Broad Money: A Guide for Monetary Policy

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Introduction

There is widespread agreement that in the long run, inflation is a monetary phenomenon. But the nature of the links from money to inflation is less clear-cut. And the notion of which monetary aggregate is more relevant for inflation and for use in monetary policy-making is also unclear.

From a policy perspective, two ideas help establish that money is an important policy variable contributing to inflation. The first is that there is a stable long-run money demand. This quantifies the long-run relationship between money and prices, taking into account the other variables influencing the long-run money-demand relationship without drawing the line of causality between them. The second idea is that money helps to forecast inflation one or two years out, even after some other variables have been taken into account. The view that money predicts inflation is consistent with the quantity theory, which associates inflation with past money growth, and with buffer-stock models, which hold that money in excess of its long-run demand tends to increase spending and puts upward pressure on prices. That money predicts inflation is also consistent with the idea that money growth is influenced by inflation expectations, which explains why money growth leads inflation. If better forecasts of inflation can be obtained by including money, then a policy strategy that includes money has a higher

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chance of meeting the inflation targets and keeping inflation within the target bands.[1]

Money's usefulness as a monetary policy tool is viewed differently in different countries. In the euro area the European Central Bank has selected for a broad measure of the money supply a reference rate that will be used in conducting monetary policy. In the United States many argue that, because of velocity shifts and financial innovations, money is a less useful policy indicator than it used to be.[2]

This paper explores the relationship between broad money and inflation in Canada.[3] First, I investigate whether stable long-run demand functions exist for broad money, and second, I ask whether broad money helps to forecast inflation even when other variables such as output and interest rates are taken into account. My results suggest that stable long-run demand functions for broad money do exist and that broad money is useful for forecasting inflation at 4- and 8-quarter horizons—the horizons of most interest to monetary policy.

Many measures of broad money are possible. These can be viewed as lying along a continuum where at one end broad money provides a high degree of liquidity and at the other end, components with less liquidity are present. Theory makes it difficult to select a cutoff point to determine the optimal degree of liquidity of broad-money assets. However, theory suggests that narrower measures of broad money, with more-liquid components, might more easily account for the leading-indicator properties of broad money. Consequently I estimate demand functions and indicator models for a variety of broad-money definitions. The estimation results suggest that some of the narrower, more liquid of the broad-money measures are the most useful. Measures of money broader than M2 and M2P, particularly those with mutual funds and Canada Savings Bonds (CSBs), do particularly well.

1 Long-Run Money-Demand Functions

The components of broad money play many roles in the economy. Some serve as means of exchange because they include transactions balances for the purchase of goods and services associated with the narrower transactions-

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1. At the Bank of Canada, money is used informally as an indicator but is not included in the Bank's Quarterly Projection Model (QPM).
2. In Humphrey-Hawkins testimony in July 1993, Chairman Alan Greenspan said that the Federal Reserve would no longer use monetary targets as guides for monetary policy (Bernanke et al. 1999, 325).
3. Aubry and Nott in this conference volume deal with narrow money in Canada.

based aggregates. Broad money also includes some other types of deposits or financial instruments that, while not purely transactions-oriented, can easily, quickly, and for little or no cost (in time and money) be converted to transactions balances.[4] Broad money also serves the precautionary money-demand motive because it can inexpensively buffer income and spending shocks. It also serves as a store of value, being an important component of how wealth is allocated. This function may be gaining importance because demographic forces favour high savers for whom wealth management is an increasing concern.

No guideline exists as to which motive dominates the demand for broad money. Motives may differ, depending on which of many possible measures of broad money is chosen. The means of exchange and precautionary demands would presumably be more important to the narrower definitions of broad money because sources of immediate liquidity are important to these motives for holding money. Clearly the store-of-value function would dominate the broadest measures of broad money, the ability to convert money to cash at short notice being less important to that function. The transactions motive and precautionary money demand give rise to most “structural” explanations as to why money helps to forecast inflation. Consequently, one might expect the narrower definitions of broad money to be most useful empirically.

Broad money is held in both the personal and non-personal sectors. The motives for holding money are most clearly articulated for the personal sector, but the data on various measures of broad money used here make it difficult to make a personal/non-personal distinction. For the most part the models here apply the concept of long-run money demand to the data that are readily available, such data usually being total rather than personal holdings of broad money.

A long-run money-demand specification that encompasses the various motives for holding money is

$$m^d = a_0 + p + a_2 y + a_3 w + a_4 i^o - a_5 i^c . \qquad (1)$$

4. Traditional measures of broad money include term deposits. Some term deposits are pre-encashable (i.e., they may be cashed before their maturity date) and are therefore very liquid, while others are non-pre-encashable and therefore less liquid. Even among non-pre-encashable deposits, some are of very short maturity (e.g., 90 days) and therefore much more liquid than, say, 5-year non-pre-encashable deposits. Others may be of longer maturity originally but the remaining term to maturity may be short. Ideally, in defining broad money that is very liquid, some component of term deposits should be omitted. But data are not available to satisfactorily break down liquid versus less-liquid term deposits.

I will estimate the model on a quarterly basis. Long-run money demand depends on income, y, proxied here by real GDP, and on wealth. Two definitions of wealth, w, are used. One, *rtw*, consists of real total wealth in the economy, and the second, *rnhw*, subtracts human wealth to arrive at a measure of real non-human capital.[5] Although the GDP deflator would be most consistent with the use of real GDP in the money-demand equation, the price variable, p, is instead taken to be the total consumer price index (CPI) because that price is of great interest to policy, the Bank of Canada's inflation targets being defined in terms of the CPI. In any case, over the forecasting horizons of most interest here, two inflation measures—the GDP deflator and the CPI—are highly correlated. The restriction of a unitary price elasticity is given by theory and makes the long-run level of real balances independent of the price level or the money supply. I take this to be one of the strongest restrictions in monetary theory and choose not to examine models that do not have long-run price homogeneity.[6] The own rate of return on broad money, i^o, is proxied by the rate of return on 5-year term deposits at banks. This is a very narrow and imperfect proxy for the own rate of return on broad money, but unfortunately very few rates of return on other components of broad money are available over the entire sample period.[7] The competing rate, i^c, is a weighted average of the non-monetary assets in non-human wealth, constructed for a representative definition of broad money.[8]

2 Definitions of Broad Money

One way of choosing among broad-money measures is to organize the various definitions according to liquidity. Liquidity has been defined many

5. Both measures of wealth are taken from Macklem (1994).
6. When broad money is defined as M2P+CSB+mutual funds at financial institutions, a test of price homogeneity cannot be rejected. For the other preferred aggregate, M2P+CSB+all mutual funds, price homogeneity is rejected. See Table 1 for definitions of broad-money aggregates.
7. Strictly speaking, a separate own rate should be calculated for each definition of broad money used here. That is another reason why the proxy for the own rate used here is imperfect.
8. The rates of return on non-monetary assets in non-human wealth are given by the 2-quarter growth rates of the TSE index for equity, the growth rate of the price of multiple listings for housing, the growth rate of the CPI for consumer durables, and the rate on 3- to 5-year government bonds for other assets. The shares are given by the share of the non-monetary asset in total assets. Strictly speaking, these shares change for each definition of the broad-money aggregate because, as the aggregates get broader and broader, more assets become monetary and fewer non-monetary. However, in the empirical analysis I use a representative measure of broad money to specify the shares, and these are held constant over all possible definitions of broad money.

ways, but one of the simplest and most useful is that of *The Concise Oxford Dictionary* (1976): “An asset is liquid if it is easily convertible to cash.” “Easily convertible to cash” is a short form that can include considerations such as transaction costs, minimum transaction requirements, and risk of capital loss. All of these factors make it less “easy” to convert the asset into cash. Because many of these criteria increase or decrease liquidity, it is difficult to rank the various definitions of broad money; an aggregate may rank highly according to one criterion but low according to another. Nevertheless, Table 1 shows the various definitions used and attempts to rank them from most liquid to least liquid. All the aggregates under consideration are simple-sum measures.

All of the definitions for broad money used here are from previous studies. As a result there may be some gaps between the various definitions or some definitions that do not seem obvious from a theoretical perspective. However, the limitations of this are more than outweighed by the benefits of having the data readily accessible. A methodology of creating various possible definitions of broad money from first principles is beyond the scope of this paper.

At the most liquid end of the spectrum, we begin with M2 and M2P, the conventional broad-money aggregates. Next, mutual funds at banks and other institutions are added to M2P, yielding M2PFIQ and M2PALLQ. Mutual funds have become increasingly important in household portfolios during the 1990s and are easily convertible into cash. Substitutions between M2P and mutual funds are clearly discernible in the data. Next, CSBs are added to M2PFIQ and M2PALLQ, producing M2P_Adj and M2PP_Adj respectively. CSBs in a variety of denominations are sold to individuals and are redeemable without penalty at any time.[9] In short, CSBs are easily convertible into cash. Then treasury bills and provincial savings bonds are added, creating M2PP. When combined with mutual funds at banks and total mutual funds, M2PPFIQ and M2PPALLQ are created. Provincial savings bonds are also easily convertible into cash. Treasury bills are also very liquid, with minimal risk of capital loss. In the early 1980s, households’ direct holdings of treasury bills grew rapidly, spurred on by high yields and falling commissions charged by financial institutions or investment dealers for the retail purchase of treasury bills.

M3β adds short-term government bonds, mortgage-backed securities, and foreign currency deposits to M2PPALLQ. These are assets with some risk of capital loss and thus somewhat less liquid than previous

9. The exceptions are the new Premium Savings Bonds, which can be redeemed only at one time during the year. These are not important in terms of the overall size of the aggregates.

