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Money in the Era of Inflation Targeting

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Abstract[1]

This paper provides evidence that the relationship between inflation and money growth has changed as the inflation-targeting regime has progressed. During the disinflation period (mid 1980s to mid or late 1991) the correlation between inflation and money aggregates was fairly consistent with the prediction of theory. Both inflation and money growth fell sharply. In 1992, inflation was stabilised around an average of little less than 2 per cent. Since then, the correlation between money growth and inflation has been fairly weak at the permanent (trend) and the business cycle frequencies. By contrast, there is a significant correlation between money and real GDP over the business cycle. As far as base velocity is concerned, it was stable up until December 1997, but broke down in late 1998. As money growth took off in the late 1990s, velocity declined rather sharply, but these downward trends are consistent with the decline of interest rates as predicted by the quantity theory of money. The demand for real-monetary base is well behaved and interest inelastic, but this relationship also broke down in late 1998. However, both velocity-interest rate and money demand function breakdown is probably only temporary. Finally, at least until March 1999, the rate of growth of the monetary base has, on average, been consistent with a nominal GDP targeting policy of 4 per cent.

[1] I am thankful to the tremendous contributions provided to me by my colleagues at the Economics Department. Many of them spent so much time and energy trying to help me write and present this note. This is only the tip of the iceberg and future research should answer more serious questions regarding inflation targeting. I particularly thank Chris Plantier, Nils Bjorksten, Dean Scrimgeour, David Archer, John McDermott, Clive Thorp, Bun Ung, Louise Rockliff, Paul Dalziel, David Mayes, Christie Smith and Adrian Pagan for their comments. The views expressed in this note are mine and they do not reflect the Reserve Bank's views.

> "The Fed has been quite successful in recent years in aggressively adjusting the fed funds rate and has come to the point of essentially ignoring information from the monetary aggregates. Ignoring the aggregates is a mistake. Evidence is overwhelming across the ages of the important role of money growth in causing inflation." ***William Poole*** *(President of the Federal Reserve Bank of St. Louis, 1994, p.109-110.*)

1 Introduction

In New Zealand, Money plays a passive role in policy and the relationship between New Zealand monetary aggregates and the rest of the economy has been neglected for a long time. There are three main reasons for this. First, the Reserve Bank of New Zealand targets the inflation rate directly and has done that very successfully, keeping inflation low and stable since 1991/1992. Second, given a particular level of the short-term interest rate (Official Cash Rate – OCR), the Bank supplies money infinitely elastically (ie, money supply is endogenous) so there has been little interest in the trend and fluctuations of monetary aggregates. Finally, the money-demand functions were thought to be unstable, and an unstable money demand makes for an unreliable transmission mechanism between money supply and inflation.

The Reserve Bank has successfully kept inflation around 2 per cent since the end of 1991 or the beginning of 1992, while monetary aggregates have been growing at rates faster than the rate of growth of nominal GDP, particularly in late 1990s. The primary motivation of this research was to investigate whether we still need to worry about inflationary consequences of money growing at rates faster than nominal GDP after seeing the increase in the growth rates of the money base, $M1$ and $M3$ in the late 1990s. To answer the question above, this paper examines permanent, business cycle and transitory fluctuations in inflation, money and output in New Zealand and investigates their relationships. It also examines whether, or not, the relationships are consistent with the quantity theory of money.

This paper provides evidence that the relationship between inflation and money growth has changed somewhat as the inflation-targeting regime has progressed. During the disinflation period (mid 1980s to mid or late 1991) the correlation between inflation and money aggregates was fairly consistent with the prediction of the theory. Both inflation and money growth fell sharply. In 1992, inflation was stabilised around an average of 2 per cent. Since then, the correlation between money growth and inflation has been fairly weak. I give an explanation for this correlation.

To analyse the relationships between inflation, money and output, the time series data are decomposed into three components: permanent component (which I will refer to as trend sometimes), business cycle and the irregular component. This decomposition is a natural decomposition of time series data in the sense that any time series can be decomposed in the same fashion.[2]

However, the decomposition is based on specific economic definitions of the business cycle. An approximate band-pass filter (Baxter-King, 1999) is used to decompose the data. The permanent component represents the long run and the permanent fluctuations in the data that are beyond the business cycle fluctuations. The business cycle fluctuations are assumed to be between 6-32 quarters in length, which is based on the assumption that the New Zealand business cycle takes (at least the last business cycle) an average of eight years from trough to peak. The irregular component represents the fluctuations in the data that occur in the very short run, which are between 2-5 quarters in length. These are highly transitory fluctuations. So this filter is unlike the HP filter; which decomposes the data into permanent and cycle components only. Thus, the cycle in the HP filter includes a fair amount of noise. The BP decomposition conforms more closely to the definition of the business cycle.

[2] Harding and Pagan (forthcoming in the Journal of Monetary Economics) argue that such decomposition is probably incorrect and inconsistent with Burns-Mitchell's original business cycle research. The point is that the permanent and the business cycle component are indistinguishable and affect each other.

Using this approach, I find that the Reserve Bank's inflation-targeting policy removed trend (permanent component) from inflation and kept it low and stable around a constant 2 per cent per annum since 1992, while the monetary base and monetary aggregates continued to fluctuate freely at higher rates. Thus, the correlation between the permanent components of inflation and money growth becomes very weak.

Further, the Reserve Bank's successful inflation-targeting policy also removed significant cyclical fluctuations from inflation even as monetary aggregates continued to display large variations. Thus, the correlation between inflation and money growth is also poor over the business cycle frequency during the period 1992-2000.

However, I find evidence that the monetary base growth rate and inflation are correlated at a very high frequency. In other words, there is a significant correlation between transitory fluctuations of inflation and the monetary base. Quarterly changes in the CPI and quarterly changes in the monetary base are highly correlated. In fact, during the period up to September 1998, the monetary base growth rate is a good predictor of future transitory fluctuations in inflation. This predictability breaks down, however, in December 1998. The paper provides some explanations for these findings and argues that the relationship will re-establish it self.

By contrast to the relationship between inflation and money, I find that cyclical fluctuations in real GDP are closely and contemporaneously associated cyclical fluctuations in the monetary base. Moreover, there is evidence that the monetary base and $M3$ may actually lead output over the business cycle. This correlation between money and output is consistent with theory. I do not conclude that there is a causal relationship running from money to output. And, further examination is required to establish the stability of such correlation. Meanwhile, it is unwise to ignore such correlation, which – if stable – might have some information about business cycle developments. At any rate, monitoring this correlation is not at all costly and the Reserve Bank should pay attention to its development.

Milton Friedman provides the intuition for the correlation, and the lack of correlation, between money and output or money and inflation. Friedman says that the temperature in the room without a thermostat, but with a heating system will be positively correlated with the amount of fuel and may vary widely. With a thermostat set at fixed temperature, there will be zero correlation between the intake of fuel and external temperature, also the room temperature will vary a little.

By analogy, without a successful monetary policy (thermostat) to stabilise inflation (or output), there will tend to be a positive correlation between the quantity of money (fuel) and inflation (temperature), and both may vary widely. With successful monetary policy, there will be zero correlation between the quantity of money and inflation. However, money may still vary widely, but inflation will vary little. In New Zealand, monetary policy from 1988-2000 aimed and achieved stable inflation. For the same reasons, the correlation between money and output is positive because the Reserve Bank of New Zealand does not target output and money.

Finally, I find evidence that the demand for money function and the velocity functions for the monetary base were stable during the period of disinflation and up to September 1998. The demand for money function becomes clearly unstable in December 1998 and so does the velocity function. I provide a simple explanation to this instability. Further, consistent with theory, income velocities are stable functions of interest rates. Evidence that money base-nominal GDP targeting rule (McCallum, 1985, 1987) of 4 per cent is consistent with the evolution of the monetary base growth rate in New Zealand is also found in the data.

The data and the notations are described in the appendix 1. Section 2 examines the relationship between inflation, money and output. Section 3 contains a discussion of money velocity during the 1990s. Section 4 looks at whether money should be used as an intermediate target. Section 5 summarises and concludes.

2 The relationship between money, output and prices under inflation targeting

Inflation in New Zealand fell sharply during the disinflation period 1988-1991 (figure 1), after which inflation has remained stable and low at around 2 per cent.

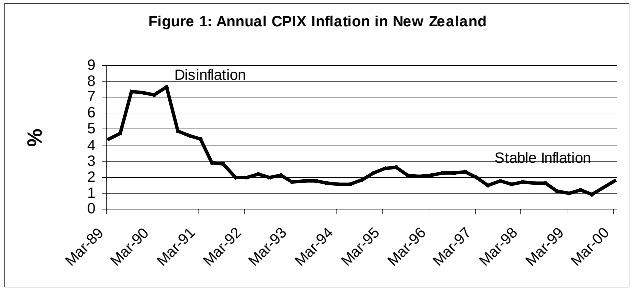


Figure 1: Annual CPIX Inflation in New Zealand

Figure 2 shows that the disinflation was associated with a decline in the growth rate of the monetary base and nominal GDP growth.[3] However, the growth rate of the monetary base exceeds the growth rate of nominal GDP at the end of the sample, by the end of 1997 and early 1998.

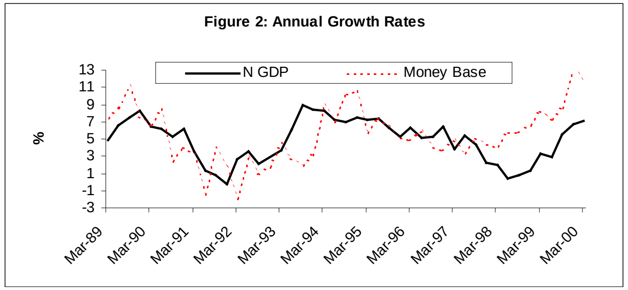
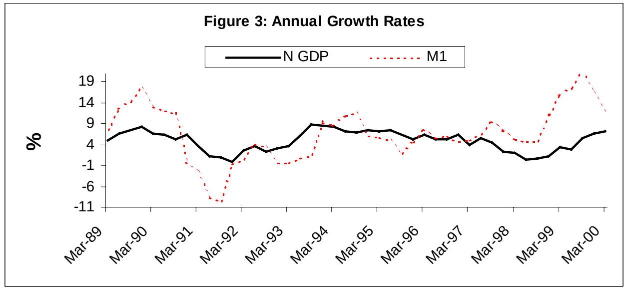


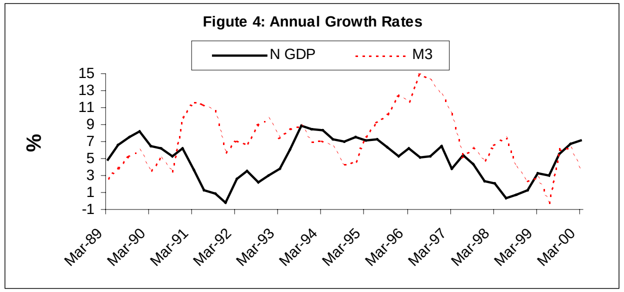
Figure 2: Annual Growth Rates

Although both $M1$ and $M3$ growth rates fell during the disinflation period they were not as highly correlated with nominal GDP growth as the monetary base was (figures 3 and 4). Also at the end of the

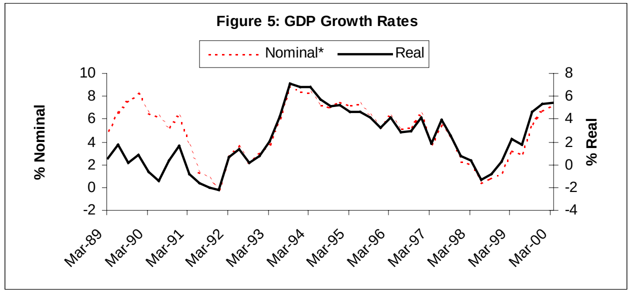
[3] Data are described fully in the appendix. It is important to note that the monetary base is corrected for the Y2K effect.

sample, the growth rates diverged and money growth took off, particularly $M1$.





