MONEY AND INCOME: A CHANGING RELATIONSHIP

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Abstract

The effect of money on output has been changing during the past two decades. This paper attempts to examine the money-income relationship in Australia and the United States during the period of the 1960s-1990s as well as the 1960s-1970s. The empirical findings of the study, based on variance decomposition and impulse response functions show a weak long-run relationship between money and income for both countries when the sample period includes the decades of the 1980s and 1990s. This result may indicate temporary short-run changes in the relationship between money and income. However, over a long period of time money has a neutral effect on output.
1. Introduction

Australia and the United States share a common experience regarding the relationship between money and income. Both countries went through a period of weakening relationships between money and income during the 1970s and 1980s. In both countries a combination of financial innovations and deregulation led to a significant change in the income velocity of money. Davis and Tanner (1997) argued that the money-income relationship in the United States started weakening in the 1970s and experienced a fatal break with the introduction of the Monetary Control Act of 1980. Friedman and Kuttner (1992) showed that during the 1980s movements of money indicated no information about the future movements of output or prices. Monadjemi (1988) and Monadjemi and Kearney (1990) showed that the relationship between money and income in Australia was significantly affected by the deregulation of the financial markets. The velocity of both M3 and Broad Money rose significantly during the latter parts of the 1980s when deregulatory measures were actively implemented. Monadjemi and Kearney (1990) argued that, as a result of altered relationship between money and income, the growth rate of money was giving misleading signals about the state of the economy. The process of monetary targeting was finally suspended in Australia in December 1985.

Recently researchers in this area have attempted to distinguish between the short-run and the long-run relationships between money and income. Tanner (1993) and Tanner and Davis (1997) have shown that there was a temporary breakdown of money-income relationship in the United States during the 1980s. However, over the period of 1874-1993, money remained the most important variable accounting for fluctuations of income. On the other hand, Rapach (1998) showed long-run neutrality of money along the lines advocated by Lucas (1970) and empirically supported by King et al. (1991) and Gali (1992). Similarly, Fung and Kasumovich (1998) used quarterly data on six OECD
countries and showed that money shocks influence nominal variables but not real variables. The purpose of this paper is to add to the body of existing literature by examining the money-income relationship in the short-run and in the long-run in Australia and the United States. In Section 2 a theoretical discussion on money-income relationship is presented. The description of data and the econometric methodology are given in Sections 3 and 4 respectively. The empirical results of the study are discussed in Section 5. A comparison with previous studies is made in Section 6. Summary and concluding remarks are offered in Section 7.

2. Theoretical Discussion

The theoretical relationship between money and output has been a popular topic in economic research. In the Hicks-Hansen, IS-LM model, money affects output through changes in the rate of interest. This is a short-run model in which the price level is assumed to be constant. As long as the investment demand curve is elastic and the demand for money is not infinitely elastic, changes in money have a positive effect on output. Monetarists, on the other hand, relied on the equation of exchange as a theoretical framework for explaining the relationship between money and income. In this setting, given that the income velocity of money is stable, money has a direct and proportional effect on output. In the long-run money has a neutral effect on output since prices change proportionally to change in money leaving the real value of output unchanged. Friedman and Schwartz (1963), and subsequent works by Friedman, attempted to provide theoretical as well as empirical support for the close relationship between money and output.

Mundell (1963) and Fleming (1962) modified the Keynesian model by introducing the effects of capital flows. Dornbusch (1976) extended the Mundell/Fleming
model and showed that the exchange rate overshoots its long-run equilibrium in response
to a change in money stock. In both Mundell/Fleming’s and Dornbusch’s models a
change in money stock affects output in the short run but not in the long-run. The effect
of money on output is neutral in the long-run.