Table 1
Broad monetary aggregates and measures of wealth

Aggregate	Description	Level at end of 1996 ($ billions)
M2	M1+ non-personal notice deposits + personal savings deposits at banks	409
M2P	M2 + TML[a] + CUCP[b] + life insurance + personal deposits at government-owned savings institutions + money market mutual funds	637
M2PFIQ	M2P + mutual funds at financial institutions[c]	715
M2PALLQ	M2P + all mutual funds[c]	829
M2P_Adj	M2PFIQ + CSBs	717
M2PP_Adj	M2PPALLQ + CSBs	834
M2PP	M2P + provincial and Canada Savings Bonds + treasury bills[d]	789
M2PPFIQ	M2P_Adj + provincial savings bonds + treasury bills[d]	837
M2PPALLQ	M2PP_Adj + provincial savings bonds + treasury bills[d]	950
M3β	M2PP + mutual funds + 1- to 3-year government bonds[d] + mortgage-backed securities + Canadian residents' foreign currency deposits booked in Canada	1,133
LLβ	M3β + bankers' acceptances + commercial paper issued by non-financial corporations	1,184
M5	LLβ + other federal, provincial, municipal, and corporate bonds held by households	1,502
NHW	Non-human wealth	1,842
TW	Total wealth	9,558

Note: My definition of M2PP (referred to as M2d in Atta-Mensah [1995]) is not the same as the definition of M2PP used elsewhere and published by the Bank of Canada. What the Bank defines as M2PP is called M2PP_Adj in this paper. Also, what the Bank defines as Adjusted M2P is called M2P_Adj in this paper.

a. Deposits at trust and mortgage loan companies.
b. Deposits at credit unions and caisses populaires.
c. Excludes capital gains and losses.
d. Excludes those held by financial institutions.

assets. LLβ adds bankers' acceptances and commercial paper, and M5 adds other bonds held by households, although such bonds, being subject to capital variation, are convertible into cash at uncertain values.

Most of these definitions of broad money consist of holdings of the personal and non-personal sectors, though in some cases only personal sector holdings are added (see Table 1). M5 goes beyond what some would call "money," but it represents one measure of fairly liquid financial assets. The purpose of this paper is not to characterize the optimal definition of broad money from a theoretical viewpoint, but to determine from an empirical standpoint which measures of broad money appear useful. Another thing I look for in the empirical results is their consistency across different definitions of broad money, as this helps us to assess the robustness of the results.

In Figure 1, I plot the progress of these broad-money aggregates over time, and in Figures 2 to 4, I show the progress of some of the explanatory variables of the money-demand functions to be estimated. Table 1 shows the relative size of the broad aggregates at the end of 1996. By way of comparison, the narrow aggregate M1 represents about $80 billion.

Before estimating long-run money-demand functions, unit-root tests were run on all the variables used. Table 2 shows that many broad-money aggregates appear to be I(2), though the power of the augmented Dickey-Fuller (ADF) tests is known to be low, and so an I(1) outcome may be suspected. The remaining broad-money aggregates are I(1). However, real money balances, except M3β and LLβ, are I(1), implying that money growth and inflation are themselves cointegrated. The other variables used in the long-run money-demand estimation are I(1). Prices are borderline I(2).

3 Unrestricted Long-Run Money-Demand Estimates

Long-run money-demand functions are estimated using the Johansen-Juselius vector-error-correction model (VECM). Estimates are for the period 1970Q1 to 1998Q4 for the first six monetary aggregates under consideration. For the last six aggregates, data are readily available only until 1996Q4, and so my regressions end then.[10] In accordance with equation (1) the variables that make up the VECM are real balances, output, wealth, and own and competing rates. The order of the VECM is selected using Akaike's final prediction error (FPE) criterion. Estimation results, shown in Table 3, are mixed.

Real total wealth, *rtw*, was initially tried with all aggregates. However, I only found reasonable estimates by using real non-human wealth, *rnhw*, for the broadest of the broad aggregates. The fact that different measures of wealth are required to produce satisfactory money-demand functions is not very encouraging.

The estimates for income and wealth elasticities vary widely for different definitions of broad money, even when the definitions are very similar. Income elasticities range from a low of 0.01 for M5 to a high of 1.60 for M2PFIQ. Wealth elasticities vary from a range of 0.02 for M2P and M2PFIQ to a high of 1.29 for M2PALLQ, an aggregate that differs from M2PFIQ only by adding mutual funds. The sum of the income and wealth

10. Since it is important to have up-to-date data on monetary indicators, this is one strike against focusing on an aggregate that is limited by data being readily available only until 1996.

Figure 1a
Broad monetary aggregates, M1 to M2PP_Adj

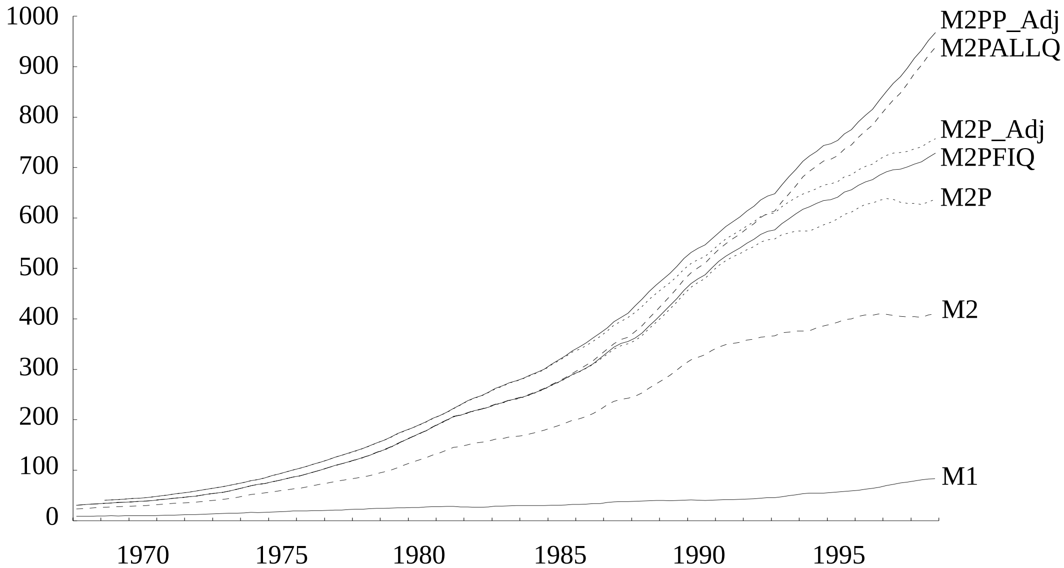


Figure 1b
Broad monetary aggregates, M2PP to M5

elasticities appears more stable, suggesting that it may be difficult to separately identify the effects of these variables. Thus these results are not very consistent across different money-supply definitions.

Own interest rate semi-elasticities are generally found to be positive, although M2PFIQ and M2PP yield counterintuitive negative interest rate semi-elasticities. Again, the semi-elasticities range quite widely over various

Figure 2
Per-capita wealth

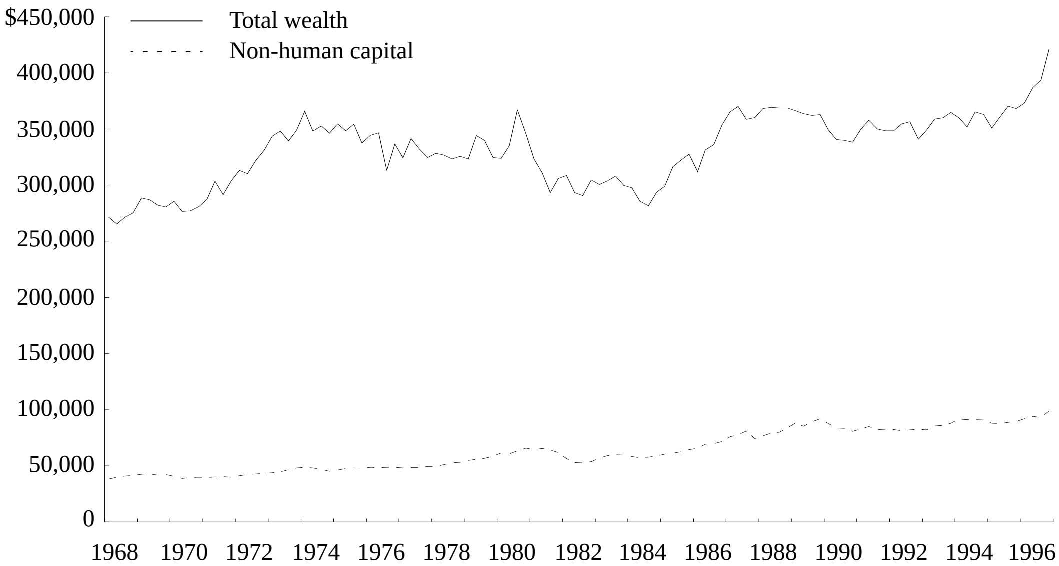
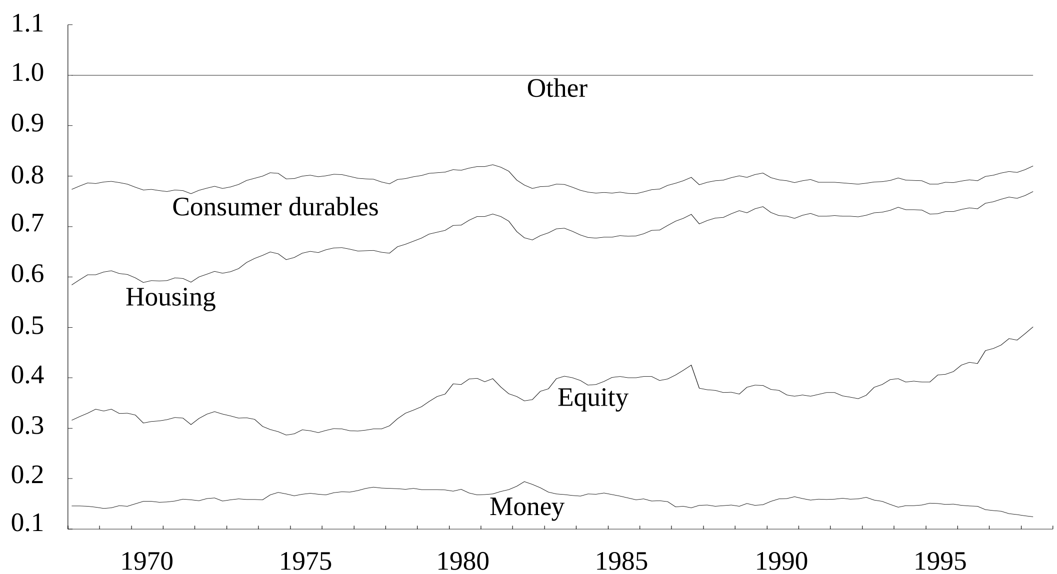
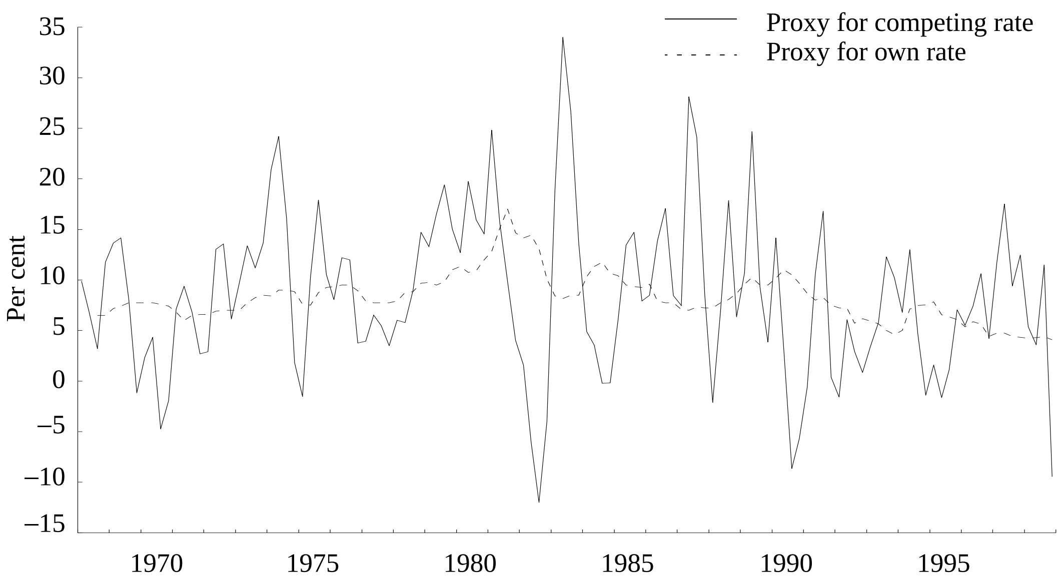