Likewise, disinflation was associated with sharp decline in the growth rate of nominal and real GDP (figure 5). Also, figure 5 may tell us something useful about the association of low inflation and real output growth beyond the identity that links them.



Subsequently, during 1992-1997, the monetary base and $M1$ grew at rates close to nominal GDP. In 1998, money growth accelerated and outstripped the growth rate of nominal GDP. These developments are intriguing and motivate the rest of this paper.

Traditional monetarist theory holds that prices should respond proportionally to changes in money in the long run. Theory also predicts that changes in money and real activity are correlated in the short run and, presumably, money leads real activity over the business cycle. In New Zealand, however, by the late 1990s trend inflation (permanent component) was not closely associated with the trend (permanent component) in the monetary base, $M1$ and $M3$.

Table 1 provides the descriptive statistics underlying figures 1-6. The sample is split into two periods. The first sub-sample is from 1988 to 1991, which is the disinflation period. The second sub-sample is from 1992 to 2000, which is the period of low and stable inflation. All variables in this table are measured on an annual basis for convenience. Inflation in the first period averaged 5 per cent with a standard deviation of nearly 2. Output growth was zero or slightly negative, with a standard deviation of 1.4. The monetary base grew at approximately 5 per cent, which is very close to the growth rate of nominal GDP (real GDP growth plus inflation). However, both $M1$ and $M3$ grew at faster rates, 5.6 and 6.6 per cent respectively, exceeding the growth rate of nominal GDP.

In the second sub-sample, the mean of inflation was less than 2 per cent and its standard deviation was quite low. Output grew at 3 per cent on average. Both $M1$ and $M3$ grew even faster in this period. $M1$ grew at 7 per cent compared with 5.6 per cent during the first period, and $M3$ grew at 7.4 per cent compared with 6.6 per cent in the first period. However, the monetary base remained stable, growing only slightly faster than nominal GDP, without a significant change in volatility. The fact that the growth rate of the monetary base is equal to the growth rate of nominal GDP up until December 1997 (or even until mid 1998) is consistent with a constant or stable velocity of money base, which is a proposition that will be tested in section 3. The coefficient of variation also tells a story of a decline in the variance of inflation, output and money during the period from 1992-2000:1.

The same statistics are also computed for the period from December 1998 to the end of the sample (not reported in table 1). Although this sub-sample includes only six observations, the statistics are worth looking at. On average, narrow money (the monetary base and $M1$) continued to grow at rates much faster than the rates seen over the entire decade to 1999, and much faster than the real economy, without inflationary consequences. The monetary base grew at slightly higher than 9 per cent and $M1$ grew at nearly 16 per cent. Broader aggregates such as $M3$ grew at less than half the rate seen during the 1990s.[4]

In order to more formally study relationships between money, inflation and output, I decomposed these time series into permanent, business cycle and the irregular components using the *approximate* Band Pass filter of Baxter and King (1999), BP filter.[5] I specify three frequency bands such that they correspond to specific definitions of "permanent," "business cycle," and "irregular" fluctuations in the data. There is a general agreement that the business cycle fluctuations are fluctuations of 6-32 quarters in length. Thus, a reasonable assumption, that the average business cycle length, from trough to peak, is about 8 years, is used. This is also consistent with the historical evidence for New Zealand (Brook, Collins and Smith, 1998). Once the business cycle frequency is defined first, the permanent component is extracted as fluctuations in the data that exceed the business cycle frequency, and the irregular fluctuations are those transitory (short-lived) fluctuations that fall within 2-5 quarters band length. In contrast, the cycle that results from the popular HP filter is a residual left out after defining the permanent component. Unfortunately, the cycles (generated by the HP filter) include a fair amount of unfiltered noise. It will be shown that this irregular component is very important in the New Zealand case. It actually dominates the fluctuations in inflation. The reason, as I will explain, is related to the RBNZ inflation-targeting policy.

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4 There is an argument that there may be some substitutions to equities and other offshore fixed-interests.

5 The filter is BP_{12} (p, q), where it passes through cycles in the data between p and q periods and 12 implies a two-sided moving average is of order 12. At the end of the sample, we pad, with forecast and backcast of original series, the data using AR (4) process. Data for monetary aggregates are short, so we rely on padding at both ends of the sample.

As I explained above, this filter allows one to define frequency bands based on economic concepts such as the length of the business cycle. The filter is linear, introduces no asymmetry or phase shifts (ie, it does not alter the timing relationships between variables at any frequency), and is not sensitive to the length of the sample.

Figures 6-8 plot the permanent components of the growth rates of money and inflation. These growth rates are measured as $(\ln x_t - \ln x_{t-1}) * 400$. For the monetary base and $M1$, the trends are consistent with theory during the disinflation period, with both trending down as the Reserve Bank pursued disinflation. The trend of both the monetary base and $M1$ then increased substantially once inflation had stabilised in 1992.

Figure 6: Permanent Components

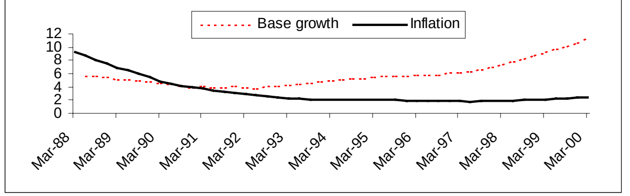


Figure 7: Permanent Components

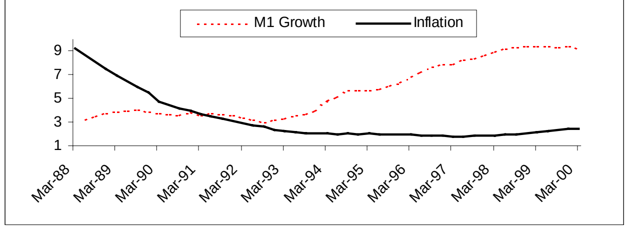
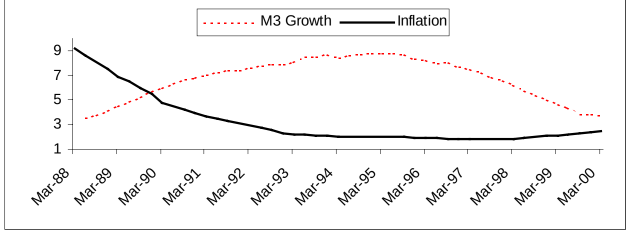
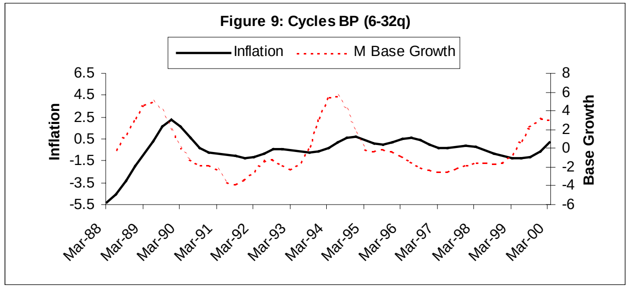


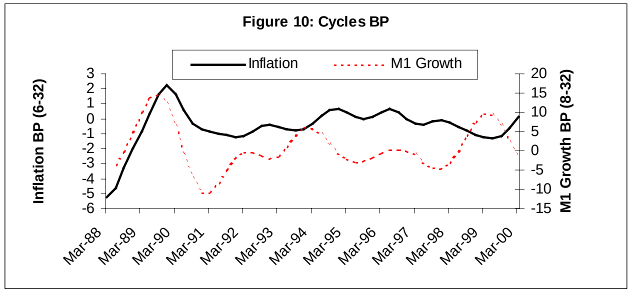
Figure 8: Permanent Components

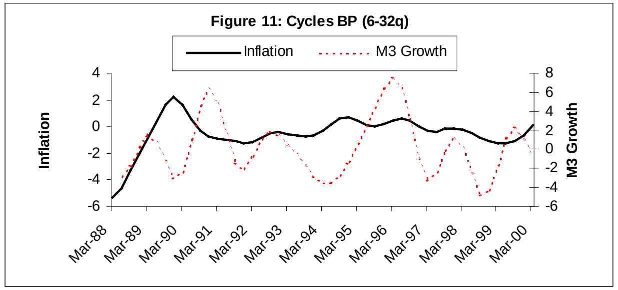


The permanent component of the rate of growth of $M3$ differs from that of the monetary base and $M1$; it deviates from inflation for the entire period from 1988-2000, but converges to inflation's trend towards the end of the sample. In general, the permanent components plotted in figures 6-8 are inconsistent with the permanent components (or trends) predicted by theory. It is quite clear that there is no relationship between trend inflation and money growth. In section 3, I will try to shed light on $M3$trend when I examine velocity trends.

Figures 9-11 plot the business cycle fluctuations of inflation and money. There is little association between the rates of growth of money and inflation during the period of disinflation, but when inflation becomes low and stable in 1992 onwards, all association with money growth at the business cycle frequency vanishes.







Intuitively, successful inflation targeting should remove the trend from inflation, which it did. Inflation varied around a stable (constant) trend of 2 per cent since 1992. In other words, inflation has a small variance (see table 1). Money, however, fluctuated rather freely at all frequencies and has a large variance relative to inflation (see table 1). It grew faster than nominal GDP especially after 1992. Thus, the correlation between a variable that moves around freely and another that is kept under control at a constant rate ought to be weak. See Poole (1994) for a useful discussion and note that this not really different from what is called the Goodhart law that is when a stable relationship is used (by policymakers) it breaks down. A theoretical proof is found in appendix 2. The idea is that the central bank has an objective to stabilise a particular variable, which is the target, at a particular target level. The central bank achieves that by controlling a particular intermediate target whose values are predictable and under the direct control of the central bank to offset shocks to its target variable. It is shown that when the central bank hits its target perfectly, the correlation between the targeted variable and the intermediate target is theoretically equal to zero.

Figure 12a plots actual inflation, its permanent component and its cycle from 1988:1-2000:1. A few things are observed. Actual inflation displays very frequent ups and downs. The permanent component (trend) is smooth, falling with inflation and averaging approximately 2 per cent from 1992 onwards. The cycle is smooth and gets smoother after 1992. Finally, trend and cycle do not add up to the ups and down in actual inflation, which displays transitory fluctuations at shorter horizons than the business cycle horizon.

