the interest spread $\left(r_t^d - r_t^0\right)$ in addition to the intercept.

The regressions of equations (2), (3), (4) are estimated for each potential break point in the time series; the parameter τ measuring the proportion of the sample at which a potential breakpoint occurs $\left(\tau = {}^{i}\!/_{T}\right)$ and assumes values: $\tau \in (0,1)$. However, for practical purposes[2] $\tau \in (0.15, 0.85)$. GH propose the following test statistics:

$$ADF^*(\tau) = \inf_{\tau \in T} ADF(\tau) : Z_\beta^* = \inf_{\tau \in T} Z_\beta(\tau) \qquad (6)$$

where

$$Z_\beta(\tau) = T(\hat{\rho}_\tau - 1) \qquad (7)$$

And $\hat{\rho}_\tau$ is the bias corrected version of the first order serial correlation coefficient of the residuals of (2), (3) and (4). The smallest values of $Z_\beta(\tau)$ and ADF (τ) are selected as the appropriate test statistic, the smaller the value of these, the greater are the chances of rejecting the null hypothesis of no cointegration with a structural break.

In summary, our methodology is to test (1) for cointegration without breaks and to test (2), (3), (4) to determine if cointegration applies subject to structural breaks in the Australian broad money demand equation.

2.3: Data Set and Its Properties

The study is based on quarterly data extending over the period 1976 (III) to 1998 (IV). Data sources are indicated in the Appendix to the paper, however, a brief description is warranted.

The variable m_t^d is calculated as $\log(M_t/P_t)$ where M_t is broad money and P_t is the CPI

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[2] This provides samples large enough for drawing statistical inferences.

on a quarterly basis. The variable y_t is $\log(Y_t/P_t)$ where Y_t is the seasonally adjusted GDP at current prices. The own rate of interest on broad money (r_t^d) is the weighted average of deposit rates offered by authorised money market dealers expressed as a real rate (r_t^d/P_t) and measured as a decimal. The inflation rate $(\dot{p}_t)$ is included as a regressor in (1) and is measured as a quarterly rate from the CPI.

The monetary aggregates and interest rates are often I(1) in studies of this kind. The results of some standard ADF and PP tests for the stationarity of the time series involved in (1) disclosed on Table 1. Note that the results encompass differing representations of unit root tests, in particular, models which include a constant but no trend term (c), and both a constant and trend term (ct). The Aikake Information criterion indicated that four lags were required in these tests for stationarity.

Table 1: Stationarity Tests

Variable	**ADF_1**		**PP**			
	T: Constant	**t: Constant Trend**	**T: Constant**	**t: Constant Trend**	**Z – Constant**	**Z – Constant Trend**
m^d	-0.349	-2.688	0.058	-2.066	0.042	-9.803
y_t	-0.089	-2.682	0.045	-2.555	-0.035	-13.633
r_t^d	-1.264	-2.106	-1.801	-2.159	-7.246	-9.046
r_t^0	-0.804	-2.681	-0.627	-1.533	-1.843	-4.729
$r_t^d - r_t^0$	-2.310	-2.334	-3.142	-3.140	-18.301*	-18.385
$\dot{p}_t$	-0.730	-2.630	-1.061	-2.777	-3.026	-13.893
Critical[(1)] Values 0.05	-2.86	-3.41	-2.86	-3.21	-14.1	-21.7

[(1)]Davidson R. and McKinnon J.G. (1993), *Estimation and Inference in Economics* (OUP, N.Y.), Table 20.1, p.708.

All of the variables included in this study are non stationary in levels[3]. However, all prove to be stationary in first difference form. Thus it is appropriate to conclude that all variables are I(1) and that cointegration tests are appropriate.

3. Results

The results of this study are discussed in the following sequence: the results of multi variate tests for cointegration are reported, initially, to determine if there is a long run equilibrium relationship for Australian broad money. The results are reported in Table 2. Then we analyse cointegration tests allowing for a single structural break. Those results are enclosed on Table 3.

3.1: Is There a Long Run Equilibrium when the Cointegrating Vector is Smooth?

The results of the Trace and λ max tests for cointegration of the Australian broad money demand equation (1) are reported on Table 2.

Table 2: Multivariate Cointegration Tests(1) of Australian Broad Money Demand

r	**Trace Test**			**l max**			**Coefficient in Cointegrating Vector**		
	Test	CV (0.05)	CV (0.10)	Test	CV (0.05)	CV (0.10)	Variable	Est. Cof	t-ratio
≥ 3	0.43	6.7	8.10	0.42	6.70	8.10	y	1.21	53.1
≥ 2	10.35	15.6	17.80	9.92	12.80	14.60	$r^d - r^0$	0.25	4.96
≥ 1	24.20	28.40	31.30	13.85	19.0	21.3	$\dot{p}$	-0.28	-6.06
≥ 0	58.83	45.2	48.4	32.63	24.9	27.3	Const	-0.19	-2.62

(1) Estimated with k = 4 lags
(2) Critical values for Trace and λ max are drawn from Osterwald-Lenum (1992), Table 11, p.472.

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[3] The interest rate spread $r_t^d - r_t^0$ is stationary in levels at 0.05 in one of the six tests, namely, PP Z-constant test. however, the evidence overall does not support the I(0) hypothesis for this variable. So we deem $r_t^d - r_t^0$ not to be I(0).