Figure 3
Composition of assets



Note: “Money” is currency and domestic and foreign currency deposits held by individuals and unincorporated businesses. “Other” includes government and corporate bonds and other financial assets.

Figure 4
Rates of return



broad-money definitions, from a low of close to 0 to a high of 0.034 for M5. Semi-elasticities for competing rates are negative, between –0.016 and –0.044.

The proxy for the own rate is very imperfect, and when it is used with broader and broader aggregates that contain components whose return varies with market rates, it becomes less useful. Also, as the aggregates become broader and broader, there is less scope to find other financial assets that can be substituted into broad money, presumably making the own rate of return a less important variable.

Generally, two cointegration vectors are found.[11] This is not surprising; in a structural model, money demand would be one cointegrating vector and the interest rate differential, found to be stationary using ADF tests, would be the other. In cases where there are two cointegrating vectors, the one shown in Table 3 is the vector most closely correlated to the stationary part of the system (i.e., that is associated with the largest eigenvalue). But because of the existence of more than one cointegrating vector, an identification problem may exist, and we should be cautious in

11. I use critical values from Johansen and Juselius (1989) for the λ-max and trace statistics. A cointegrating vector is considered to exist if both the trace and the λ-max statistics are significant at the 5 per cent level.

Table 2
Unit-root tests

	Augmented Dickey-Fuller tests				
	First difference	**Level**		**First difference**	**Level**
		Sample: 1969Q1–1998Q4			
*r*M2	–3.2*	–1.6	M2	–3.4*	0.7
*r*M2P	–4.0*	–1.0	M2P	–2.9	–0.3
*r*M2PFIQ	–4.3*	–2.5	M2PFIQ	–3.3*	–0.8
*r*M2PALLQ	–4.2*	–3.3*	M2PALLQ	–3.0	–1.1
*r*M2P_Adj	–3.3*	–1.4	M2P_Adj	–3.2*	0.2
*r*M2PP_Adj	–3.3*	–3.1	M2PP_Adj	–3.3*	0.2
		Sample: 1969Q1–1996Q4			
*r*M2PP	–3.2*	–0.3	M2PP	–2.9	0.9
*r*M2PPFIQ	–3.8*	–0.6	M2PPFIQ	–3.2*	1.6
*r*M2PPALLQ	–4.0*	–2.3	M2PPALLQ	–3.6*	1.7
*r*M3β	–2.8	–2.5	M3β	–2.1	–1.2
*r*LLβ	–3.0	–2.3	LLβ	–2.2	–0.9
*r*M5	–3.4*	–2.6	M5	–2.5	–0.6
y	–6.1*	–1.6	i^b	–6.8*	–2.5
rtw	–3.6*	–2.6	i^c	–9.0*	–3.0
rnhw	–4.4*	–2.7	$i^b–i^c$	–8.7*	–3.8*
p	–3.1	–0.5			

Notes: Unit-root tests are based on the regressions $\Delta x_t = b_0 + b_1 t + A(L)\Delta x_{t-1} + b_2 x_{t-1}$.
The order of $A(L)$ is chosen on the basis of Akaike's final prediction error (FPE) criterion.
All variables except interest rates are in logs. A monetary aggregate prefixed by an *r* indicates that the nominal aggregate has been deflated by the CPI. The sample for aggregates *r*M2PP through M5 ends in 1996Q4.
* Significant at the 5 per cent level.

interpreting the cointegration vector shown as long-run money demand. This lack of identification probably primarily affects the interest rate coefficients.[12]

12. If the two structural cointegration vectors in the data are given by the money-demand function and the interest rate differential

$$rm - a_1 y - a_2 w - a_3 i^o + a_4 i^c$$
$$i^o - i^c,$$

then there is an identification problem. But every possible cointegration vector must be a linear combination of the two structural vectors, yielding

$$(rm - a_1 y - a_2 w - (a_3 - b))i^o + (a_4 - b)i^c,$$

where b is the weight given to the second equation. b affects only the interest rate coefficients, meaning that the other coefficients are identified and estimated consistently by the Johansen-Juselius procedure.

Table 3
Estimates of long-run money demand, 1970Q1–1998Q4

Variables	Order of VECM[a]	First CI vector[b]	Corresponding loadings	Number of CI vectors[c]
*r*M2,*y*,*rtw*,i^b,i^c	3	[1 –1.26 –0.31 –0.028 0.026]	[–0.01* 0.01 –0.23 1.8* –13.4*]	2
*r*M2P,*y*,*rtw*,i^c	3	[1 –1.57 –0.02 –0.014 0.021]	[–0.02* 0.01 –2.4 2.2* –12.7*]	1
*r*M2PFIQ,*y*,*rtw*,i^b,i^c	3	[1 –1.60 –0.02 0.005 0.015]	[–0.03* 0.00 –5.2 2.7* –14.5*]	2
*r*M2PALLQ,*y*,*rtw*,i^b,i^c	4	[1 –0.85 –1.29 –0.032 0.042]	[–0.01* –0.00 3.19 1.4* –15.9*]	2
*r*M2P_Adj,*y*,*rtw*,i^b,i^c	3	[1 –1.54 0.08 –0.004 0.016]	[–0.02* 0.02* 0.79 2.7* –18.4*]	1
*r*M2PP_Adj,*y*,*rtw*,i^b,i^c	3	[1 –1.34 –0.41 0.005 0.022]	[–0.02* 0.01 4.0 1.9* –20.4*]	1
*r*M2PP,*y*,*rnhw*,i^b,i^c	2	[1 –0.60 –0.55 –0.051 0.044]	[–0.01 0.00 0.01 0.6* –15.1*]	2
*r*M2PPFIQ,*y*,*rnhw*,i^b,i^c	2	[1 –0.69 –0.60 –0.023 0.027]	[–0.01* 0.01* 0.02 1.0* –26.9*]	2
*r*M2PPALLQ,*y*,*rnhw*,i^b,i^c	2	[1 –0.73 –0.65 –0.006 0.020]	[–0.01 0.01 0.02 1.2 –38.9*]	2
*r*M3β,*y*,*rnhw*,i^b,i^c	2	[1 –0.16 –0.85 –0.028 0.041]	[–0.01* 0.00 0.01 0.7* –17.5*]	2
*r*LLβ,*y*,*rnhw*,i^b,i^c	2	[1 –0.48 –0.74 –0.019 0.026]	[–0.01* 0.01 0.02 1.0* –27.4*]	3
*r*M5,*y*,*rnhw*,i^b,i^c	2	[1 –0.01 –0.94 –0.034 0.038]	[–0.01 0.01* 0.01 0.01* –18.9*]	2

Note: Sample for *r*M2PP through *r*M5 ends in 1996Q4.
a. VECM chosen on the basis of Akaike's FPE criterion.
b. Cointegration vector.
c. According to Johansen-Juselius trace and λ-max statistics.
* Significant at the 5 per cent level.

The loadings for real balances are negative and generally significant, though small. This is consistent with the idea that real balances should decline when money is greater than its long-run demand. Money gaps, the difference between actual money and its long-run demand as estimated by the Johansen-Juselius cointegration vectors, have a positive effect on own rates and a negative effect on competing rates. This may reflect a market-clearing mechanism as well. One of the ways for positive money gaps to be eliminated is for money demand to rise through an increase in own rates or a decrease in competing rates. Loadings for output are generally small and insignificant. Those for wealth are usually insignificant.

In summary, the estimates of Table 3 provide limited support for the existence of a long-run money-demand function of the type specified in equation (1). Estimated coefficients generally have the expected signs. However, the estimated demand functions are not stable across different definitions of broad money. This is disconcerting because it is difficult to explain from an economic point of view why monetary aggregates that differ by only one or two components should have demand functions that are very different. Additional results (not reported) indicate that the estimated long-run money-demand functions are not stable when estimated over various subsamples and that the estimates of long-run demand are very sensitive to the choice of the VECM order. Thus these results are not very robust.

4 Restricted Long-Run Money-Demand Functions

Given the results in the previous section, I dropped the wealth variable, which appeared to contribute to the instability of the Table 3 estimates. The proxy for the own rate is also dropped; it had the wrong sign for several of the broad aggregates considered in Table 3. The restricted system consists of m, y, and i^c, a very typical choice of variables for money-demand functions. Estimates for this system are shown in Table 4.