In this paper a model based on Mundell/Fleming and Dornbusch is developed and
the short-run and the long-run effects of money on output are distinguished by using
appropriate assumptions. Equations 1-5 show the theoretical framework of the model.

\[
y_t = \beta_1 (e_t - p_t) - \beta_2 (r_t - \Delta p_{t+1}) + u_{1t} \\
m_t = p_t + \beta_3 y_t - \beta_4 r_t + u_{2t} \\
m_t = -\gamma \Delta p_t + u_{3t} \\
\Delta p_t = \beta_5 - (y^n + u_{4t}) \\
E\Delta e_{t+1} = r_t - (r^* + u_{5t})
\]

where

\[y_t = \text{level of output}\]
\[e_t = \text{nominal exchange rate defined as the price of foreign currency}\]
\[p_t = \text{price level}\]
\[r_t = \text{nominal interest rate}\]
\[r^* = \text{foreign rate of interest}\]
\[y^n = \text{natural level of output}\]
\[m_t = \text{nominal value of money stock}\]
\[E = \text{expectation operator}\]

All variables except the rate of interest are in logarithms. Equation 1 is the aggregate
demand equation in which the level of output is a function of real exchange rate and the
real rate of interest. Equation 2 is the money market equilibrium where the demand for
money is equal to the real supply of money. In equation 3 it is assumed that authorities change the monetary condition with respect to the level of inflation. This equation represents the government’s reaction function where the government systematically reacts to changes in the rate of inflation. Equation 4 is the Phillips curve type of relationship where inflation is a function of deviation of output from its natural level. Finally, the interest parity condition is presented in equations. \( u_{1t}, u_{2t}, u_{3t}, u_{4t}, \text{ and } u_{5t} \) are disturbances or innovations in different markets.

Depending on the type of expectations formation used in the model, a change in money may or may not have an effect on the level of output in the short-run. However, irrespective of how expectations are formed, a change in money in the long-run has a neutral effect on output. In the long-run private agents anticipate fully how the government sets the monetary condition and act so that they neutralize the effect of money on output. If we assume adaptive formation of expectations, the effect of a change in money on output can be positive as long as the private sector has not anticipated the outcome of government policy. In terms of the model, equation 3 can be altered in order to present the short-run and the long-run behaviour of the private sector. As long as private agents are not fully aware of government policy, equation 3 remains valid. However, in the long run, the private sector fully anticipates how the government is conducting monetary policy and equation 3 becomes

\[
m_t = u_{3t} \tag{3'}
\]

Furthermore, in the long run \( y_t = y^n, \Delta p_t = \Delta p_{t+1} = 0 \). The long-run solution to this model can be obtained by incorporating the above assumptions into equations 1 and 2.

\[
y'' + u_{4t} = \beta_1 (e_t - p_t) - \beta_2 (r^* + u_{5t}) + u_{1t} \tag{6}
\]

\[
u_{3t} - p_t = \beta_3 (y^n + u_{4t}) - \beta_4 (r^* + u_{5t}) + u_{2t} \tag{7}
\]
For the sake of simplicity assume that \( \gamma_0 = \rho^* = 0 \), so that \( u_{4t} \) and \( u_{5t} \) represent stochastic processes from the natural level of output and the world rate of interest respectively. The long-run solution of the model after combining (3'), (4), (5), (6) and (7) is presented in equation (8):

\[
\begin{bmatrix}
 r_i \\
 y_t \\
 e_t \\
 p_t \\
 m_t
\end{bmatrix} =
\begin{bmatrix}
 1 & 0 & 0 & 0 & 0 \\
 0 & (\beta_2 + \beta_3 \beta_4) & (1 - \beta_1 \beta_3) & 1 & -1 & \frac{1}{\beta_1} \\
 \beta_1 & \beta_1 & 1 & -1 & 0 & \frac{1}{\beta_1} \\
 0 & 0 & 1 & 0 & 0 & \frac{1}{\beta_1} \\
 u_{5t} & u_{4t} & u_{3t} & u_{2t} & u_{1t} & u_{0t}
\end{bmatrix}
\]

In equation (8) the relationship between money and output is a random term \( u_{4t} \) with an expected value of zero. This implies that in the long-run money has no systematic impact on output. However, assuming rational expectations, if agents cannot fully anticipate the effect of government policies, changes in monetary condition may have a positive effect on output. In this case it is assumed that the government has an informational advantage \( \varepsilon_t \) over the private sector. Accordingly equation 3' changes to

\[
m_t = -\gamma \Delta p_t + \varepsilon_t + u_{3t}
\]

By incorporating this assumption into the model, \( \varepsilon_t \) enters into the relationship between \( m_t \) and \( y_t \) and consequently changes in money produce a non-neutral effect on output.