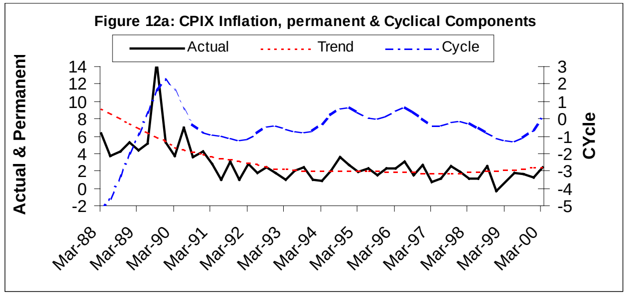


Figure 12a: CPIX Inflation, permanent & Cyclical Components

Figure 12b, magnifies the period of low and stable inflation, which is from 1992 onwards. The trend's average is about 2 per cent. The cycle nicely and smoothly fluctuates around actual inflation, but trend and cycle do not add up to actual inflation, which displays even more ups and downs than earlier in the sample.

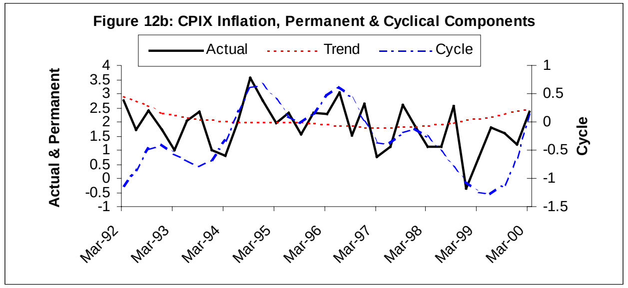


Figure 12b: CPIX Inflation, Permanent & Cyclical Components

Figure 13 plots actual inflation and the high frequency transitory fluctuations of inflation that have 2-5 quarters in length. The correlation between actual inflation and the irregular component is quite apparent. The irregular component varies between –1.5 to 2 per cent over this period of time. I tested these random fluctuations for whiteness. The test statistic rejected the hypothesis that the irregular component (transitory fluctuations) of the CPIX inflation is a white noise.[6] The policy implications of such finding should be further studied in future research. Figure 12a, 12b and 13 leave me with one conclusion: the Reserve Bank inflation-targeting policy has

[6] The Kolmogrov-Smirnov Cumulated Periodogram value is 0.2903, which exceeds the critical values at 1%, 5% and 10% levels (0.2881, 0.2404 and 0.2157 respectively).

successfully removed trend from inflation in the sense that trend inflation is almost a constant, and smoothed out its fluctuations at the business cycle frequency. What is left in the data is not inflation. What is left constitutes transitory changes in the price level that are not related to inflation.

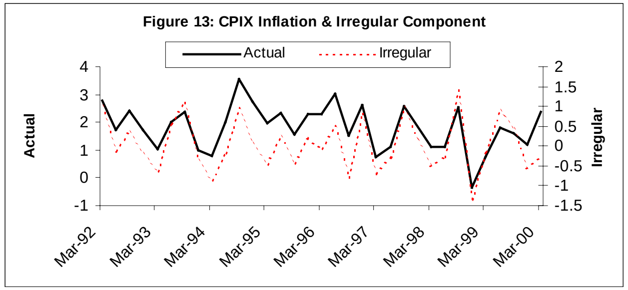


Figure 13: CPIX Inflation & Irregular Component

To illustrate the effectiveness of inflation targeting further, figure 14 plots annual inflation, its permanent component and two measures of inflation expectations, the Reserve Bank survey of one-year ahead inflation expectations and the National Bank survey data. The figure demonstrates the credibility of the inflation-targeting programme in New Zealand.

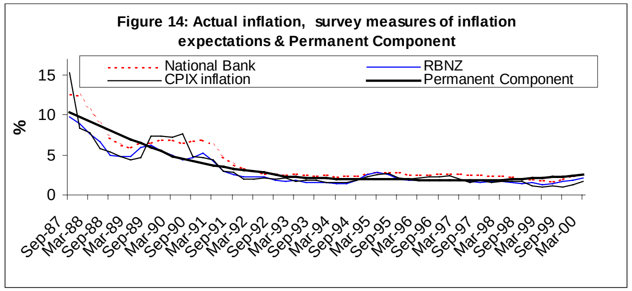


Figure 14: Actual inflation, survey measures of inflation expectations & Permanent Component

Figures 13 and 14 suggest that transitory fluctuations in inflation around a constant, 2 per cent, have not altered public's expectations about future inflation. To the extent that inflation targeting is in fact "inflation expectations" targeting, transitory fluctuations should not be relevant to the setting of interest rate. Policy response to realised inflation fluctuations of the sort shown in figure 13 is problematic, and may be destabilising. Future research should examine this issue in depth.

Econometric evidence

We established that there is no relationship between the permanent and the cyclical components of inflation.[7] To further examine the correlation between inflation and money at high frequency I estimate four regressions for *actual* inflation (since it is dominated by the irregular component) and money using annual differences of the levels.[8] Annual differences, like quarterly differences, are dominated by high frequency fluctuations. The regressions are labelled model (I), (II) (III) and (IV).

In model (I), inflation is regressed on a constant and lags of the rates of growth of the monetary base and real output. Model (II) is similar to model (I) except that the output gap replaces output growth. In model (III), I only used a constant and the lags of the monetary base growth rate as the explanatory variable. In model IV, I regress inflation on expected inflation and lags of the monetary base growth rate.

Expected inflation is measured by the Reserve Bank survey, which measures a one-year a head expected inflation. The sample is from December 1990 to September 1998 (we lose some data due to annual differencing). Results are reported in table 2. In all four regressions the error term is modelled as a moving average MA (3) because the inflation rate is defined as $\Delta_4 \ln p_t * 100$. The estimation method is a Maximum Likelihood.

The lags of output growth (coefficients b) are significant with negative signs.[9] The output gap is never significant (coefficients $\tilde{b}$), but the lags of the rate of growth of the monetary base explain a large portion of the fluctuations of measured inflation. The constant terms are not significant except in model (III). The goodness of fit measured by adjusted R^2 for the four regressions are 0.84, 0.75, 0.73 and 0.87 respectively. Model (IV) that has only two regressors has a larger R^2 than all other models, which have more regressors. The goodness of fit measured by $\bar{R}^2$ suggests that lagged base growth, not only explains quite a large portion of the variation of inflation at high frequency, it has a leading information about transitory fluctuations of inflation.

Out-of-sample forecasts are also computed and plotted in figure 15. The models are estimated from December 1990 to September 1998. Then forecasts from December 1998 to September 2000 are computed from models I, II, and to December 2001 from models III and IV.[10] The forecasts are dynamic forecasts. The first three models over-predict inflation systematically. The last model, which does not include a constant and includes only expected inflation and one lagged value of the monetary base growth rate predicts inflation's downturns quite well. I report the actual values and the forecasts and the Root Mean Squared Errors in table 3. Based on RMSE, the models can be ranked in terms of out-of-sample performances; these are model (IV) followed by (III), (II) and (I). Output growth and the output gap models don't do as well as models with only money and money and expected inflation. The results suggest that money growth provides significant leading information of up to 5 quarters about short-term transitory fluctuations of inflation. Note that the improvements in RMSE from model I to model IV mean that model's I to III forecasts were inefficient.

Finally, I reverse the regressions where I regress money growth on lagged inflation. I found no feedback from lagged inflation to the monetary base. I fit up to six lagged values of inflation and test

[7] In real business cycle literature, the permanent component is highly elated to business cycle fluctuations.

[8] That is the variables are defined as $\Delta_4 \ln x_t * 100 = (\ln x_t - \ln x_{t-4}) * 100$.

[9] Meltzer (1977) finds similar results for the US. However, in the equation of exchange, inflation depends positively on money growth and negatively on real output growth. In essence, money growth is a proxy for aggregate demand or expected inflation stemming from demand, while output growth represents supply. So for given money growth rate, an increase in real output growth lowers the inflation rate. Some economists will generally disagree and expect real output growth to positively correlate with inflation arguing that the output gap is the sum of the change in real output provided that potential output is constant and the change in potential output is zero, which is hardly the case in reality.

[10] These models only include lagged money. The models with output require information about output that we did not have at the time of the estimation.

using F and Wald statistics that the sum of the coefficients on lagged inflation are equal to zero. The hypothesis could not be rejected in all models.

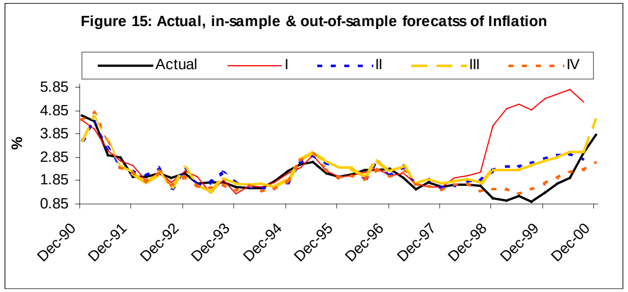


Figure 15: Actual, in-sample & out-of-sample forecatss of Inflation

The models I through IV break down when observations starting in December 1998 and up to the end of 1999 are included. The breakdown shows in the reduction of the t statistics of individual coefficients and the fit of the models. This breakdown will be investigated in more detail in the next section.

I also estimated models I, II, III with lagged inflation as a regressor (explanatory variable) and without the constant term. Regressions are not reported to save space, but the results are available upon request. Inflation is persistent. The coefficients on lagged inflation in model I II and III are 0.63, 0.81 0.85 respectively. In model I, the contemporaneous money base growth rate, the first, second and fifth lags are all very significant, but output growth is either insignificant or it has a negative sign. The forecast improves because of the inclusion of lagged inflation in the regression. In model II, the output gap is insignificant. The fifth lag of the monetary base growth rate is always significant.

Laidler (1999, p.20) reviews the evidence in the Canadian case and finds that narrow money seems to lead inflation and output as well. Recently, Gerlach and Svensson (2000) and Altimari (2001) provide evidence that money and credit indicators have significant leading information about inflation in the Euro area. There is a serious issue here about whether the Bank should be interested in forecasting high frequency fluctuations in inflation.

Money and output

Mishkin (1983), using data for the US, has provided support for the proposition that monetary shocks have real short-run effects. This proposition that the two variables are associated in the U.S. data is widely accepted (see Cecchetti (1995), DeLong (2000), Svensson (2001, p.1) and Woodford (forthcoming). International evidence is not widely confirmed and correlation may be weaker in one historical data set than in another (Robert Lucas, 1995).

In New Zealand the correlation between money and real output turns out to be much stronger than that between money and inflation. Figures 16-18 plot fluctuations in the monetary base, $M1$ and $M3$ respectively against real output fluctuations at the business cycle frequency of 6-32 quarters. From figure 16, we see that the turning points of the monetary base are very close to those of real output. The relationship is less clear-cut with respect to $M1$ in figure 17. In figure 18, $M3$ has a long and variable lead for output's cyclical movement.