The conclusion drawn from Table 2 is that one cointegrating vector exists. This involves the variables Broad money, real GDP (y), the interest spread ($r^d – r^0$) and actual inflation $(\dot{p})$. This outcome is indicated by the values of the Trace and λ max test statistics in comparison with relevant critical values. The hypothesis $r \geq 0$ is supported because the Trace statistic (58.83) and the λ max (32.63) exceed their respective critical values at 0.05 and 0.10 levels of significance. However, no support is found for the presence of more than one cointegrating vector: $r \geq 2$ and $r \geq 3$ are rejected because the Trace and λ max tests are less than their critical values.

The estimated coefficients from the cointegrating vector associated with the contegration of (1) are correctly signed and significant. Inflation reduces the demand for money, the coefficient associated with this variable (-0.28) is significant. The higher the margin between the rate of interest on money and alternative assets ($r^d – r^0$), the higher is the demand for broad money (coefficient = 0.25, t-ratio 4.96), while the income elasticity of demand for money is greater than one (1.21) suggesting that money is a luxury good.

3.2: Does Australia's Long Run Demand for Broad Money Break?

Long run money demand relationships are often thought to be structurally unstable. So standard cointegration tests such as that proposed by Johansen and Juselius (1990) may not provide a clear picture when structural breaks occur. This possibility prompts a further question. Are there structural breaks in the Australian long run demand for Broad money equilibrium relationship? To explore this issue, the three versions of the GH model in expressions (2), (3) and (4) are estimated. The results are shown on Table 3.

Table 3: Australian Broad Money: Cointegration Subject to Structural Breaks

Model ®	**Model 1:**	**Model 2:**	**Model 3:**
Statistics ¯	**Equation (2)**	**Equation (3)**	**Equation (4)**
$ADF^{*}(\tau)$	-3.82 (-5.28)	-6.89* (-6.0)	-5.14 (-6.0)
$Z_{\beta}^{*}(\tau)$	-55.41* (-53.58)	-69.89* (-68.94)	-72.74* (-68.94)
Break Point	91/I	91/IV	91/I

*Critical values for GH tests are included in brackets. They are extracted from Gregory and Hansen (1996) Table 1, p.109.

Model 1 (equation 2) allows for a change in intercept only and the evidence in column (2) of Table 3 is conclusive. The $ADF^{*}(\tau)$ (-3.82) is greater than its critical value (-5.28) suggesting that the null hypothesis of no cointegration should be accepted. The same outcome is suggested by $Z_{\beta}(\tau)$ (-55.41) which is larger than the cut of score (-58.58) suggesting also that the null be accepted. The evidence for cointegration subject to both an intercept shift and a change in the relationship between Broad money demand and real GDP (Model 2) is clear. Both the $ADF^{*}(\tau)$ and $Z_{\beta}^{*}(\tau)$ exceed their respective cut off scores and it is appropriate to reject the null of no cointegration. The regime shift indicated here is located in the fourth quarter of 1991 when the Australian economy was experiencing a deep recession and both monetary and fiscal policy stances were being recast.

The fourth column of Table 3 indicates a mixed result for Model 3, which hypothesises that there is an intercept shift and a slope change pertaining to the effect of the interest spread on Broad money demand. The $ADF^{*}(\tau)$ statistic (-5.14) exceeds its critical value (-6.0), but the

$Z_{\beta}^{*}(\tau)$ suggests that there is cointegration subject to this regime shift. The break occurs in the first quarter of 1991 which is the same date as the break occurring in Model 1.

4. Conclusion

There does appear to be a stable long run broad money demand relationship using recent Australian data. This analysis reveals some qualified support for one cointegrating vector linking broad money, real GDP, the interest rate spread and inflation. Real GDP and the interest spread increase the demand for Broad money while inflation reduces it. Further broad money is characterised by these results as a luxury good because the income elasticity of demand for it exceeds the value one.

Money demand relationships have a reputation for being structurally unstable. This raises serious doubts, the reliability of standard cointegration techniques which make no allowance for structural breaks. The innovation in this analysis is to test for cointegration when the broad money demand relationship shifts suddenly. The study reveals that cointegration still applies to broad money demand when there is a substantial break occurring in the last quarter of 1991. This break occurs in the midst of a deep recession and follows substantial revisions of both fiscal and monetary policy. Interest rates, for example, almost halved in the nine months ending in June 1991 as a consequence of the change in the direction of monetary policy.

The key result is that broad money demand is cointegrated in the presence of structural breaks. This leads to the following policy implication. Broad money possesses a stable long relationship over the period 1976 to 1998 subject to a regime shift occurring during the 1991 recession. However, broad money remained a reliable indicator of liquidity conditions throughout this period.

Appendix

Variable		**Data Sources**
Broad Money	(M_t)	Broad Money Stock (nom $mill) DMA 13MU DX Database
Interest on medium to long term debt: Weighted average of 5 and 10 year T/B's	(r^0)	Table F.02: Interest Rates and Yields Capital Market RBA Bulletin on DX Database
Weighted average of AMMD's deposit rates	(r^d)	Table N.13 NIFR Interest Rates and Exchange Rates. ABS Treasury Model Database
CPI	(P)	GCPIA PU DX Database
Seasonally Adjusted Real GDP ($mill 89/90 prices)	(y)	SMAQ.AC GPM DX Database

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