The estimates of long-run money demand associated with these systems are quite uniform across different measures of broad money. This is reassuring because it is difficult to explain why adding a component to one measure of broad money could produce substantially different estimates of income elasticity and interest rate semi-elasticity.

A unique cointegration vector is found for all measures of broad money. Income elasticities range between 1.4 and 1.8, the broader measures of money tending to have the larger elasticities. Interest rate semi-elasticities range between –0.02 and –0.04.

The effect of money gaps on real balances is, with one exception, significantly negative, the real balances having larger loadings than those

Table 4
Restricted estimates of long-run money demand, 1970Q1–1998Q4

Variables	Order of VECM[a]	First CI vector	Corresponding loadings	Number of CI vectors[b]
*r*M2,y,i^c	4	[1 –1.39 0.022]	[–0.02* –0.03* –25.7*]	1
*r*M2P,y,i^c	4	[1 –1.54 0.022]	[–0.03* –0.02* –23.8*]	1
*r*M2PFIQ,y,i^c	4	[1 –1.64 0.020]	[–0.05* –0.02 –25.0*]	1
*r*M2PALLQ,y,i^c	4	[1 –1.84 0.040]	[–0.05* –0.02 –18.9*]	1
*r*M2P_Adj,y,i^c	4	[1 –1.47 0.015]	[–0.06* 0.03 –26.7*]	1
*r*M2PP_Adj,y,i^c	4	[1 –1.70 0.032]	[–0.05* 0.00 –29.7*]	1
*r*M2PP,y,i^c	4	[1 –1.71 0.023]	[–0.02 –0.02 –28.3*]	1
*r*M2PPFIQ,y,i^c	4	[1 –1.73 0.017]	[–0.05* 0.01 –29.2*]	1
*r*M2PPALLQ,y,i^c	4	[1 –1.82 0.020]	[–0.06* 0.02 –30.1*]	1
*r*M3β,y,i^c	4	[1 –1.63 0.026]	[–0.08* –0.02 –22.1*]	1
*r*LLβ,y,i^c	4	[1 –1.73 0.019]	[–0.11* –0.01 –29.2*]	1
*r*M5,y,i^c	4	[1 –1.57 0.029]	[–0.07* –0.03 –23.0*]	1

Note: Sample for *r*M2PP through *r*M5 ends in 1996Q4.
a. VECM chosen on basis of Akaike's FPE criterion.
b. According to Johansen-Juselius trace and λ-max statistics.
* Significant at the 5 per cent level.

found in the full system that was presented in Table 3. This indicates a faster elimination of money gaps via changes in real balances. The effects of money gaps on output are, again, small and generally insignificant. This is not generally supportive of a buffer-stock story, in which one would expect excess money to put upward pressure on spending. The effect of money gaps on interest rates is negative and always statistically significant. This could represent a liquidity effect, whereby excess supply of money puts downward pressure on rates of return.

The long-run money-demand estimates shown in Table 4 are similar for different definitions of broad money, and they have estimated coefficients that are consistent with economic theory.[13]

5 Stability of Long-Run Money Demand

In the United States, economists have argued that money is no longer a useful policy variable. For example, Estrella and Mishkin (1996) state that

> Since the 1980s, advocates of a central role for monetary aggregates have been confronted with a deterioration of the traditional relationships between money and policy targets. . . . (p. 1)

13. When mutual funds are defined to include capital gains and losses, estimates of long-run money demand are similar to those in Table 4.

> Therefore, we must conclude that the monetary aggregates, the monetary base, and M2 in particular, are currently not very useful for monetary policy purposes. Whatever their informational content may have been in earlier time periods, they do not seem to provide adequate and consistent information at present in the United States. (p. 28)

It is, therefore, interesting to examine whether long-run broad-money demand and indicator-model content appear stable in Canada or whether the same deterioration occurred in the 1980s in Canada as it did in the United States. This section examines the stability of the long-run broad-money-demand functions.

In Table 5, the sample is split into two subsamples, one from 1970Q1 to 1984Q4 and the second from 1982Q1 to 1998Q4. With the exception of M2, LLβ, M5, and possibly M2PALLQ, the long-run demand functions appear reasonably stable across the subsamples.[14]

In part this degree of stability is surprising because we know that in recent years the substitution towards mutual funds and away from deposits included in M2P has caused M2P growth to decline fairly sharply. Yet this shift does not show up as instability in the demand for M2P and M2 reported here. It may be that the shift is too recent to have a great influence on the evidence of stability, or it may be that the shift is not large enough to show up as marked differences in the long-run money-demand function. In any case this substitution is internalized within broader aggregates such as M2P_Adj and M2PP_Adj.

In Table 6, estimates are shown of long-run money demand over the entire sample, with an order of 3 for the VECM. This is to test for the model's sensitivity to changes in this parameter. A drastic change in long-run money-demand estimates could be evidence of the underlying model's instability. However, Table 6 shows that the model is essentially immune to this change.

Overall, the long-run money-demand functions appear to be stable; estimation results show little difference across various subsamples and for different orders of the VECM. The estimation results are also robust across different definitions of broad money. There is no evidence that shifts in velocity or financial innovation have undermined the stability of the long-run money-demand relationship for most measures of broad money since the 1980s. In contrast to narrower aggregates such as M1, with the broad aggregates no dummy or shift variables are required to produce a long-run

14. Chow-type tests detect no break in the demand functions in the entire sample for any of the aggregates except M2.

Table 5
Estimates of long-run money demand over two subsamples

	1970Q1–1984Q4		1982Q1–1998Q4[a]	
Variables	**CI vectors**	**Loadings**	**CI vectors**	**Loadings**
rM2,y,i^c	[1 –0.82 –0.045]	[0.00 0.05 25.7]	[1 –1.35 0.027]	[–0.01 –0.01 –49.6]
rM2P,y,i^c	[1 –1.78 0.024]	[–0.07 –0.06 –21.8]	[1 –1.54 0.025]	[–0.02 –0.01 –51.4]
rM2PFIQ,y,i^c	[1 –1.78 0.023]	[–0.08 –0.06 –21.7]	[1 –1.77 0.025]	[–0.01 –0.00 –51.4]
rM2PALLQ,y,i^c	[1 –1.78 0.022]	[–0.08 –0.06 –21.5]	[1 –2.14 0.038]	[–0.03 –0.00 –47.8]
rM2P_Adj,y,i^c	[1 –1.53 0.010]	[–0.10 0.04 –2.7]	[1 –1.57 0.021]	[–0.05 –0.00 –38.8]
rM2PP_Adj,y,i^c	[1 –1.80 0.022]	[–0.10 0.04 –3.7]	[1 –1.70 0.048]	[–0.01 –0.00 –59.5]
rM2PP,y,i^c	[1 –1.80 0.022]	[–0.07 –0.00 –21.2]	[1 –1.84 0.034]	[–0.05 –0.01 –47.5]
rM2PPFIQ,y,i^c	[1 –1.71 0.017]	[–0.06 0.04 –15.4]	[1 –1.84 0.034]	[–0.02 –0.02 –35.6]
rM2PPALLQ,y,i^c	[1 –1.72 0.017]	[–0.06 0.04 –15.6]	[1 –1.95 0.036]	[–0.09 –0.01 –47.7]
rM3β,y,i^c	[1 –1.67 0.013]	[–0.15 –0.03 –16.6]	[1 –1.47 0.037]	[–0.07 –0.02 –25.3]
rLLβ,y,i^c	[1 –1.70 0.019]	[–0.15 –0.02 –15.6]	[1 –2.82 –0.026]	[–0.02 0.05 21.0]
rM5,y,i^c	[1 –1.73 0.042]	[–0.05 –0.04 –14.3]	[1 –2.71 –0.00]	[–0.04 0.04 12.6]

a. Sample for rM2PP through rM5 ends in 1996Q4.

Table 6
Restricted estimates of long-run money demand, 1970Q1–1998Q4

Variables	Order of VECM[a]	First CI vector	Corresponding loadings	Number of CI vectors[b]
rM2,y,i^c	3	[1 –1.39 0.023]	[–0.02* –0.03* –25.7*]	1
rM2P,y,i^c	3	[1 –1.54 0.022]	[–0.03* –0.02* –22.0*]	1
rM2PFIQ,y,i^c	3	[1 –1.64 0.020]	[–0.05* –0.02 –25.0*]	1
rM2PALLQ,y,i^c	3	[1 –1.84 0.039]	[–0.05* –0.02 –19.0*]	1
rM2P_Adj,y,i^c	3	[1 –1.46 0.015]	[–0.06* –0.00 –26.7*]	1
rM2PP_Adj,y,i^c	3	[1 –1.70 0.032]	[–0.05* –0.00 –17.9*]	1
rM2PP,y,i^c	3	[1 –1.71 0.023]	[–0.02 –0.02 –28.3*	1
rM2PPFIQ,y,i^c	3	[1 –1.73 0.017]	[–0.05* 0.01 –29.2*]	1
rM2PPALLQ,y,i^c	3	[1 –1.82 0.020]	[–0.06* 0.02 –30.9*]	1
rM3β,y,i^c	3	[1 –1.63 0.026]	[–0.08* –0.02 –22.1*]	1
rLLβ,y,i^c	3	[1 –1.73 0.019]	[–0.11* –0.01 –29.2*]	1
rM5,y,i^c	3	[1 –1.57 0.029]	[–0.07* –0.03 –23.0*]	1

Note: Sample for *r*M2PP through *r*M5 ends in 1996Q4.
a. VECM chosen on the basis of Akaike's FPE criterion.
b. According to Johansen-Juselius trace and λ-max statistics.
* Significant at the 5 per cent level.

demand function that is otherwise stable; evidently the financial innovations that plagued M1 are easily internalized. This does not necessarily imply that the dynamics around long-run money demand are stable, but the results in section 8, which looks at out-of-sample forecasts, do give some indication of dynamic stability.

6 The Effect of Broad Money on Prices

The Johansen-Juselius estimation results in Table 4 show that broad money has a significant effect on real balances, but the results do not identify whether that is because money falls or prices rise, or both, in response to a money gap. This section focuses on broad money's effect on prices.