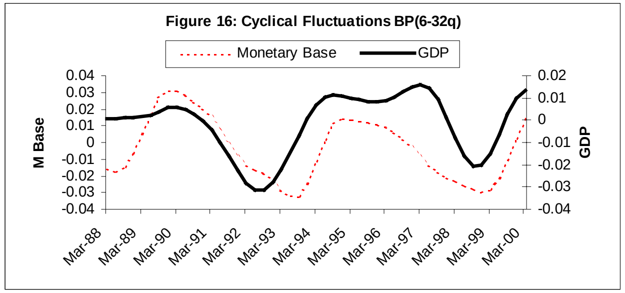


Figure 16: Cyclical Fluctuations BP(6-32q)

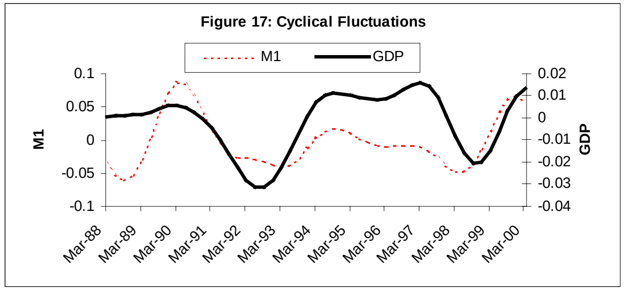


Figure 17: Cyclical Fluctuations

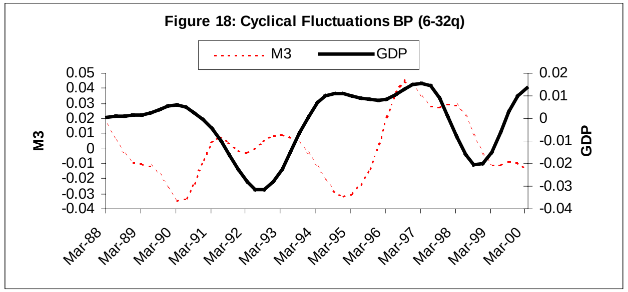


Figure 18: Cyclical Fluctuations BP (6-32q)

The association of money and output over the business cycle is consistent with economic theory (neoclassical and New Keynesian models). This prediction can also be confirmed using new money-matching models that build on the search-theoretic approach (Wallace, 1997). This correlation between money and output can also be a result of monetary policy in New Zealand not being directly concerned with stabilising output or targeting money. Thus, leaving both variables to fluctuate freely preserving the correlation in the data.

It is very well documented that real GDP growth is highly correlated with money growth in the United States. In 1992, this correlation broke down. Milton Friedman says, imagine money being a fuel and output is the temperature. The temperature in the room without a thermostat but with a heating system will be positively correlated with the amount of fuel and may vary widely. With a thermostat set at fixed temperature, there will be zero correlation between the intake of fuel and external temperature, also the room temperature will vary a little. By analogy, without a successful monetary policy to stabilise the economy (thermostat), there will tend to be a positive correlation between the quantity of money (fuel) and output (temperature), and both may vary widely. With successful monetary policy, there will be zero correlation between the quantity of money and output. However, money may still vary widely, but GDP will vary little. In New Zealand, monetary policy from 1988-2000 did not aim at stabilising either variable directly.

More evidence

The cross-correlation functions may also suggest that the monetary base has leading information about real output.[11] I test the hypothesis that the cross-correlation functions at all eight leads, all eight lags and all leads and eight lags are zero for the cases of real output with the monetary base, $M1$ and $M3$ respectively. The P values of the Q statistics are 0.0001, 0.0001 and 0.0001 for output and the money base, which means the hypothesis that the correlation is zero is rejected for all leads, all lags and lags and leads. The P values for the case of output and $M1$ are 0.0863, 0.0001 and 0.0001 respectively. These P values suggest that $M1$ does not lead output over the cycle, it is contemporaneously correlated and when we take all lags and leads there is a significant correlation. For output and $M3$, the same P values are 0.0098, 0.3857 and 0.0259. It is clear that the correlation is much weaker than in the previous two cases, but the lead coefficient of $M3$ is quite significant. However, for money to be considered as an indicator for future business cycle fluctuations, the correlation with output must be stable over time. Further examination is required when more data are gathered in the future.

This correlation between money and output is consistent with Friedman and Schwartz's seminal monograph *A Monetary History of the United States* (1963), which includes detailed examinations of the relationship between money and real output. One of their conclusions that every major depression in the United States during the period 1867-1960 was associated with (or preceded by) a large contraction in the money supply. However, it is quite difficult to establish that there is a causal relationship running from money to output. Meanwhile it is unwise to ignore such correlation, which – if stable – might have some information about future recessions and booms. At any rate, monitoring this correlation is not at all costly and the Reserve Bank should pay attention to its development.

[11] Statistics are available upon request. For example, Zellner et al (1991) and Zellner and Min (1999) find evidence that lagged money growth has important leading information about output growth in many countries.

Discussion

There is no correlation between money growth and inflation at trend and business cycle frequencies in New Zealand data. This is largely due to the fact that inflation has been kept low and stable from 1992 onwards even as money fluctuated freely. This has been illustrated in figures 6 and 11. The intuition is that inflation has a low variance (does not fluctuate) because the Reserve Bank controls it, while money has a large variance, which implies that correlation between these two variables is weak. Table 1 reports the sample standard deviations and the coefficients of variation of actual data. Appendix 2 provides a theoretical argument.[12]

It was shown that most of the fluctuations in the inflation rate are transitory fluctuations. We also found a strong correlation between the monetary base growth rate and inflation at high frequency. Econometric evidence suggests that the monetary base growth have a statistically significant five quarters leading information about actual inflation. However, this relationship breaks down in December 1998, which will be examined in more details in the next section.

There has been a significant increase in the growth rates of the monetary base, $M1$ and also $M3$ since inflation was stabilised in 1992. The demand for money, which will be investigated in the next section, has also increased significantly. We know that because the Reserve Bank supplies money on demand and supply is equal to demand. The demand for narrow money increases either because the interest rate falls or income and wealth increase or both. It also increases because of changes in government's debt and real asset prices. The demand for narrow money (cash) can also be affected by other variables such as increasing bank fees, higher taxes, or

[12] Wong, Grimes and Meads (1994) using the old (unrevised) money aggregate data set argue that $M3$ is a more stable indicator for monetary policy than $M1$, and also better than broader measures such as financial wealth. Greville (1989) suggests that $M1$ is a preferred indicator.

flourishing black market activities.[13] [14] However, the growth rate of money also increases because economic agents become convinced that inflation remained stable and so they demand more money (Brunner and Meltzer, 1993). Recall that the RBNZ supplies money on demand. Figure 14 demonstrates the permanency of the decline in inflation and shows that inflation expectations have been anchored at a low level. If inflation expectations remained anchored at this low level, it is likely that the demand for money will further increase as people become increasingly convinced of the permanency of low inflation. Since the Reserve Bank supplies money on demand, it follows that the money supply will also increase proportionally.

Lee and Fisher (1996) found evidence of low correlation between money growth and inflation in many industralised countries during the period of the gold standard, which is also a period of remarkable price stability.

In neoclassical models, inflation acts as a tax on activities involving cash. Individuals reduce their money holdings, buy fewer goods and services and overall output falls when inflation is high. New search-theoretic approach models predict the same outcome. Molico (1999) finds that inflation lowers the average amount of real money held per person proportionally to an individual's money holdings.

The other important issue that emerges from the above analysis is the fact that there are no inflationary consequences when the rate of growth of money exceeds the rate of growth of nominal output. This can be interpreted as an indication of the credibility of inflation targeting policy in New Zealand. It is, however, also dependent on the nature of the shocks hitting the economy. If supply shocks start to dominate the fluctuations in output and inflation in the future, inflation might increase via the increase in inflation expectations and wage pressures. When workers expect high inflation they demand higher money wages.

[13] Drew and Plantier (2000) suggest that the real interest rate was high during the disinflation period, and that it fell significantly after 1992.

[14] Giles (1999) reports increasing black market activities in New Zealand.

Before I turn to issues related to velocity and money demand I take another look at the implications of low and stable inflation regime in New Zealand for welfare. Although no solid conclusion can be drawn without serious modelling and research in this area, there are two pieces of evidence that low and stable inflation increases real output.

Figure 5 shows that nominal GDP is highly correlated with real GDP growth when inflation was under control from 1992 onwards. Does this correlation tell us anything about welfare or the real economy? Lucas (1973) model implies that when demand shocks dominate the fluctuations of output and inflation, nominal spending increases real output by more than increasing and inflation if inflation is kept low and stable. This may sound like a tautology to many, but one can arrive at a similar prediction from search-theoretic models. Molico (1999) shows that inflation can have distribution effects on money holdings across the population. He finds that if new money is created and distributed to individuals in a lump sum, an increase in the rate of monetary expansion would decrease the dispersion of prices and improves welfare if inflation is sufficiently low.

Finally, there is evidence that the relationship between the monetary base, $M1$ and $M3$ is stable or in other words the two variables are cointegrated. It implies that the small size of the monetary base is not an issue. Figure 19 plots the ratio of $M1$ to the monetary base (without correcting for Y2K), in levels (not in logs) and using monthly data from March 1988 to December 2000. The stability of this multiplier relationship is quite obvious. Figure 20 plot the ratio of $M3$ to the base. This appears less stable than $M1$/base, but it reverts to the mean over a long time.

Figure 19: M1/ M base

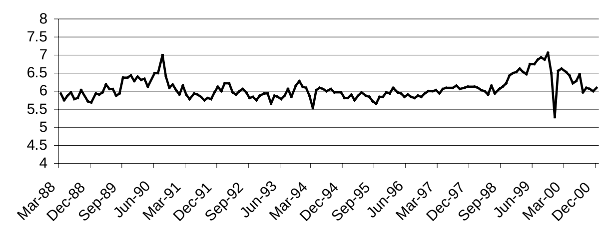
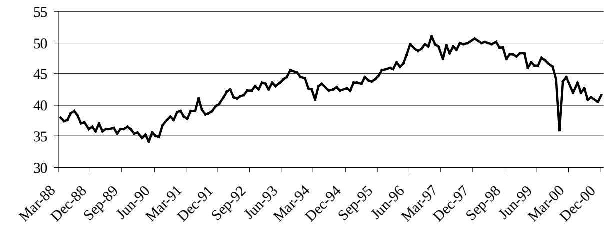


Figure 20: M3 / M base



I tested the ratios $M1$/base and $M3$/base for unit root. The ADF test suggests that the hypothesis of unit root can be rejected at the 1 per cent level for $M1$/base when the Y2K outlier is excluded. The hypothesis is also rejected by the Phillips-Perron test at the 1 per cent level. However, the hypothesis of unit root for $M3$/base is harder to reject. Results are not reported but they are available upon request.[15] The results for $M1$/base implies that $M1$ and money base are cointegrated. However, one should be careful when interpreting cointegration relationships in small span of data.

Velocity and demand for money functions

The income velocity of money is defined as the rate at which money circulates through the economy in order to finance transactions, and is equal to the ratio of real income to real money demand.

$\ln V_t = \ln(y_t / (M_t / P_t))$, or equivalently, $\ln V_t + \ln M_t = \ln P_t + \ln y_t$ (1)

In this identity, where the total payment made for the purchase of goods and services must be equal to total receipts, V_t represents velocity, y_t is real GDP, M_t is a measure of money and P_t is a measure of the price level. Typically, real GDP is used as a proxy for transactions.

[15] I run the first difference on a constant term, lagged level of the ratio, and lagged differenced value using both ADF and Phillips-Perron tests from March 1988 to December 1998. For $M3$ trend is significant.