The empirical analysis of this paper is based on vector autoregressive (VAR) in which every variable is a function of its own lag and lags of other variables in the model. The VAR model is presented in equation 9.

\[
Y_t = A(L)Y_t + V_t
\]

where \( Y_t \) is a vector of five time series \( (m_t, p_t, y_t, r_t, e_t) \), \( A(L) \) is a 5x5 polynomial matrix in the lag operator L and \( V_t \) is a vector of random disturbances with \( V_t \sim (0, \Sigma) \).

### 3. Econometric Methodology
Most macroeconomic time series are non-stationary in levels and the use of conventional regression techniques for such data tends to produce spurious results. However, non-stationary time-series data may be *cointegrated* if some linear combinations of the series become stationary. That is, the series may wander around, but in the long-run there are economic forces that tend to push them to an equilibrium. That is, cointegrated series will not move far away from each other and are linked in the long-run.

Johansen (1988 and 1991) suggested tests for determining numbers of cointegrating vectors among a group of variables. Consider the following p variable ECM representation:

\[
\Delta Y_t = u + \sum_{i=1}^{k} \Gamma_i \Delta Y_{t-i} + \Pi Y_{t-k} + \epsilon_t
\]

(10)

\[
\Gamma_j = -\left(I - \sum_{i=1}^{j} \phi_i \right)
\]

(11)

\[
\Pi = -\left(I - \sum_{i=1}^{k} \phi_i \right)
\]

(12)

where \(u\) is the constant term, \(Y_t\) is \((p\times1)\) vector of the variables under study, and the disturbance vector \(\epsilon_t\) of dimension \((p\times1)\) is distributed as an i.i.d. Gaussian process with zero mean and variance \(\Omega\) and where \(I\) is the identity matrix. [See Johansen (1991) for details.]

The long-run relationships in the data set are determined by the rank of \(\Pi\). If time series are non-stationary and cointegrated, then \(\Pi\) is not full rank, but \(0 < \text{rank}(\Pi) = r < p\), where \(r\) is the number of cointegrating vectors. Johansen (1991) proposed two likelihood testing procedures in order to estimate the rank of \(\Pi\). The first tests the hypothesis that the number of cointegrating vectors is, at most, equal to \(r\) (Trace test). The second tests the hypothesis that the number of cointegrating vectors is equal to \(r\) (Max Eigenvalue
test). When the series are found to be cointegrated, Johansen further demonstrated that \( \Pi \) can be factored as:

\[
\Pi = \alpha \beta'
\]

where \( \beta \) is the matrix of \( r \) cointegrating vectors and \( \alpha \) is the matrix of weights attached to each cointegrating vectors in equation 3. Both \( \alpha \) and \( \beta \) are \((p \times r)\) matrices.

### 4. Data Description

All of the data in this study are monthly time series collected from the Time Series Data Express, dx v2.1, site license held by the School of Economics, University of New South Wales, Sydney, Australia.

The interest rate series are averaged over-night money market rates during the month. The exchange rate series are end of the month bilateral exchange rates against the U.S. dollar measured by the number of U.S. currency in one unit of domestic currency. The price level is the all items consumer price indices. The money stock is the monthly observation on M1. The level of output is measured by the index of industrial production.

### 5. Empirical Results

The starting point of the empirical analysis is to investigate the time series properties of five variables under consideration. To this end, Dickey-Fuller and Phillips-Perron’s tests were employed and both tests indicated that all five time series are non-stationary in levels and stationary in first differences. Non-stationary series may be cointegrated if their variances do not explode over time. The Johansen tests for cointegration were applied to five variables involved in this study and the results are presented in Table 1. According to these results the hypothesis of one cointegrating
vector for Australia and two cointegrating vectors for the United States cannot be rejected at the 5 per cent significant level.