The VECM in Table 4 contains a real balance equation of the form

$$A(L)\Delta(m-p) = C(L)\Delta y + D(L)\Delta i^c + Emgap + G(i^o - i^c)\,. \qquad (2)$$

In Table 7, I estimate a similar equation for prices:

$$A1(L)\Delta p = A2(L)\Delta m + C^1(L)\Delta y + D^1(L)\Delta i^c + E^1 mgap + Fygap + G(i^o - i^c)\,. \qquad (3)$$

Table 7
Price equations

	1970Q1–1998Q4			**1970Q1–1984Q4**			**1982Q1–1998Q4**[a]		
	E^1**=0**		E^1**,** ***A2(1)*****=0**	E^1**=0**		E^1**,** ***A2(1)*****=0**	E^1**=0**		E^1**,** ***A2(1)*****=0**
	Coefficient	***t*****-statistic**	**Significance level (%)**	**Coefficient**	***t*****-statistic**	**Significance level (%)**	**Coefficient**	***t*****-statistic**	**Significance level (%)**
M2	0.012	1.7	4.0	0.016	1.5	22.9	0.020	1.8	43.9
M2P	0.015	2.2	2.2	0.017	1.0	25.1	0.024	1.8	39.0
M2PFIQ	0.024	2.9	0.7	0.018	1.1	24.5	0.033	2.4	18.5
M2PALLQ	0.019	3.0	0.9	0.019	1.1	24.1	0.032	2.9	7.0
M2P_Adj	0.028	2.4	4.7	0.051	2.1	3.5	0.031	1.8	32.2
M2PP_Adj	0.030	3.2	1.3	0.050	2.1	3.4	0.041	2.9	7.8
M2PP	0.009	0.9	59.3	0.021	1.4	36.0	0.022	1.9	39.4
M2PPFIQ	0.021	1.5	17.7	0.038	2.0	2.3	0.027	1.7	47.6
M2PPALLQ	0.023	1.6	17.3	0.038	2.0	2.3	0.027	1.7	50.8
M3β	0.016	2.0	31.6	0.010	0.6	68.87	0.013	1.0	75.2
LLβ	0.024	2.2	22.5	0.011	0.7	73.7	0.057	2.4	21.3
M5	0.012	1.7	9.9	0.019	0.3	40.7	0.065	4.3	0.2

Note: Grey shading indicates models that produce significant *t*-statistics.
a. Sample for M2PP through M5 ends in 1996Q4.

Equation (3) decomposes real balances into their components—prices and money—and adds an output gap. Data for the output gap are taken from the Bank of Canada's Quarterly Projection Model. The interest rate differential between the proxy for the own rate on broad money and the competing rate is also added to both equations (2) and (3) to remedy the fact that the own rate was dropped from calculation of the money gap. Put another way, if money demand depends on output, own, and competing interest rates, then two cointegrating vectors belong in the full VECM: one that can be formed by using the Johansen procedure on real balances, output, and competing interest rates; and a second that consists of the interest rate differential.[15] In economic terms the interest rate differential may have an effect both through its influence on long-run money demand and because of supply factors. This differential can be thought of as a proxy for the intermediation spread for banks (one of the components of the competing rate is the government bond rate). When the rate paid on deposits rises relative to other rates of return, banks may look for ways to encourage their clients to move into more-profitable lines by means other than interest rates—by raising service charges, for example. When this differential is high, bank profitability would be reduced, affecting their balance sheets and possibly having repercussions on bank deposits.

Testing for $E^1 > 0$ is a way of determining whether money gaps matter to the inflation process. Testing for $E^1 = 0$ and $A2(L) = 0$ is a way of testing whether broad money affects inflation through money growth or money gaps. The output gap is included in equation (3) because it is part of a competing model of price determination. Nesting the output gap within this model allows one to determine whether money matters even after the effect of the output gap is taken into account.

15. Along the lines of my discussion in note 12, the two structural cointegration vectors can be written

$$rm - a_1 y + a_5 i^c - a_3 di ,$$

where

$$di = i^o - i^c \text{ and } a_5 = a_4 - a_3 \text{ and } a_2 = 0 .$$

If we use the same argument as in note 12, all the parameters of the first structural cointegration vector are identified except a_3, the coefficient of the interest rate differential. Since that is an I(0) variable it can be dropped and the other parameters estimated consistently in the 3-variable system. However, in the VECM, or any dynamic equation such as (2), the system's second cointegration vector should be added back to the system, not only because it may be a significant variable in its own right, but also because it may be necessary to determine whether the money gap is significant.

Lagged changes in the interest rate differential could also be added to equation (3). However, these were not significant and worsened the equation fit.

In Table 7, the estimates of equation (3) are shown over the whole sample and over the subsamples 1970Q1–1984Q4 and 1982Q1–1998Q4. Over the entire sample most broad aggregates contribute significantly to inflation. In the subsamples the results are more mixed. Over the first subsample only a few aggregates contribute significantly to inflation; over the 1980s and 1990s, when the variance of inflation was much lower, almost all aggregates contribute significantly. The evidence shows that, overall, broad money contributes to inflation.

7 Restricted Price Equations

The ADF tests from Table 2 indicate that the price level is borderline I(2) and that several money aggregates appear to be I(2). The effect this has on the price equation can be seen in the following simple first-order version of equation (3):

$$\begin{aligned}\Delta p_t \;=\; & a\Delta p_{t-1} + b\Delta m_{t-1} + c\Delta y_{t-1} + d\Delta i_{t-1} + eMGAP_{t-1} \\ & + fYGAP_{t-1} + g(i^o - i^c)_{t-1} + u_t. \qquad (4)\end{aligned}$$

This can also be written

$$\begin{aligned}\Delta p_t - \Delta p_{t-1} \;=\; & (a+b-1)\Delta p_{t-1} + b(\Delta m_{t-1} - \Delta p_{t-1}) + c\Delta y_{t-1} \\ & + d\Delta i_{t-1} + eMGAP_{t-1} + fYGAP_{t-1} \\ & + g(i^o - i^c)_{t-1} + u_t. \qquad (5)\end{aligned}$$

In equation (5) all variables are stationary except the variable representing lagged price changes if prices are I(2). By imposing the constraint $a + b = 1$, that variable is eliminated from equation (5).

In the general case rather than the first-order system described in equation (5), the constraint involves imposing A1(1) + A2(1) = 1. When the restriction is true, one should expect little difference between the restricted and unrestricted estimates.

Estimates with this restriction are shown in Table 8. Again, over the entire sample period most broad aggregates contribute significantly to inflation. The same is true in the first subsample. However, in the second subsample none of the broad aggregates in this restricted version are significant. This is likely because in the second subperiod the inflation process changed; inflation was no longer a unit-root process.[16] For example, if economic agents gave some weight to the inflation targets in Canada in their expectations, coefficients on lagged money and prices would sum to

16. In fact, a unit-root test rejects a unit root in inflation over this period.

Table 8
Restricted price equations

	1970Q1–1998Q4[a]			1970Q1–1984Q4			1982Q1–1998Q4[a]		
	E^1=0		**E^1, *A2(1)*=0**	**E^1=0**		**E^1, *A2(1)*=0**	**E^1=0**		**E^1, *A2(1)*=0**
	Coefficient	***t*-statistic**	**Significance level (%)**	**Coefficient**	***t*-statistic**	**Significance level (%)**	**Coefficient**	***t*-statistic**	**Significance level (%)**
M2	0.001	0.3	6.2	0.015	1.2	4.9	0.000	0.0	82.6
M2P	0.006	0.9	6.6	0.024	1.4	3.3	0.000	0.0	84.2
M2PFIQ	0.015	1.8	1.9	0.025	1.5	3.3	0.003	0.3	69.4
M2PALLQ	0.014	2.1	0.5	0.027	1.5	3.1	0.011	1.1	32.2
M2P_Adj	0.024	2.0	8.3	0.060	2.4	0.5	–0.007	–0.4	84.9
M2PP_Adj	0.019	2.0	2.0	0.060	2.4	0.5	0.008	0.6	42.8
M2PP	0.001	0.1	76.0	0.027	1.8	2.3	–0.005	–0.5	90.9
M2PPFIQ	0.020	1.4	19.4	0.048	2.7	0.1	–0.006	–0.5	94.5
M2PPALLQ	0.031	2.3	2.6	0.047	2.7	0.1	–0.003	–0.2	97.3
M3β	0.015	1.7	22.7	0.021	1.2	62.7	0.018	1.3	52.0
LLβ	0.023	2.1	13.2	0.027	1.5	47.3	–0.010	–0.7	70.0
M5	0.010	1.4	3.3	0.004	0.5	26.8	0.005	0.5	34.1

Note: Grey shading indicates models that produce significant *t*-statistics.
a. Sample for M2PP through M5 ends in 1996Q4.

less than 1. If this were the case, the need for the restriction would disappear and the results of Table 7, with no restriction, would be appropriate. One indication that the restriction is not appropriate over this latter period is that the output gap, a variable that tends to be reliably associated with future inflation, also becomes insignificant in the price equation over this subsample. Consequently, the fact that broad money does not predict inflation in this subsample specification likely does not mean that broad money has become less informative; rather it reflects the inappropriateness of the restriction for this subsample. When the restriction is removed, broad money continues to predict inflation during the 1980s and 1990s.

8 Recursive VECM Indicators

The recursive VECM methodology is a way of mimicking how accurately forecasters would have predicted inflation had they used the VECM approach to first estimate long-run money demand and then forecast inflation. Unlike the within-sample methodology, which uses a single equation such as (3) to assess whether money matters, the recursive VECM methodology relies on assessing out-of-sample system forecasts. Thus the results could be very different. Using this methodology, I initially estimated long-run money demand in the manner used in Table 4 for the sample period 1970Q1 to 1974Q2. The residuals of this vector are added to a vector autoregression (VAR) in first differences for *m, p, y,* and i^c. Inflation forecasts of the form

$$\frac{400}{k}\Delta_k p \quad k=1,2,4,8 \tag{6}$$

are made for observations 1974Q3 to 1976Q2. The forecast errors of these inflation forecasts are calculated. The sample is extended by one observation to 1974Q3. Long-run money demand, price forecasts, and forecast errors are recalculated, and so on until the last observation exhausts the data.