If velocity of money is unstable, money demand is also unstable and the monetary authorities cannot rely on a reliable transmission mechanism between money supply and inflation. In other words, money supply can expand and contract without reliably increasing or decreasing nominal spending. From the identity above, the reason why there has not been a higher rate of inflation in New Zealand recently in the face of an increase of money supply must be a decrease in velocity. It is important to know if this decrease is a random fluctuation or if this is a predictable outcome deriving from stable economic relationships.

Base velocity is trendless from 1988 to the end of 1997 (figure 21).[16] This means that base velocity is mean-reverting, or in other words, the monetary base, real GDP and the price level were probably cointegrated (or remain in a stable relationship vis-à-vis each other) between March 1988 and December 1997.

However, it is clear from figure 21 that base velocity fell sharply at the end of the sample, and it is hard to reject the hypothesis that velocity has a unit root (is nonstationary) if the sample is extended to include the observations from 1998 onwards.[17]

Figure 22 shows that $M1$ velocity has a mild trend early in the sample. The slope then turns negative in mid 1990s.[18] For $M3$ velocity, figure 23 shows a clear downward trend from 1988 to date, which is consistent with the rise of $M3$ trend depicted in figure 8 earlier.[19] An increase in $M3$ above nominal GDP pushes velocity down.

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16 The ADF test for unit root rejects the hypothesis that it has a unit root. The regression consists of the change in velocity on a constant, lagged level of velocity and one lagged change of velocity. Trend and three lagged values of the change in velocity were found insignificant and dropped out. The ADF statistic is 3, which exceeds the asymptotic critical value at the 5% level, -2.68. Also, the DFGLSu (Elliott, 1999) rejects the unit root hypothesis. The statistic is –3.361 compared to the 5% critical value of –2.73.

17 Unit root implies that time series is nonstationary, but nonstationary time series does not necessarily have a unit root.

18 The ADF and the DFGLSu tests could not reject the unit root hypothesis.

19 The ADF and the DFGLSu could not reject the hypothesis that this trend is stochastic.

Figure 21: Money Base Velocity

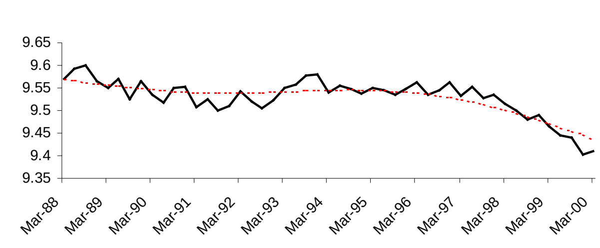


Figure 22: M1Velocity

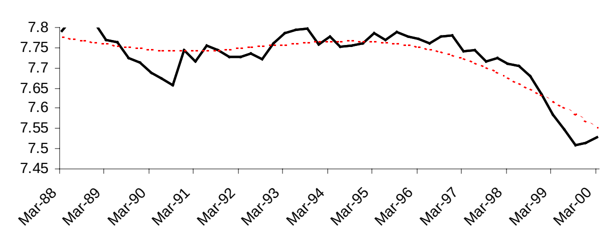
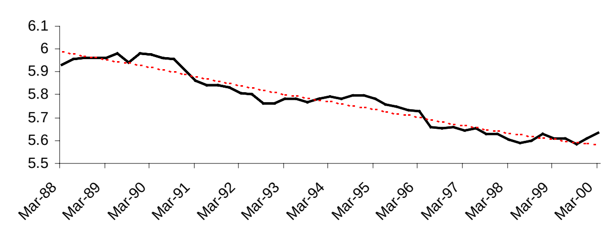


Figure 23: M3 Velocity



The downward trend of the income velocity of money, especially $M3$, is inconsistent with the story that financial innovation has induced instability in the velocity of money. Financial innovation is generally portrayed as having simplified the process of making payments, thereby reducing households' demand for real-money balances, which would induce the income velocity of money to rise, not to decline. For velocity to fall, the demand for real-money balances must increase by more than the increase in real output.

There could be many reasons for increases in the demand for real-balances, which I will briefly discuss later in this section, but one compelling reason for the demand for money to increase is if economic agents believe that the level of inflation fell permanently. Brunner and Meltzer (1993) explain that while economic agents respond to cyclical changes in inflation by changing their money holding, they change their money holding fully and permanently only when they are confident that inflation is permanently lower. I speculate that this interpretation suggests that in New Zealand the effect of inflation targeting on increasing the demand for real-money balances dominates the effect expected from financial innovation. This proposition is a subject of future research.

Lee and Fisher (1996, p. 67) examined data of different countries during the gold standard and found that the money stock grew faster than real output when inflation rates (using different prices) were stable. They found that velocity had been falling over the same period. Velocity not being constant does not violate the quantity theory provided that velocity remains a stable function of interest rates or institutional changes that affect velocity. Siklos and Eckhold (1997) examine the income velocity of $M3$ in New Zealand and argue, convincingly, that it slopes downward because of several institutional developments.

We do not have a long span of data for New Zealand to test several regime shifts. Nevertheless, trends emerging from plotting velocity against the 90-day interest rate and the 10-year government bond yield may represent "long-run" relationships. Figures 24-29 show that velocity and its trend fell as inflation and thus nominal interest rates fell. It is still not obvious from visual inspection of the data whether these relationships are stable or not.

Figure 24: Base Velocity, R 90 & Trends

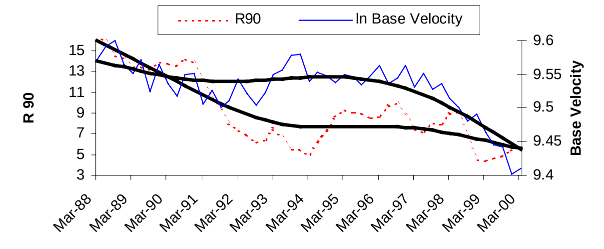


Figure 25: Base Velocity, R10 & Trends

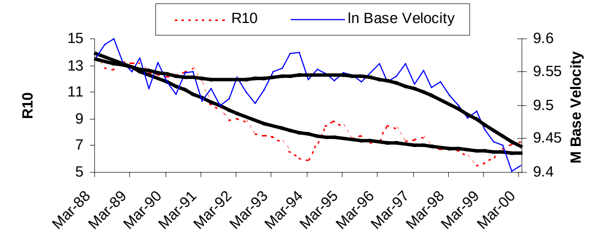


Figure 26: M1 Velocity, R 90 & Trends

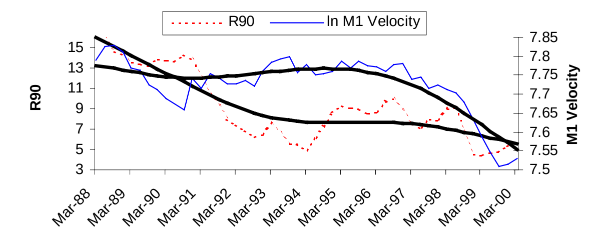
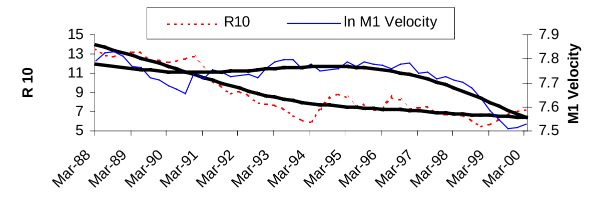


Figure 27: M1 Velocity, R10 & Trends



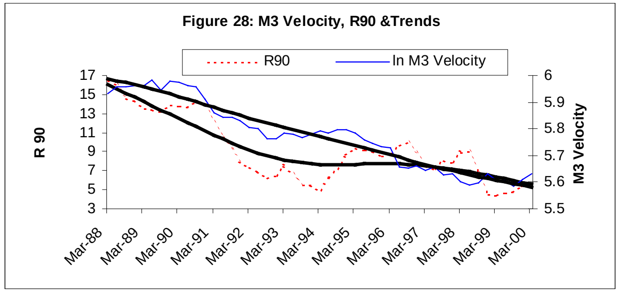


Figure 28: M3 Velocity, R90 &Trends

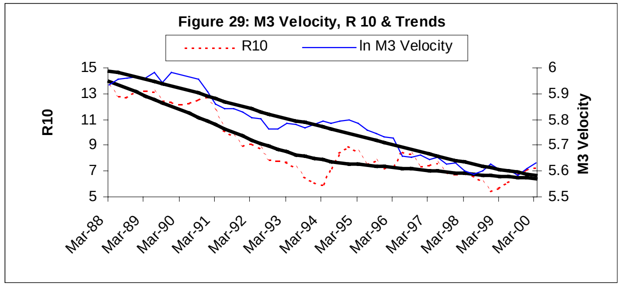


Figure 29: M3 Velocity, R 10 & Trends

Econometric evidence

A stable relationship between velocity and the interest rate implies that the two variables are cointegrated. This is in principle testable, though ideally cointegration analysis should cover a long time span, which is longer than the span of our data series. Given the span of our data, it is difficult to provide reliable econometric evidence that velocity is a stable function of interest rates. Recall that base velocity has a unit root if the whole sample from 1988 to 2000 is used. I report the results of the Engle-Granger (1987) test in table 4.[20]

[20] The first two regressions in table 3 are the Engle-Granger two-step procedure. First we regress interest rate on a constant and velocity in levels. Second, the residuals of this regression, η_t, are tested for unit root using the ADF test (as recommended by Engle and Granger (1987)). Of course it is quite difficult to determine precisely whether the variables are cointegrated or not, because of many factors such as the power of the test. However, the error correction term φ_2 in the last equation is perhaps more indicative of the presence of cointegration between velocity and the interest rates than the significance of ϕ_1 provided that

The three regressions in table 4 were estimated for all three different measures of velocity (ie base velocity, $M1$ and $M3$ velocities). In each case, the 90-day interest rate and the 10-year government bond yield are used separately. I carried out the tests over a sample from March 1988 to March 2000. The number of lags is four in each case, but lags that are not statistically significant are dropped out.[21] Statistics (of the error correction terms) reported in table 4 suggest that base velocity is probably cointegrated with the 10-year government bond yield. The evidence for the 90-day interest rate is only significant at the 10 per cent level. $M1$ velocity is not cointegrated with interest rates, however, $M3$ velocity is probably cointegrated with interest rates. There is no obvious reason to why $M1$ velocity is not cointegrated with interest rates while $M3$ velocity is.
Although I bootstrapped the error correction regressions, the results should be interpreted with caution because we have a short span. I would conclude that only mild econometric evidence in favour of cointegration between velocity and interest rates are present in the data.

Since we found some statistical evidence in favour of cointegration between base velocity and interest rates (March 1988 – March 2000), one would like to have a feel for the size of the elasticities. The interest rate and the income elasticities of the demand for money have policy implications, as explained in White (2001).[22]

The demand for real balances

Milton Friedman's demand for real-money balances may be written as a function of interest rates (the 90-day, 10-year government bond yield etc.), total wealth, prices of assets in addition to real output. Unfortunately, not all data are readily available in New Zealand. For

ζ_t is *iid* with a zero mean. Further, I bootstrap the last equation (the error correction) and report the mean and standard error.