The existence of cointegrating vectors indicates that there is a joint long-run equilibrium between the variables included in the model. However, when money, income and other variables are cointegrated, it does not necessarily mean that changes in money have a significant impact on income. In other words, the existence of an equilibrium between a group of variables does not indicate that the equilibrium exists between any pair of variables in the model. The latter can be examined by investigating how one variable responds when another variable is shocked. These dynamic interactions between variables may be studied using variance decompositions (VDC) and impulse response functions (IRF). Both of these dynamic responses are drawn from the coefficients of error correction model (ECM). However, since coefficients of error correction model are in a reduced form, they convey very little information about the structural coefficients of the model. To draw useful information from the structural coefficients of the model, identifying restrictions have to be imposed on the ECM. In this study, as suggested by Orden and Fisher (1993), a Choleski-type of identifying restriction is imposed on the ECM. When this type of restriction is used, the ordering of variables imposes a particular recursive structure on the model, such that earlier variables contemporaneously influence the latter variables, but not vice versa. The order that is chosen here is, \( m_t, p_t, r_t, e_t \) and \( y_t \). In this order \( m_t \) contemporaneously influences all other variables, \( p_t \) influences the other three variables except \( m_t \) and so on. Other recursive orders were used but they produced similar results.

In order to show the response of income to changes in money in earlier and later sub-periods, Johansen’s test results for the earlier period as well as VDC and IRF for the entire sample period and the early sub-period were estimated. These results are reported in Tables 2, 3 and 4 and Figures 1 and 2. It is clear from the comparison of Tables 1 and
that the cointegration between five time series was much stronger for both countries in
the earlier period. During that period the hypothesis of three cointegrating vectors for
Australia and four cointegrating vectors for the United States cannot be rejected. These
results indicate that a set of time series are bounded in more directions in the earlier
period than in the entire sample period.

The results of VDC in Table 3 indicate that, for both countries, money is not an
important variable in explaining forecast error variance of income when the entire sample
period is considered. However, according to the results in Table 4, money is a significant
variable in explaining variation of income in Australia during the period prior to the
deregulation of financial markets. A similar result is not obtained for the United States.
The VDC results for the U.S. indicate neutrality of money in the 1960s as well as during
the entire sample period. The results of IRF presented in Figure 1 are consistent with the
VDC results. That is, over the entire sample period, money has a significant effect on
output in both countries during the short-run. Regarding the earlier sample periods, a
money shock has a significant influence on output only in Australia over a limited range.
In the long run the effect of money on output is neutral in both cases.

6. A Comparison with Previous Studies

The empirical findings of this study are consistent with the results of Rapach
and Tanner and Davis (1997). Rapach (1998), in the context of VAR model, examined
the importance of money supply, money demand, real spending and supply shocks in
explaining variation of output and some other variables. The empirical analysis of the
study are based on U.S. quarterly data over the period of 1959:1-1994:4. Both VDC and
IRF showed insignificant responses of output to one standard deviation shock of money.
In this study output responded significantly in the short-run to a spending shock. Output
responded most significantly to a supply shock both in the short-run and in the long-run. Rapach provided a detailed comparison of his results with the results of previous studies. Aside from differences in the magnitude of IRF and coefficient of VDC, generally the results presented in Rapach (1998) regarding non-neutrality of money shocks are consistent with those reported in Keating (1992) and King et al. (1991). The pattern of the response of output in U.S. to a monetary policy shock reported in this study is very similar to that documented in Rapach (1998). Both responses are significant in the first year or so but tend to become insignificant from the beginning of the second year.