Root-mean-squared errors (RMSEs) are calculated for four different horizons: 1, 2, 4, and 8 quarters. From a monetary policy perspective the 4- and 8-quarter horizons are the most interesting because it takes that long for current monetary policy actions to affect prices; thus a price forecast that looks ahead 4 to 8 quarters is useful for determining what policy actions should be taken today. When calculating the RMSEs, I ignored the first 20 observations because they correspond to samples with very few degrees of freedom and therefore are potentially unreliable forecasts. For the 1970Q1–1998Q4 results the first simulation period used for the RMSE calculation will be 1979Q2.

Table 9
Recursive VECMs for price-inflation-forecast RMSEs (percentage)

		Horizon				Horizon				Horizon			
		1	**2**	**4**	**8**	**1**	**2**	**4**	**8**	**1**	**2**	**4**	**8**
		1970Q1–1998Q4				**1970Q1–1984Q4**				**1982Q1–1998Q4**			
No money		1.94	1.86	1.96	2.26	3.25	3.11	2.96	2.69	1.54	1.43	1.46	2.31
M2	No money gap	2.01	1.88	1.70	1.80	3.65	3.41	2.79	2.45	1.63	1.39	1.25	1.03
	With money gap	1.97	1.84	1.87	1.95	3.44	3.16	3.05	2.51	1.56	1.33	1.19	1.30
M2P	No money gap	2.04	1.94	1.71	1.70	3.75	3.54	2.86	2.39	1.70	1.43	1.27	1.04
	With money gap	2.02	1.88	1.82	1.91	3.58	3.28	3.09	2.86	1.64	1.39	1.24	1.38
M2PFIQ	No money gap	2.05	1.95	1.73	1.72	3.75	3.53	2.86	2.40	1.68	1.43	1.25	1.15
	With money gap	2.05	1.91	1.86	1.96	3.58	3.27	3.08	2.87	1.37	1.40	1.24	1.49
M2PALLQ	No money gap	2.06	1.98	1.78	1.89	3.75	3.54	2.86	2.40	1.67	1.40	1.24	1.49
	With money gap	2.07	1.96	1.93	2.08	3.59	3.28	3.07	2.86	1.72	1.53	1.39	1.71
M2P_Adj	No money gap	1.94	1.83	1.61	1.64	3.48	3.33	2.94	2.69	1.70	1.43	1.12	1.08
	With money gap	1.98	1.80	1.64	1.52	3.33	2.93	2.46	1.49	1.63	1.37	1.07	1.20
M2PP_Adj	No money gap	1.94	1.86	1.96	2.26	3.48	3.33	2.95	2.69	1.74	1.53	1.32	1.33
	With money gap	1.95	1.85	1.64	1.72	3.33	2.92	2.46	1.47	1.70	1.52	1.27	1.43
		1970Q1–96Q4				**1970Q1–1984Q4**				**1982Q1–1996Q4**			
No money		2.07	1.96	2.05	2.32	3.25	3.11	2.96	2.69	1.93	1.70	1.69	2.69
M2PP	No money gap	2.14	2.06	1.88	1.89	3.63	2.51	2.89	2.28	2.27	1.86	1.78	1.74
	With money gap	2.18	2.05	1.94	1.94	3.50	3.46	2.57	1.91	2.07	1.65	1.42	1.46
M2PPFIQ	No money gap	2.17	2.07	1.88	1.86	3.44	3.43	2.87	2.24	2.17	1.84	1.71	1.74
	With money gap	2.25	2.10	1.99	1.92	3.38	3.06	2.55	1.81	1.98	1.64	1.42	1.50
M2PPALLQ	No money gap	2.16	2.07	1.85	1.85	3.43	3.42	2.87	2.25	2.17	1.83	1.67	1.75
	With money gap	2.25	2.11	1.99	1.92	3.37	3.05	2.55	1.83	1.97	1.65	1.41	1.52
M3β	No money gap	2.06	1.92	1.83	2.08	3.55	3.35	2.94	2.71	2.22	1.83	1.73	1.74
	With money gap	2.13	2.01	2.04	2.10	3.28	2.91	2.51	1.99	2.11	1.78	1.62	1.99
LLβ	No money gap	2.05	1.90	1.77	1.90	3.56	3.35	2.90	2.64	2.24	1.85	1.65	1.60
	With money gap	2.12	1.99	1.97	1.98	3.29	2.92	2.52	2.02	2.15	1.81	1.54	1.85
M5	No money gap	2.01	1.82	1.63	1.86	3.44	3.16	2.63	2.19	2.21	1.76	1.61	1.62
	With money gap	2.07	1.90	1.87	1.95	3.26	2.89	2.59	1.85	2.13	1.75	1.51	2.01

Note: Grey shading indicates models that produce lower RMSEs than the base model that excludes money.

Three different sets of VARs or VECMs are compared. The first excludes money entirely and consists of a VAR in first differences for *p, y,* and i^c. The second includes money growth and consists of a VAR in first differences for *m, p, y,* and i^c. The third consists of a VECM that includes both money growth and money gaps; that is, a VAR in first differences for *m, p, y,* and i^c augmented by the residuals from estimates of the long-run money-demand function. In Table 9, estimates are shown for the full sample 1970Q1–1998Q4 and for two subsamples, 1970Q1–1984Q4 and 1982Q1–1998Q4.

Rather than use the 4-variable system of *m, p, y,* and i^c as the basis for forecasting inflation, it might seem preferable to use the 5-variable system of *m, p, y,* i^c, and *di* (*di* being the interest rate differential used in section 6) to estimate the effect of money on inflation. The same arguments made in section 6 for including the interest rate differential apply here when making out-of-sample VECM forecasts. However, the 5-variable system fared poorly compared with the 4-variable system without the interest rate differential, posting less-accurate inflation forecasts across the board. Consequently, I present the results from the more parsimonious 4-variable system.

For the full sample (see Table 9), broad money would have reduced inflation-forecast errors for 4- and 8-quarter-ahead forecasts using any definition of broad money. Reductions of up to 20 to 30 per cent occurred. For shorter forecast horizons, M2P_Adj and M2PP_Adj help reduce inflation-forecast errors, as do the broader aggregates M3β, LLβ, and M5. Over the 1970Q1–1984Q4 period, money reduces inflation errors for 4- and 8-quarter-ahead forecasts for all measures of broad money as well as 2-quarter-ahead forecasts for M2P_Adj, M2PP_Adj, and the broader measures of money. Over the 1982Q1–1996Q4 subsample, broad money is again important at all 4- and 8-quarter horizons and also for some of the narrower measures of broad money at 2-quarter horizons. In summary, broad money helps reduce inflation-forecast errors, especially at 4- and 8-quarter horizons for all measures of broad money, and over both subsamples as well as over the full sample period.

As in the price equations estimated in Table 8, the short-run dynamics of the VARs and VECMs are next restricted to take into account possible nonstationarity of some of the data. In the money and price equations the coefficients of lagged money and lagged prices are constrained to sum to 1. In the output and interest rate equations the money effects and the price effects are constrained to sum to 0. Restricted estimates are shown in Table 10. The results are broadly similar to those of Table 9, which had no restrictions. Broad money does best at 4- and 8-quarter horizons. The results

Table 10
Restricted recursive VECMs for price-inflation-forecast RMSEs (percentage)

		1970Q1–1998Q4				1970Q1–1984Q4				1982Q1–1998Q4			
		Horizon				Horizon				Horizon			
		1	**2**	**4**	**8**	**1**	**2**	**4**	**8**	**1**	**2**	**4**	**8**
No money		1.94	1.84	1.87	2.03	3.24	3.08	2.92	2.98	1.54	1.40	1.42	2.22
M2	No money gap	2.04	1.95	1.85	1.98	3.65	3.39	2.78	2.63	1.72	1.51	1.47	1.52
	With money gap	2.05	1.97	2.06	2.13	3.47	3.26	3.28	2.99	1.65	1.48	1.53	1.56
M2P	No money gap	2.04	1.98	1.86	2.03	3.93	3.52	2.83	2.44	1.80	1.58	1.55	1.56
	With money gap	2.10	2.03	2.06	2.23	3.63	3.42	3.34	3.15	1.93	1.53	1.55	1.71
M2PFIQ	No money gap	2.04	1.97	1.82	1.93	3.93	3.52	2.82	2.46	1.76	1.52	1.41	1.33
	With money gap	2.10	2.02	2.04	2.14	3.63	3.41	3.34	3.16	1.41	1.54	1.46	1.54
M2PALLQ	No money gap	2.03	1.96	1.78	1.85	3.73	3.52	2.82	2.47	1.72	1.49	1.31	1.11
	With money gap	2.09	2.01	2.00	2.07	3.64	3.42	3.34	3.16	1.67	1.44	1.31	1.43
M2P_Adj	No money gap	1.94	1.84	1.65	1.70	3.46	3.31	2.89	2.59	1.85	1.66	1.57	1.57
	With money gap	2.00	1.88	1.71	1.67	3.32	2.95	2.65	2.27	1.81	1.65	1.57	1.68
M2PP_Adj	No money gap	1.93	1.82	1.58	1.57	3.46	3.31	2.89	2.60	1.78	1.57	1.35	1.19
	With money gap	1.98	1.83	1.62	1.53	3.32	2.90	2.66	2.28	1.73	1.54	1.34	1.41
		1970Q1–1996Q4				**1970Q1–1984Q4**				**1982Q1–1996Q4**			
No money		2.07	1.94	1.96	2.13	3.24	3.08	2.92	2.98	1.89	1.63	1.59	2.59
M2PP	No money gap	2.16	2.12	2.00	1.99	3.61	93.5	2.87	2.10	2.34	1.97	1.87	2.01
	With money gap	2.21	2.12	1.98	1.99	3.53	3.24	3.65	2.05	2.12	1.75	1.89	2.35
M2PPFIQ	No money gap	2.17	2.09	1.91	1.85	3.44	3.42	2.81	1.93	2.22	1.94	1.78	1.90
	With money gap	2.23	2.11	1.91	1.83	3.41	3.19	2.61	1.79	2.06	1.82	1.89	2.34
M2PPALLQ	No money gap	2.15	2.05	1.80	1.68	3.43	3.41	2.81	1.92	2.21	1.89	1.57	1.52
	With money gap	2.21	2.07	1.81	1.65	3.41	3.20	2.61	1.74	2.09	1.83	1.76	2.10
M3β	No money gap	2.05	1.88	1.69	1.67	3.53	3.25	2.67	2.27	2.24	1.82	1.55	1.04
	With money gap	2.08	1.93	1.94	2.17	3.40	3.17	3.15	3.52	2.13	1.74	1.49	1.40
LLβ	No money gap	2.04	1.87	1.66	1.59	3.53	3.26	2.65	2.16	2.26	1.85	1.52	1.26
	With money gap	2.07	1.92	1.90	2.08	3.40	3.19	3.13	3.40	2.13	1.76	1.48	1.48
M5	No money gap	2.00	1.78	1.54	1.48	3.42	3.09	2.50	2.09	2.19	1.71	1.35	0.80
	With money gap	2.02	1.81	1.76	1.94	3.25	2.95	2.86	3.09	2.11	1.67	1.33	1.10

Note: Grey shading indicates models that produce lower RMSEs than the base model that excludes money.

also indicate that, contrary to the U.S. case (see Estrella and Mishkin 1996), broad money has remained a useful indicator of inflation since the 1980s.