[21] I also used the yield gap, 90-day interest rate differential with the US and the 10-year government bond yield differential and found similar results. The interest rate differential accounts for the exchange rate. Results are available upon request.

[22] The argument is that monetary policy that involves changes in interest rate would be effective only if the demand for central bank money is interest inelastic.

example, we do not have adequate data on real capital and wealth and our samples are short, which makes it difficult to estimate large number of parameters. Instead, I will estimate a Keynesian demand for money function, where real money is a function of real output and the interest rate only. I use five different interest rates as regressors, the 90-day interest rate, the 10-year government bond yield, the yield gap, the 90-day interest rate differential (New Zealand minus the US interest rate) and the 10-year government bond yield differential. In particular, the New Zealand-US interest rate differential will account for the openness of the New Zealand economy.

The regression equation I estimate is reported in table 5. The endogenous variable is $\ln m_t'$, which is the real monetary base defined as $\ln M_t - \ln P_t$, where M_t is the monetary base and P_t is the GDP deflator. The explanatory variables are the natural logarithms of real GDP and the nominal interest rate (in annualised percentage forms). The theory predicts that the income elasticity is positive and the interest semi elasticity is negative. The estimations were carried out using the non-linear dynamic least squares method of Phillips and Loretan (1991) to estimate the long-run interest rate semi-elasticity and the income elasticity of the demand for money.[23]

The regression is subject to overfitting because it includes lag and lead terms on the RHS of the equation. The sample is small (1988-1997). The simple specification of the Keynesian demand for money function will mitigate the overfitting problem and take into account the small sample size. I fit the model for the monetary base, $M1$ and $M3$. Because the results are qualitatively similar (especially for $M1$), I only report the results for the monetary base.

Results are reported in table 5. They should be interpreted with caution because of small span and sample size. In general, the income elasticity and the interest rate's semi-elasticities of demand

[23] This single-equation estimation technique is asymptotically equivalent to a maximum likelihood on a full system of equations under Gaussian conditions. This technique provides estimators that are statistically efficient, and whose t-ratios can be used for inference in the usual way. Most importantly, this method takes into account both the serial correlation of the errors and the endogeneity of the regressors that are present when there is a cointegration relationship.

for the monetary base have the magnitudes and signs predicted by theory. Income elasticities are very close to one.[24] In the second column, when the interest rate is the 90-day rate, the income elasticity of the demand for real-money base is not statistically different from unity. This also true when the 90-day interest rate differential is used in column 5. Although the rest of the income elasticities that are reported in columns 3 and 4 and 6 seem close to unity in magnitudes, they are still statistically different from one. The interest rates' elasticities are calculated to be $\hat{b}_2 \bar{i}_t$ where $\bar{i}_t$ is the mean of the interest rate used in the regression. The interest rate elasticities are -0.05, -0.08, -0.0004, -0.04 and -0.02 respectively. They are statistically different from zero. Thus, the demand for the real- monetary base seems interest- inelastic.[25]

The demand for money relationship seems to break down around September 1998. Interestingly, the demand for money breaks down in September 1998, indicating instability of the relationship between velocity and interest rates. I ran the same regressions by adding one observation at a time to the sample starting from March 1998, ie rolling regressions. I found that all the statistics that I reported in table 5 become less significant the more observations are added to the sample. Also, a sequential Chow test indicates instability in the period December 1998 onwards. One can argue that this is related to the large drop in the interest rate, which requires some time for adjustment, but further examination is necessary when more data become available. Alternatively, the demand for money curve shifts for other reasons such as institutional changes related to notes and coins being processed outside the Reserve Bank, increases in bank fee on ATM transaction and the increase in the underground economy. In a very careful econometric study, Giles (1999) provides estimates of the underground economy in New Zealand, which has been increasing as a percentage of GDP. The effect of the increase in the underground economy of the demand for the monetary base

[24] The income elasticity of the demand for real $M3$ is > 1.

[25] A recent paper by Mark and Sul (2001) use a powerful test based on panel data of 19 countries to estimate the demand for money function. They reported interest rate elasticity equal to –0.02 with an asymptotic standard error of 0.003. For New Zealand's demand for real $M1$, the interest elasticity is also small. It is approximately 0.025 for $M3$.

can be tested. However, these hypotheses are not straightforward to test because we have only a few observations. Future research should attempt to identify factors that shift the demand for money.[26]

Discussion

Base velocity remained stationary during the period 1988 to 1997, but a sharp downward trend started to emerge in 1998. Income velocity of $M1$ followed a more or less similar pattern, but the income velocity of $M3$ declined continuously from 1988 to date. Further, there is evidence that velocity is a stable function of both short and long-term interest rates, in the sense that these two variables share a common trend. The fact that velocity has not been constant does not necessarily imply instability. Meltzer (1998) examines the stability of base velocity of the US money base and shows that although it has a trend, it has been a stable (although perhaps non-linear) function of long-term interest rates during the period 1919-1995. McGrattan (1998) produces similar evidence.[27]

Until 1998, the demand for real-money balances seems to be interest inelastic and the income elasticity of the demand for real-money base is close to unity. Money, output, prices and interest rates seem not to have wandered away from each other during an extended period of successful inflation targeting in New Zealand. In the short run, velocity and interest rates may move in different directions, but in the long run they are move together. There is some evidence of such equilibrium.

[26] There has been an explosive increase in growth rate of 50 and 100 bills since 1983. The proportion of the100 dollar bills of the total notes in circulation increased from less than 10 per cent in 1983 to slightly more than 30 per cent in 2000. The 50 and 100-dollar notes combined, make about 50 per cent of total notes in circulation in 2000 compared to 10 per cent before 1983.

[27] Meltzer uses the long-term interest rate. He argues that short-term rates are heavily influenced by the actions of central banks so their information content is questionable. They reflect current conditions in the credit markets and other temporary and cyclical changes, while long-term rates are dominated by *persistent* changes. Nominal long-term rates reflect expected real returns to capital over the business cycle and expected inflation.

Instability in the demand for money function occurs in late 1998. During the period from December 1994 to September 1998, the 90-day interest rate averaged about 8.7 per cent.[28] In December 1998, the 90-day interest rate suddenly dropped to 4.5. Velocity simply cannot adjust to such sudden changes in a short period of time. There is usually a lag, which would be stable and short if changes in interest rates were gradual, but is less predictable for large movements.

It would be interesting to study further the late 1998 breakdown in the demand for money function. The Keynesian demand for money equation that I have estimated is limited. It does not account for other factors that could influence the demand for money, such as changes in asset prices (e.g., housing prices), in wealth, in other interest rates that are beyond the control of the Reserve Bank (like the 10 year government bond yield) and changes in expected inflation.

Should money be an intermediate target?

In this section I discuss some of the arguments for and against monetary targeting. On balance, I argue that targeting the monetary base in New Zealand is possible, but neither necessary nor desirable.

Monetary targeting

Taylor (1998) argues that most central banks carry out their money supply decision by setting short-term interest rates, but the ultimate tool of monetary policymakers is still to adjust the money supply. The Reserve Bank does not target any quantity of money and never did during the period covered by this study (March 1988 – March 2000). The question is whether doing so would be feasible and desirable.[29]

[28] It is probably not very informative talking about the average interest rate when the level of interest rate has a unit root. This is just to make the point that there was a sudden sharp fall in interest rate.

[29] The Bank has experimented with setting targets for primary liquidity early in the period of inflation targeting. In the 1990s and up 1999, the Bank targeted cash settlement account. The idea is that lowering the target would induce excess

There are three popular arguments against monetary targeting. First, accurate control of the money stock ($M1$ and broader aggregates such as $M3$) is not feasible because the central bank does not have complete control over it. Second, demand for money functions are not stable because of rapid and irregular changes in technology and financial institutions, therefore, monetary targeting of $M1$, $M2$ and/or $M3$ is not possible. Third, even if the central bank can control the monetary base, by doing so it may induce significant volatility in interest rates that is harmful to the real economy.

The first criticism implies that the central bank cannot exert total control over the monetary aggregates because of many reasons including changes in the money multiplier. While this is true, the monetary base is the liability of the central bank and, in principle, under the complete control of monetary authorities. For New Zealand, figure 19 and econometric evidence illustrates that the ratio of $M1$/base is stationary and the relationship between $M1$ and the base is fairly stable over time.

Controlling the monetary base in New Zealand is not feasible under the OCR regime because it is not possible to control both the interest rate and the monetary base at the same time. The quantity of the monetary base and the short-term interest rate are simultaneously determined. Moreover, it makes little sense to advocate using the base as an intermediate target for inflation while the empirical correlation between the monetary base and inflation is weak. It has been shown earlier that the correlation between the monetary base and inflation has become even weaker during the period following the adoption of the OCR in March of 1999.

The second argument that has been frequently used in New Zealand and elsewhere against monetary targeting is that the introduction of new financial assets (or regulations) changes asset demands such that it induces changes in the relationship between monetary aggregates, instruments and aggregate demand. The argument that monetary aggregates are unstable in New Zealand is an empirical issue, which has not been tested for the last 12 years. It has been

demand for money as commercial banks compete for funds to settle their accounts with the RBNZ, which will raise over-night interest rate.

shown in section 3 that the income velocity of the monetary base in New Zealand has been a stable function of interest rates from March 1988 to December 1997 and the demand for the real-money base is well behaved. Although the evidence is less significant statistically for $M1$ and $M3$ velocities, these aggregates are also stable functions of interest rates over the same period. The demand for the monetary base started to rise in 1998. All in all, the demand for money function has been stable, and precisely because the Reserve Bank did not and does not target the monetary base or monetary aggregates.

The third argument against monetary targeting, that it increases the volatility of the interest rate, suffers from an endogeneity problem as well. One cannot tell, by examining New Zealand's historical data, whether or not the monetary base rule would induce an explosive oscillation in interest rates.[30] Intuitively one might expect the interest rate to vary to clear the money market if money is under tight control. The reverse is true.

Money-base nominal GDP targeting

One straightforward way to assess this matter is to check whether the data are consistent with a money base-nominal GDP targeting rule (McCallum, 1985, 1987, and 1997). The rule is essentially a nominal GDP targeting rule when changes in velocity are not large. Meltzer (1987), Gordon (1985), Hall and Mankiw (1994) and Feldstein and Stock (1994) also advocate nominal GDP targeting rule. The money-base rule suggests changes in the base ΔM_t^B when nominal GDP growth (Δx_t) deviates from a target (Δx^*). Nominal GDP growth is the sum of inflation and real GDP growth. Let us assume that the Reserve Bank targets a 4 per cent annual growth rate of nominal GDP. It is hard to tell what the inflation target is and what the GDP target is just by looking at this 4 per cent. Let annual inflation target be 1.5 (0.015) per cent and real GDP growth rate's target is 2.5 (0.025) per cent. A 4 (0.04) per cent nominal GDP target on an annual basis implies a 1 (or 0.01) per cent on a quarterly basis. We then ask whether the rate of growth of the monetary base implied by such a rule adjusted for changes in velocity would be

30 McCallum (1985, p. 583) has concluded that it does not.

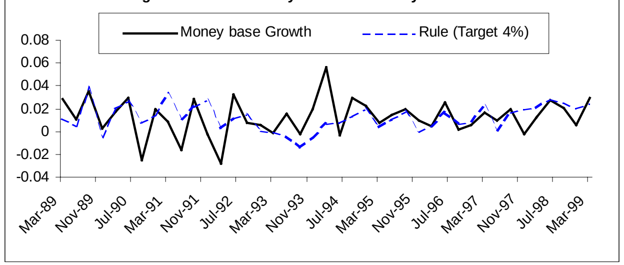
consistent with the actual historical rate of growth of the monetary base. The rule is computed by:

$$\Delta M_t^B = \Delta x^* - \Delta V_t^a + 0.5(\Delta x^* - \Delta x_t) \qquad (2)$$

All variables are in natural logarithms. Velocity is the average growth of base velocity over a period of one year. Money base growth rate (Y2K-adjusted) and the rule are plotted in figure 30.