Fung and Kasumovich (1998) examined the responses of money, income, interest rate, price level and the real exchange rate to a monetary policy shock over the period of 1950s to the mid 1990s. In this study monetary shocks were identified as those that have no long-run effect on output and interest rates but influence the price level and the stock of money proportionally. The empirical results of this study based on cointegration and IRF supported the long run neutrality of money for six OECD countries. The responses of income to shocks of money were insignificant over entire 40 quarters for Canada, France, Germany, Japan and the United Kingdom. For the United States, similar to the results of this study, the response of income was significant in the short run but not in the long run.
**Table 1**

COINTEGRATION RESULTS LATTER PERIOD

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Trace</th>
<th>95% CV</th>
<th>Alternative</th>
<th>λ Max</th>
<th>95% CV</th>
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<tr>
<td>Australia (1968.1-1993.12)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>r ≤ 4</td>
<td>1.17</td>
<td>3.76</td>
<td>r = 4</td>
<td>1.17</td>
<td>3.76</td>
</tr>
<tr>
<td>r ≤ 3</td>
<td>7.34</td>
<td>15.41</td>
<td>r = 3</td>
<td>6.17</td>
<td>14.90</td>
</tr>
<tr>
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<td>r = 2</td>
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<td>21.07</td>
</tr>
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<tr>
<td>United States (1960.1-1993.12)</td>
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</tr>
<tr>
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<td>124.34*</td>
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<td>73.65*</td>
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**Table 2**

COINTEGRATION RESULTS EARLIER PERIOD

<table>
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<th>Hypothesis</th>
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<th>Alternative</th>
<th>λ Max</th>
<th>95% CV</th>
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Table 3
VARIANCE DECOMPOSITION OF OUTPUT

Australia (1968.1-1993.12)

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<tr>
<th>Months</th>
<th>$m_t$</th>
<th>$p_t$</th>
<th>$r_t$</th>
<th>$e_t$</th>
<th>$y_t$</th>
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<td>0.00</td>
<td>0.00</td>
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<td>10</td>
<td>8.20(1.5)</td>
<td>1.12(1.5)</td>
<td>15.89(1.5)</td>
<td>0.20(1.1)</td>
<td>74.60(2.7)</td>
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<td>15</td>
<td>7.22(1.8)</td>
<td>5.05(1.8)</td>
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<td>0.20(1.3)</td>
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<td>30</td>
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<td>9.66(2.1)</td>
<td>31.41(4.0)</td>
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<td>35.91(5.1)</td>
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<td>41.52(6.5)</td>
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United States (1960.1-1993.12)

<table>
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<th>Months</th>
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<th>$p_t$</th>
<th>$r_t$</th>
<th>$e_t$</th>
<th>$y_t$</th>
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Table 4
VARIANCE DECOMPOSITION OF OUTPUT

Australia (1968.1-1979.12)

<table>
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<th>$r_t$</th>
<th>$e_t$</th>
<th>$y_t$</th>
</tr>
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<td>1.58(2.28)</td>
<td>93.24(4.38)</td>
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<td>6.02(5.09)</td>
<td>14.09(5.96)</td>
<td>3.78(5.05)</td>
<td>74.20(9.93)</td>
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<tr>
<td>15</td>
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<td>26.59(17.20)</td>
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<td>1.99(7.25)</td>
<td>38.99(11.87)</td>
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<td>20.52(18.72)</td>
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United States (1960.1-1973.12)

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<th>$r_t$</th>
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<td>24.77(11.05)</td>
<td>2.18(10.40)</td>
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Figure 1
Response of Output to a Money Shock

Australian output in response to a money shock

US output in response to a money shock
7. Summary and Concluding Remarks

An attempt was made in this paper to examine the effect of change in money on output using monthly data on Australia and the United States. The theoretical model of the study predicts long-run neutrality of money. This prediction is supported by the empirical results. VDC and IRF results show that over the period of the 1960s to the early 1990s money shocks had insignificant effects on output in both countries. This result is consistent with those reported in Keating (1992), King et al. (1991) and Rapach (1998).

To distinguish between the short-run and the long-run effects of money on output, the sample period was divided to exclude periods of monetary instability in both countries. These periods consisted of 1968-1979 for Australia and 1960-1973 for the United States. The empirical analysis of these sub-periods indicated a stronger cointegration between five time series relative to the entire sample period. However, the VDC and IRF showed the importance of money in explaining variation of output only in Australia and not for the United States.
References