9 The Source of the Information in Broad Money

The results discussed above show that broad money helps to forecast inflation even after output and interest rates are taken into account. But is it possible that broad money helps to forecast inflation only because it contains narrow money, which has been shown to be a leading indicator of inflation at long horizons? This section tests that hypothesis in two ways: by estimating recursive VECMs for broad-money aggregates from which narrow money has been removed and by comparing broad-money VECM forecasts to those of narrow money.

Three measures of narrow money are considered. The first is the conventional aggregate M1;[17] the second is M1_Adj, which adjusts recent data for M1 for shifts due to financial innovation and the elimination of reserve requirements; and the third is M1++, which adds chequable and non-chequable notice deposits to M1 and so internalizes some of the shifts between M1 and notice deposits that have occurred over the last 20 years. M1 was for a long time the Bank of Canada's preferred measure of narrow money, but recent instability has prompted the Bank to consider other narrow aggregates, such as M1_Adj and M1++.

The long-run money-demand functions are little changed by excluding narrow money, as is shown in Table 11. Income elasticities tend to be higher, as would be expected when excluding a component that is inelastic. Table 12 shows the results of recursive VECMs for broad money excluding M1. (Results that I have not shown are similar if M1_Adj or M1++, rather than M1, is excluded from broad money.) In general, RMSEs are a bit higher when narrow money is excluded, suggesting that both narrow and broad money contribute to forecasting inflation. But RMSEs do not increase drastically when narrow money is excluded, as we would expect if all of the forecasting power in broad money had been coming from its narrow-money component. And finally, comparing recursive VECM RMSEs for M1, M1_Adj, and M1++ to those of broad money (Table 10) or to those of broad money excluding M1 or M1_Adj (Table 12) shows that forecasts of inflation at various horizons made using several measures of broad money would have been more accurate over the various sample periods than forecasts made using narrow money. For example, for the full sample, both M2P_Adj and M2PP_Adj have lower RMSEs at 1-, 2-, 4-, and 8-quarter horizons compared with any of the narrow aggregates tested here.

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17. M1 includes currency, personal chequing accounts, and current accounts.

Table 11
Restricted estimates of long-run money demand for broad money excluding M1Adj, 1970Q1 to 1998Q4

Variables	Order of VECM	First CI vector	Corresponding loadings	Number of CI vectors[a]
rM2,y,i^c	4	[1 –1.88 0.056]	[–0.00 –0.01 –11.9*]	1
rM2P,y,i^c	4	[1 –1.82 0.042]	[–0.01 –0.02* –14.4*]	1
rM2PFIQ,y,i^c	4	[1 –1.90 0.023]	[–0.03* –0.02* –23.8*]	1
rM2PALLQ,y,i^c	4	[1 –2.15 0.032]	[–0.04* –0.02 –24.3*]	1
rM2P_Adj,y,i^c	4	[1 –1.61 0.020]	[–0.03* –0.01 –21.3*]	1
rM2PP_Adj,y,i^c	4	[1 –1.93 0.023]	[–0.04 0.00 –38.2*]	1
rM2PP,y,i^c	4	[1 –2.06 0.041]	[–0.02 –0.01 –15.9*]	1
rM2PPFIQ,y,i^c	4	[1 –1.97 0.021]	[–0.02* 0.00 –25.8*]	1
rM2PPALLQ,y,i^c	4	[1 –2.07 0.020]	[–0.04* 0.02 –28.9*]	1
rM3β,y,i^c	4	[1 –1.80 0.023]	[–0.08* –0.02 –22.0*]	1
rLLβ,y,i^c	4	[1 –1.91 0.017]	[–0.11* –0.01 –27.7*]	1
rM5,y,i^c	4	[1 –1.70 0.029]	[–0.06* –0.03* –22.4*]	1

Note: Sample for *r*M2PP through *r*M5 ends in 1996Q4.
a. According to Johansen-Juselius trace and λ -max statistics.
b. VECM chosen on the basis of Akaike’s FPE criterion.
* Significant at the 5 per cent level.

10 Narrowing the Broad-Money Aggregates

The above results demonstrate that many of the broad-money measures used here have stable money-demand functions and help to forecast inflation. Some of them can, however, be ruled out as useful measures of broad money for policy because they fail a number of tests. For example, M3β and LLβ, expressed in real terms, are found to be I(2), although in several cases they are only borderline I(2). The power of unit-root tests is low and so these series may indeed be I(1), but they do call into question the results of the long-run money-demand function estimation.

Of the broad aggregates that remain, M5, which generally produces among the most accurate inflation forecasts, does not have a long-run demand function that is particularly stable over the 1980s and 1990s. So given the criteria presented in the introduction, it, too, would be ruled out as a useful aggregate.

The remaining aggregates that consistently produce the most reliable forecasts are M2P_Adj and M2PP_Adj—that is, M2P with CSBs and mutual funds. These aggregates produce some of the best inflation forecasts and they also have stable demand functions over the last 30 years.

Table 12
Restricted recursive VECMs for price-inflation-forecast RMSEs (percentage), broad money excluding M1

		Horizon				Horizon				Horizon			
		1	**2**	**4**	**8**	**1**	**2**	**4**	**8**	**1**	**2**	**4**	**8**
		1970Q1–1998Q4				**1970Q1–1984Q4**				**1982Q1–1998Q4**			
No money		1.94	1.84	1.87	2.03	3.24	3.08	2.92	2.98	1.54	1.40	1.42	2.22
M2	No money gap	1.97	1.91	1.94	2.20	3.52	3.42	3.37	3.89	1.77	1.51	1.53	1.69
	With money gap	1.96	1.92	2.19	2.50	3.31	3.26	3.78	4.32	1.69	1.51	1.64	1.68
M2P	No money gap	2.01	1.94	1.89	2.10	3.59	3.39	3.01	3.21	1.86	1.63	1.64	1.74
	With money gap	1.99	1.92	2.12	2.57	3.36	3.18	3.55	4.36	1.80	1.60	1.67	1.81
M2PFIQ	No money gap	2.01	1.93	1.85	2.01	3.59	3.39	3.01	3.21	1.81	1.56	1.48	1.48
	With money gap	1.99	1.91	2.08	2.50	3.36	3.18	3.54	4.37	1.78	1.55	1.52	1.62
M2PALLQ	No money gap	2.00	1.91	1.80	1.92	3.60	3.39	3.01	3.19	1.74	1.50	1.33	1.22
	With money gap	1.99	1.89	2.03	2.42	3.37	3.18	3.53	4.37	1.68	1.43	1.32	1.41
M2P_Adj	No money gap	1.95	1.85	1.72	1.89	3.41	3.23	2.79	2.78	1.86	1.67	1.63	1.72
	With money gap	1.96	1.79	1.68	1.83	3.24	2.92	2.74	2.96	1.71	1.64	1.49	1.59
M2PP_Adj	No money gap	1.93	1.80	1.61	1.71	3.40	3.23	2.79	2.78	1.79	1.57	1.38	1.34
	With money gap	1.96	1.79	1.68	1.83	3.24	2.92	2.74	2.93	1.71	1.64	1.49	1.59
		1970Q1–1996Q4				**1970Q1–1984Q4**				**1982Q1–1996Q4**			
No money		2.07	1.94	1.96	2.13	3.24	3.08	2.92	2.98	1.89	1.63	1.59	2.59
M2PP	No money gap	2.16	2.12	2.02	2.04	3.61	3.43	2.80	2.17	2.31	1.95	1.85	2.05
	With money gap	2.20	2.11	2.03	2.11	3.50	3.18	2.66	2.41	2.01	1.69	1.64	1.95
M2PPFIQ	No money gap	2.20	2.09	1.95	1.97	3.41	3.37	2.75	1.94	2.22	1.92	1.81	2.04
	With money gap	2.26	2.11	1.97	1.97	3.36	3.11	2.49	1.83	2.03	1.74	1.70	2.03
M2PPALLQ	No money gap	2.17	2.04	1.84	1.77	3.40	3.36	2.74	1.92	2.20	1.90	1.62	1.71
	With money gap	2.23	2.07	1.87	1.78	3.35	3.10	2.49	1.84	2.04	1.75	1.65	1.83

(continued)

Table 12 (continued)
Restricted recursive VECMs for price-inflation-forecast RMSE (percentage), broad money excluding M1

		Horizon				Horizon				Horizon			
		1	**2**	**4**	**8**	**1**	**2**	**4**	**8**	**1**	**2**	**4**	**8**
		1970Q1–1996Q4				**1970Q1–1984Q4**				**1982Q1–1996Q4**			
M3β	No money gap	2.05	1.88	1.73	1.77	3.53	3.24	2.72	2.51	2.24	1.83	1.55	1.10
	With money gap	2.06	1.89	1.90	2.19	3.35	3.06	3.00	3.50	2.13	1.75	1.52	1.45
LLβ	No money gap	2.04	1.88	1.71	1.71	3.53	3.24	2.70	2.42	2.26	1.86	1.53	1.37
	With money gap	2.05	1.88	1.87	2.08	3.34	3.06	2.93	3.30	2.17	1.80	1.55	1.54
M5	No money gap	2.01	1.80	1.57	1.54	3.43	3.10	2.53	2.22	2.19	1.70	1.33	0.84
	With money gap	2.02	1.80	1.78	2.00	2.66	2.49	2.56	3.27	2.10	1.65	1.31	1.10
		1970Q1–1998Q4				**1970Q1–1984Q4**				**1982Q1–1998Q4**			
M1	No money gap	1.98	1.93	1.84	2.01	3.62	3.44	2.89	2.53	1.67	1.55	1.47	1.29
M1_Adj	No money gap	1.97	1.89	1.82	1.97	3.62	3.44	2.89	2.53	1.65	1.49	1.40	1.20
M1PP	No money gap	2.02	1.91	1.85	1.98	3.64	3.42	3.15	3.12	1.73	1.50	1.38	1.47
	With money gap	2.04	1.88	1.88	2.08	3.50	3.15	3.11	3.42	1.65	1.44	1.42	1.60

Note: Grey shading indicates models that produce lower RMSEs than the base model that excludes money.