I compute the rule for a nominal GDP target of 4 per cent. The rule suggests that, on average, the rate of growth of the monetary base has been consistent with targeting 4 per cent nominal GDP growth. The mean of the quarterly actual rate of growth of the monetary base is 0.0126 per cent and that implied by the rule is 0.0124 per cent. The standard deviations are 0.016 and 0.011 respectively. The variances are statistically equal. Testing the hypothesis about the means also indicates that they are equal.[31] However, quarter to quarter movements reveal some differences. The rule suggests that monetary conditions were either too loose (high money growth) or too tight (less money growth) on several occasions.

Figure 30: Base Money Growth & Money Base Rule



For example, during the period 1990-1991 actual monetary conditions were tighter and more volatile than the conditions implied

[31] To test for the equality of the variances, the ratio of the variances is distributed $F_{41,41}$. Student's t statistic is given by $\mu_1 - \mu_2 / (S\sqrt{1/n_1 + 1/n_2})$ where μ is the mean, subscript 1 denote actual and 2 denotes simulated, S is the standard deviation, which is $\sqrt{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2 / n_1 + n_2 - 2}$ and n is the sample size. The t value is very small. Both $F_{41,41}$ and t statistics are insignificant.

by the rule. Also, the rule suggests a much smoother and more gradual tightening profile during the period 1992-1993 than the actual, followed by a much smoother and gradual loosening. The rate of growth of the monetary base implied by the rule matches actual growth rate very well from December 1994 up to the end of 1997. Thereafter, the rule suggests considerable easing during the Asian crisis.

At a minimum, the money base/nominal GDP targeting rule seems to be a useful tool for a "consistency check" or an indicator of the Bank's policy reactions to deviations of inflation and real output target from target values.[32]

Summary and conclusions

At trend and business cycle frequencies, the monetary base growth rate and monetary aggregates do not correlate with inflation. While the rates of inflation and money growth moved together during the disinflation period before 1992 they diverged after inflation stabilised. At the end of the sample in March 2000 the trend of the rate of growth of $M3$ converges to inflation's trend, but at the business cycle frequency, the relationship between money aggregates and prices is weak both in terms of levels and growth rates.

By contrast, at high frequencies (2 to 5 quarters) there is a significant correlation between money and inflation, both in levels and in growth rates. This holds true for the monetary base, albeit less significant for $M1$ and $M3$. High frequency fluctuations in inflation are monitored but not controlled by the Reserve Bank, which targets longer horizon fluctuations (2+ years). My interpretation of this result is that the relationship persists precisely because inflation is not targeted at a high frequency.

The relationship between money and output growth at business cycle frequencies (activity that occurs over 6-32 quarters) is stronger than the relationship between money and inflation. Cyclical fluctuations

[32] As always, one should be alert to large "one-off" shocks when computing the rule. For example, ignoring Y2K effects clearly distorts the rule.

in the base and monetary aggregates are correlated with those of real output contemporaneously and at several leads. There is evidence that money actually lead output over the business cycle, but the lead is long and variable. Note that unlike inflation, neither money nor output is targeted by the Reserve Bank.

Up to December 1997, the monetary base grew at rates close to nominal GDP growth. The levels of the monetary base, $M1$ and $M3$ seem to share a similar trend with the nominal GDP. Subsequently however, the monetary base and $M1$ especially have been growing faster than nominal GDP. Since the Reserve Bank of New Zealand supplies money on demand, the high growth rates represent increasing demand for money, even in real terms. Why have these growth rates not been inflationary, and should we expect to see higher inflation in the future?

Upon reflection, the increase in the demand for currency and broader aggregates should not be surprising. Economic agents adjust their money holdings up when they believe that inflation has fallen permanently, and by setting short term interest rates the Reserve Bank of New Zealand supplies the additional money on demand.

Most economists agree that sustainable money growth beyond nominal GDP growth is inflationary. Whether, or not, the increase in the growth rate of money in New Zealand constitutes a threat to the Bank's inflation target at some point in time is an important question. It has been argued that as long as the Bank's inflation targeting regime is credible – in the sense that the Bank does not trade on the Phillips curve and inflation expectations are stable around the target – excess money growth is perhaps a consequence of credibility. But, there are motives other than the "transactions motive" to hold money, such as the precautionary and the speculative motives. What would happen if an economic environment that is conducive to speculative investments encourages households to spend the extra money holdings in the housing market? In this situation one cannot continue to argue that money growth is not a concern, and one should worry about inflationary

pressures stemming from excess demand for housing.[33] Monetary impulses transmit through relative prices. However, relative price changes are not always the same. They vary from one business cycle to another. It depends on what drives the cycle. A cycle driven by housing boom changes relative prices in a different way from a cycle driven by export growth.

There is evidence that velocity was a stable function of short- as well as long-term interest rates, with the relationship stronger for base and $M3$ velocities than for $M1$ velocity. There is no obvious reason to why this is the case. Money, output, prices and interest rates seem not to have wandered away from each other during an extended period of successful inflation targeting in New Zealand. Velocity and interest rates would, from time to time, deviate from each other, but they are expected to be move together in the long run. The demand for real-money base is fairly interest-inelastic, and the income elasticity of the demand for real-money base is generally not different from unity during the period up to December 1997.

Velocity and demand for money appear to have become unstable in late 1998. One explanation for this might be that in December 1998 the 90-day interest rate suddenly dropped dramatically from almost 9 per cent to 4.5 per cent. Velocity simply cannot adjust to such sudden changes in a short period of time. There is usually a lag, which would be stable and short if changes in interest rates were gradual, but is probably longer given such a large shock. I expect a stable relationship to re-emerge once the adjustment is complete and in the absence of persistent shocks that might delay the adjustment process.

What if the Reserve Bank targeted GDP growth via the monetary base instead of targeting inflation? An interesting counterfactual experiment is illustrated by computing the growth rate of the monetary base that would be implied by a money base – nominal GDP policy rule. Under a rule by which the Reserve Bank targeted nominal GDP growth of 4 per cent per annum (from March 1989 to

[33] Home ownership in New Zealand is high, 70 per cent. Also, the ratio of value of housing stock to annual disposable income is nearly 300 per cent for the period up to 1999.

March 1999[34]), the growth of the monetary base would have been similar to what has actually been the case under inflation targeting on average.

The mean of the actual quarterly rate of growth of the monetary base has been 0.0126 per cent while that implied by the rule is 0.0124 per cent. The standard deviations are 0.016 and 0.011 respectively. The standard deviations (variances) and the means are thus not statistically different. However, quarter-to-quarter movements reveal some interesting differences, and the rule suggests that monetary conditions were either too loose (high money growth) or too tight (less money growth) during several notable time periods.

For example, during the period 1990-1991 actual monetary conditions were tighter and more volatile than conditions implied by the rule. The rule would have suggested a smoother and more gradual tightening profile during the period 1992-1993 than was the case, followed by a smoother and more gradual loosening. The rate of growth of the monetary base implied by the rule matches the actual growth rate very well from December 1994 up to the end of 1997. Thereafter, the rule suggests considerable easing during the Asian crisis.

The money base-nominal GDP targeting rule is a sensible indicator of the performance of the inflation-targeting regime. Although it might not be operational in New Zealand under the OCR regime, it would serve as a crosscheck for policy. Money should be included in the policymakers' information kit on the grounds that it could provide information about real output fluctuations over the business cycle frequency as it was shown in figures 16-18. This information can be used by the Reserve Bank to cross check estimates of the output gap.

It is argued that under inflation targeting, especially when it is successful and the central bank is credible, more benefits may be realised from using monetary data as indicators for output rather than from using them as instruments or intermediate targets for inflation.

[34] Nominal GDP data are available up to March 1999.

Future research might usefully try to explain the apparent instability in velocity and demand for money function in late 1998. In the Keynesian demand for money that I estimated, changes in real output and real interest rates explain real-money balances. However, the model omitted other factors that might also affect the demand for money, such as changes in asset prices (housing prices), wealth, other interest rates that are beyond the control of the Reserve Bank like the 10 year government bond yield, and expected inflation. These factors certainly matter in setting policy, and their inclusion might reasonably explain the recent instability.

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Table 1:
Descriptive Statistics

	1989:1-1991:4			1992:1-2000:1		
	μ	σ	σ/μ	μ	σ	σ/μ
PCPIX inflation	5.0	1.9	0.38	1.8	0.4	0.22
Nominal GDP Growth	3.1	3.2	1.03	4.4	2.5	0.56
Nominal GDP Growth*	4.7	2.7	0.57	4.9	2.3	0.47
Real GDP growth	-0.3	1.4	4.66	3.1	2.2	0.70
Money base growth	5.3	3.5	0.66	5.6	3.1	0.55
$M1$ growth	5.6	9.4	1.67	7.0	5.3	0.75
$M3$ growth	6.6	3.3	0.50	7.4	3.4	0.46

- μ is the mean, σ is standard deviation. And σ/μ is the coefficient of variation.
- All variables are defined as $(\ln x_t - \ln x_{t-4})*100$.
- Quarterly nominal production GDP is not readily available. Nominal GDP growth* is the expenditure-based GDP.
- Student's *t* statistics are used to test the null hypotheses that the means are equal in the two samples. The hypotheses cannot be rejected, except in the case of PCPIX inflation.
- The hypothesis that the standard deviations are the equal across sub-samples could not be rejected either, except in the case of inflation.

Table 2:

$$\Delta_4 \ln P_t = \sum_{i=0}^{j} a_i \Delta_4 \ln M_{t-i} + \sum_{i=1}^{j} b_i \Delta_4 y_{t-i} + u_t,\ u_t = MA(3)$$

(1990:4-1998:3)

	Model I		Model II		Model III		Model IV	
	Estimate	Prob	Estimate	Prob	Estimate	Prob	Estimate	Prob
Constant	0.75	0.1450	0.83	0.0970	1.24	0.0030		
$E_{t-1}\Delta\overline{P}_{t+3}$	-	-	-	-	-	-	0.78	0.0000
a_0	0.16	0.0001	-	-		-	-	-
a_1	0.18	0.0001	-	-	-	-	-	-
a_2	0.11	0.0001	-	-	-	-	-	-
a_3	-	-	-	-	-	-	-	-
a_4	-	-	0.08	0.0080	0.05	0.0300	-	-
a_5	0.09	0.0010	0.15	0.0001	0.12	0.0000	0.07	0.0030
a_6	0.04	0.0490	0.07	0.0310	0.06	0.0290	-	-
b_1	-		-	-	-	-	-	-
b_2	-0.15	0.0040	-	-	-	-	-	-
b_3	-0.19	0.0001	-	-	-	-	-	-
b_4	-0.15	0.0001	-	-	-	-	-	-
$\tilde{b}_1$	-	-	0.10	0.1990	-	-	-	-
$\tilde{b}_2$	-	-	-0.16	0.0590	-	-	-	-
$\tilde{b}_3$	-	-	-0.13	0.1350	-	-	-	-
$\tilde{b}_4$	-	-	0.006	0.9480	-	-	-	-
$\overline{R}^2$	0.84		0.75		0.73		0.87	-
σ	0.28		0.35		0.37	-	0.25	-
$LM(9)$	6.8		4.03		5.0	-	2.40	-
DW	1.92		1.65		1.63	-	1.99	-

- Equations estimated using Pagan (1974) method.
- P is CPIX, M is the monetary base, and y real GDP. All growth rates are defined as $(\ln x_t - \ln x_{t-4})*100$, output gap is computed using the HP filter. The coefficients $\tilde{b}$ refer to the output gap as a regressor.
- The hypotheses that the sum of the coefficients $a = 0$ is rejected in all models. The P values of the F tests are 0.0001. The hypothesis that the sum of the coefficients $b = 0$ is rejected (p value =0.0001). The hypothesis that the sum of the coefficients $\tilde{b} = 0$ (for the output gap) cannot be rejected (p value=0.2318). The hypothesis that the coefficient of survey data of inflation expectations = 1 is rejected.

Table 3:
Out-of-sample forecast performance of models (I), (II), (III) and (IV)

		Forecasts			
Period	Actual Inflation	I	II	III	IV
1998:4	1.09	4.20	2.47	2.32	1.46
1999:1	1.00	4.94	2.59	2.32	1.48
1999:2	1.18	5.12	2.76	2.32	1.30
1999:3	0.94	4.90	2.82	2.52	1.50
1999:4	1.33	5.38	3.32	2.67	1.73
2000:1	1.74	5.58	3.41	2.85	1.95
2000:2	1.98	5.76	3.28	3.06	2.22
2000:3	3.04	5.22	2.99	3.10	2.31
2000:4	3.80	NA	NA	3.44	2.63
RMSE		3.65	1.54	1.12	0.56

Table 4:
The Engle-Granger Test for Cointegration Error Correction Coefficient

$\ln V_t = \alpha + \beta t + \delta i_t + \eta_t$ [a]

$\Delta \eta_t = \phi_0 + \phi_1 \eta_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta \eta_{t-i} + \xi_t$

$\Delta \ln V_t = \varphi_0 + \varphi_1 \Delta i_t + \varphi_2 \eta_{t-1} + \zeta_t$

Sample (1988:1-2000:1)

i	ϕ_1	φ_2	Bootstrap Mean and standard error
Dependent Variable Base Velocity			
i^{90d}	-0.19 (0.10)	-0.19 (0.10)	-0.19 (0.10)#
i^{10y}	-0.23 (0.10)	-0.23 (0.10)	-0.23 (0.10)*
Dependent Variable $M1$ Velocity			
i^{90d}	-0.05 (0.06)	-0.043 (0.06)	-0.043 (0.06)
i^{10y}	-0.10 (0.07)	-0.06 (0.07)	-0.06 (0.06)
Dependent Variable $M3$ Velocity			
i^{90d}	-0.24 (0.09)	-0.23 (0.10)	-0.23 (0.10)*
i^{10y}	-0.28 (0.09)	-0.25 (0.10)	-0.25 (0.10)*

- ***a*** Velocity is defined as the ratio of real GDP to real-money, where money is deflated by the CPI.
- The distribution of ϕ_1. The 5% critical value is about–3.50 and the 10% critical value is about 3.18. See Fuller, W A, Introduction to Statistical Time Series, Wiley, New York, 1976, P. 373.
- The Kolmogrov-Smirnov statistics to test the whiteness of ζ_t are: 0.1170, 0.1192, 0.1404, 0.1510, 0.1783 and 0.1684 for the regressions above respectively. All statistics are lower than the 5% critical value 0.2402. The mean of ζ_t is zero in all regressions. Thus, ζ is *iid* with a zero mean.
- Standard errors in parentheses.
- Asterisk denotes significant at the 5% level.
- # denotes significant at the 10% level.

Table 5:
Demand for real- base money

$$\ln m'_t = a + b_1 \ln y_t + b_2 i_t + \sum_{i=-p}^{p} \delta_i \Delta \ln y_{t-i} + \sum_{i=-p}^{p} \gamma_i \Delta i_{t-i} + \rho(\ln m'_{t-1} - a - b_1 \ln y_{t-1} - b_2 i_{t-1}) + z_t$$

Sample 1988:1 – 1997:4

Explanatory variables	Dependent variable m'_t = monetary base - P				
a	-9.2 (0.0001)	-8.2 (0.0001)	-10.6 (0.0001)	-8.99 (0.0001)	-8.60 (0.0001)
b_1 (a)	0.97 (0.2120)	0.88 (0.0013)	1.1 (0.0001)	0.95 (0.1083)	0.91 (0.0092)
b_2					
i_t^{90d}	-0.006 (0.0001)	-	-	-	-
i_t^{10y}	-	-0.009 (0.0001)	-	-	-
$i_t^{90d} - i_t^{10y}$	-	-	-0.01 (0.0001)	-	-
$i_t^{90d} - i_t^{90d*}$ (b)	-	-	-	-0.01 (0.0001)	-
$i^{10y} - i_t^{10y*}$	-	-	-	-	-0.01 (0.0001)
ρ	-0.31 (0.0001)	-0.24 (0.0001)	-0.37 (0.0001)	-0.25 (0.0001)	-0.33 (0.0062)
σ (c)	0.012	0.012	0.012	0.012	0.012
$\overline{R}^2$	0.97	0.97	0.97	0.97	0.97
DW	1.99	2.23	1.87	2.06	2.50
Kolmogrov-Smirnov (d)	0.1412	0.2160	0.1042	0.1283	0.2578
p	3	3	3	3	3

- *a* The hypothesis is that the coefficient = 1
- *b* Asterisk denotes the US
- *c* The standard error of the regression
- *d* The Kolmogrov-Smirnov tests the null hypothesis that the residuals are white noise. The 5 per cent critical value is 0.3298 (For computation, see Fuller, W A, introduction to Statistical Time Series, Wiley, New York, 1976, P. 387).
- P-values of the Wald statistics are in parentheses.
  $m' = M_t - P_t$, where M is base money, P is GDP deflator and y is real GDP.
- Newey-West method is used to compute consistent estimate of the coefficients.

Appendix 1:
Data, description and statistics

For the past four years, the Reserve Bank has been improving the quality of its monetary statistics. The data used in this paper represent the Bank's latest revision. Data are available on the RB's website. I use currency in circulation, $M1$ and $M3$ to measure money. The definition of the monetary base in New Zealand does not conform to the monetary base in the United States or textbooks. There are no reserves requirements in New Zealand so it is mainly currency. The monetary base in New Zealand consists of currency in circulation and bank deposits at the Reserve Bank plus currency held by commercial banks. The latter two components are small in size so the base consists of notes and coins in the hands of the public mainly.

The monetary base is adjusted for the Y2K effect by assuming that the growth rate in 1999 is equal to the historical average, which is approximately 5 per cent; December's 1999 published observation is then reduced by approximately 400 million dollars.

In New Zealand, $M1$ includes currency in the hands of the non-bank private sector, transaction accounts that can be accessed via cheques, less inter-institutional cheque accounts, and less government transaction deposits.[35] The broadest measure of money used in this paper is $M3$. This consists of $M2$ and all other New Zealand dollar (NZD) funding, less the contribution of these accounts attributable to inter institutional and government accounts.[36]

Real output is measured by real GDP, y_t. The consumer price index ex-credit services, PCPIX and the GDP deflator are used to measure prices. Five measures of interest rates are used in this paper. I use the 90-day interest rate, i_t^{90d}, the 10-year government bond rate and

[35] Quarterly $M1$ is average of the seasonally adjusted monthly MM1_z series.

[36] Quarterly $M3$ is average MM3 monthly data. Another type of money is $M2$, which consists of $M1$ plus non-cheque EFTPOS accounts, other call funding less inter-institutional and government accounts that would ordinarily fall in the non-cheque EFTPOS category. This is not used in this paper.

the difference of the two (yield gap); i_t^{90d} and i_t^{10y} and their US counterparts, i_t^{90d*} and i_t^{10y*} are also used. Money, real GDP and prices are seasonally adjusted.[37] The monetary data are quarterly averages of the monthly series. The sample spans the period March 1988 to March 2000 because, first, the monetary aggregates are only available from 1988. Second, the Reserve Bank started targeting a lower inflation rate around that time. Third, quarterly nominal GDP or GDP deflator is not readily available.[38] Quarterly data are used to compute growth rates.[39] Inflation expectations are ERCPI2, the Reserve Bank survey data of one-year ahead inflation expectations and the NEIT, the National bank's survey of one-year ahead inflation expectations.

[37] $M3$ is not seasonally adjusted because it has no seasonal pattern.

[38] Statistics New Zealand publishes annual data only.

[39] Four observations are lost from the beginning of the sample for annual differencing.

Appendix 2:

This example is taken from Poole (1994) to illustrate why the correlation between inflation and many other relevant macroeconomic variables such as the output gap or money growth break down in New Zealand. Consider the following simple model:

$$\pi = \alpha X + \beta M + \eta ,$$

of a central bank whose objective is to control inflation, π by using the money supply as an intermediate target. The central bank chooses M to offset the effects of X on π. Assume that $\eta \sim N(0,\sigma_{\eta}^{2})$, that $X \sim N(0,\sigma_{X}^{2})$, and that it is independent of η. The optimal quantity of M is $M^{*} = \frac{\pi^{T} - \alpha X}{\beta}$. For the sake of generality, assume that the central bank has a control problem, so that it cannot hit M^{*} exactly each period. Instead, M is given by $M = \gamma M^{*}$, where $\gamma > 1$, $\gamma = 1$, or $\gamma < 1$ ($\gamma - 1$ is thus the per cent deviation from the target.) If the central bank perfectly offsets the effects of X on π, ie, $\gamma = 1$, then it can be shown that the covariance between inflation and money is zero.

$\sigma_{\pi,M} =$ Covariance $(\pi, M) =$ Covariance $(\alpha X + \beta\gamma(\frac{\pi^{T} - \alpha X}{\beta}) + \eta, M)$. This gives:

$$\text{Covariance}(\pi, M) = \alpha(1-\gamma)(\frac{-\alpha\gamma}{\beta})\sigma_{X}^{2} ,$$

The covariance between the inflation rate and money is equal to zero if γ is equal to one. Similar models can be developed that yield essentially zero correlation between the output gap and inflation. It is also worth noting that equation (3) cannot be estimated when $\gamma = 1$ since X and M are perfectly collinear.

Note that this is not far different from the Goodhart Law that is when a stable relationship is discovered and used by policymakers, it breaks down.