11 Current Forecasts Based on Broad Money

This section asks what the broad-money aggregates are now forecasting for inflation. It also takes a closer look at forecasts based on M2P_Adj and M2PP_Adj, the preferred measures of broad money.

I generated forecasts in the same manner as for the restricted recursive VECM indicators of section 8 (Table 10). The only models shown are those that exclude money gaps, because money gaps were not found to improve forecasting accuracy in section 8's assessment of the historical period. In addition, the sequence of inflation forecasts may tend to be somewhat spiky because successive forecasts involve revising the starting point of the forecast and re-estimating the coefficients of the indicator models; thus a smoothing method is used. The objective is to use a moving average of inflation forecasts that is long enough to smooth out any spikes but short enough that it does not impair broad money's ability to forecast turning points in inflation. With these objectives in mind I used a 4-quarter moving average of inflation forecasts.

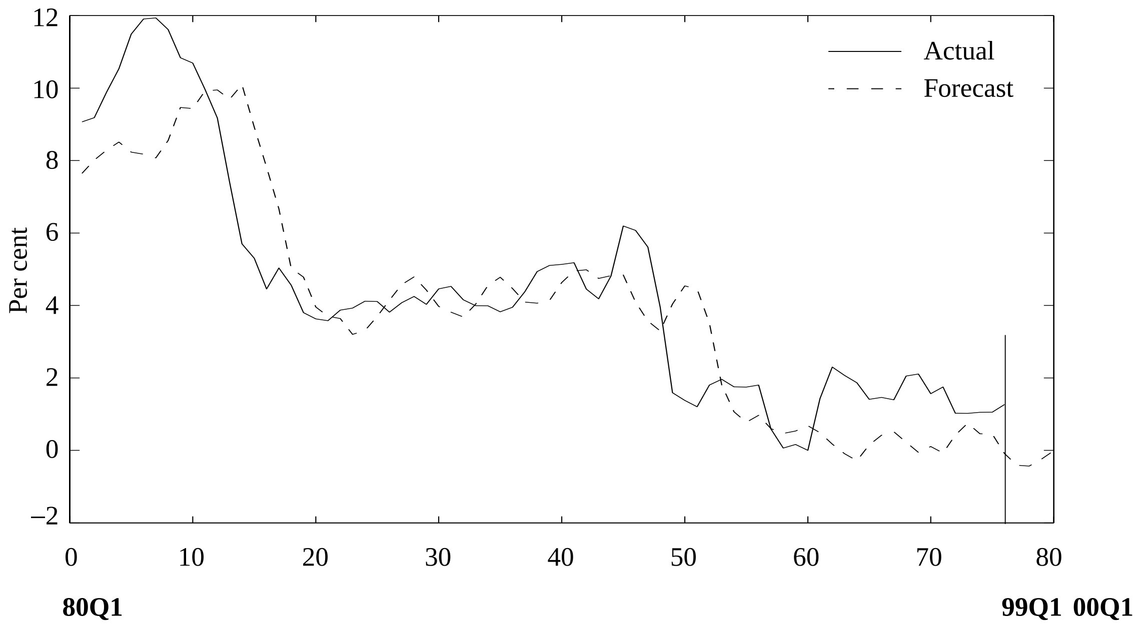
Figure 5 shows that M2P_Adj does a reasonable job of forecasting inflation over the period 1980Q1–1998Q4, but over the last five years it has under-predicted inflation. Over the forecast horizon the M2P_Adj model predicts average inflation of 0 over the next four quarters and less than 0 over the next eight quarters.

The downward bias in recent quarters may be because M2P_Adj does not fully internalize the shift out of deposits and into mutual funds that recent data reveal. M2P_Adj includes mutual funds at financial institutions, but excludes other mutual funds. Thus this aggregate may now be less reliable than an aggregate that includes all mutual funds. The same downward bias over the last five years is evident in inflation forecasts based on M2 and M2P, aggregates that include no mutual funds. It appears that the shift out of deposits and into mutual funds, even if it does not show up as instability in the long-run money-demand function, affects inflation forecasts derived from aggregates that exclude mutual funds. In fact, it is this effect that has caused the Bank in recent years to de-emphasize M2 and M2P and focus more on M2PP_Adj as a policy guide.

In Figure 6, models based on M2PP_Adj, which includes all mutual funds, also forecast reasonably well over the historical period, but unlike M2P_Adj, these models show no particular bias over the last five years. Over the forecast horizon, M2PP_Adj is forecasting average inflation of just under 2 per cent at both 4- and 8-quarter horizons.

Figure 5
M2P_Adj inflation forecasts

4-quarter horizon



8-quarter horizon

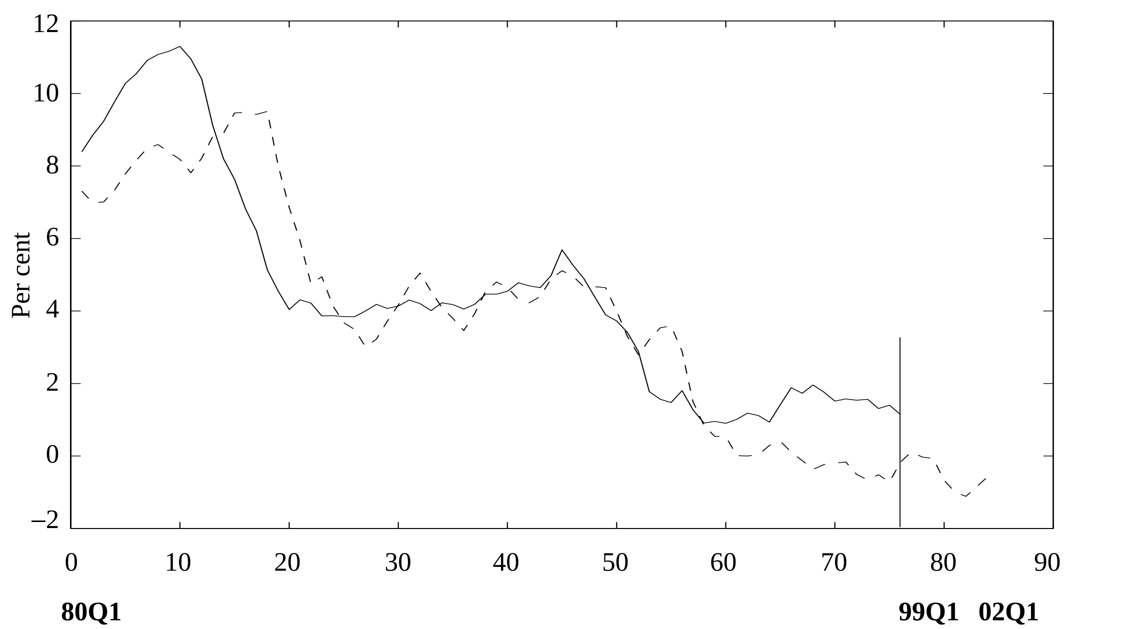
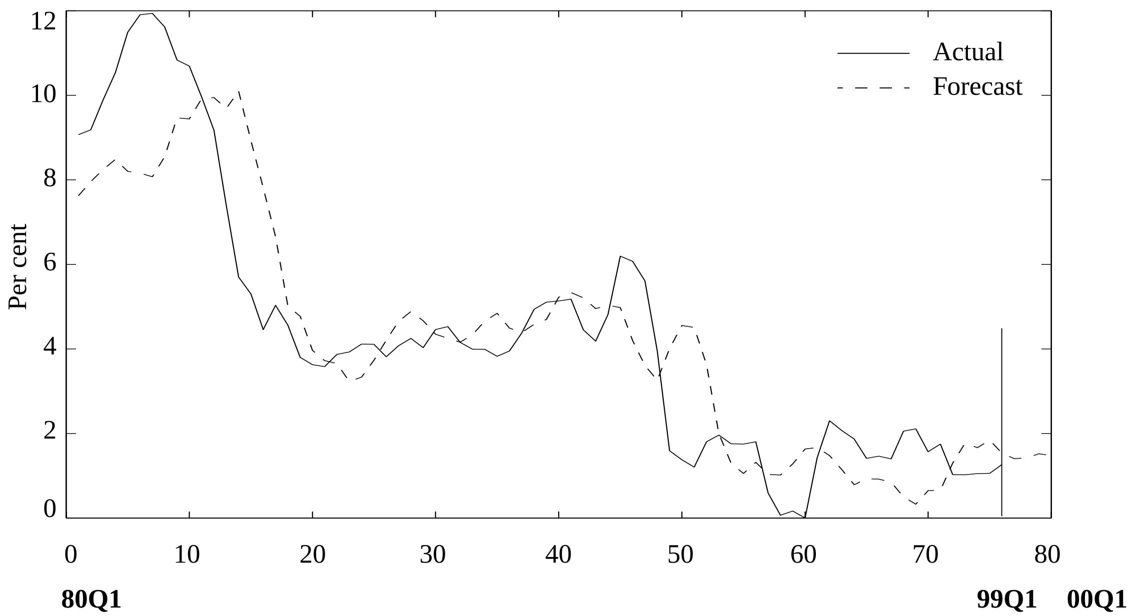
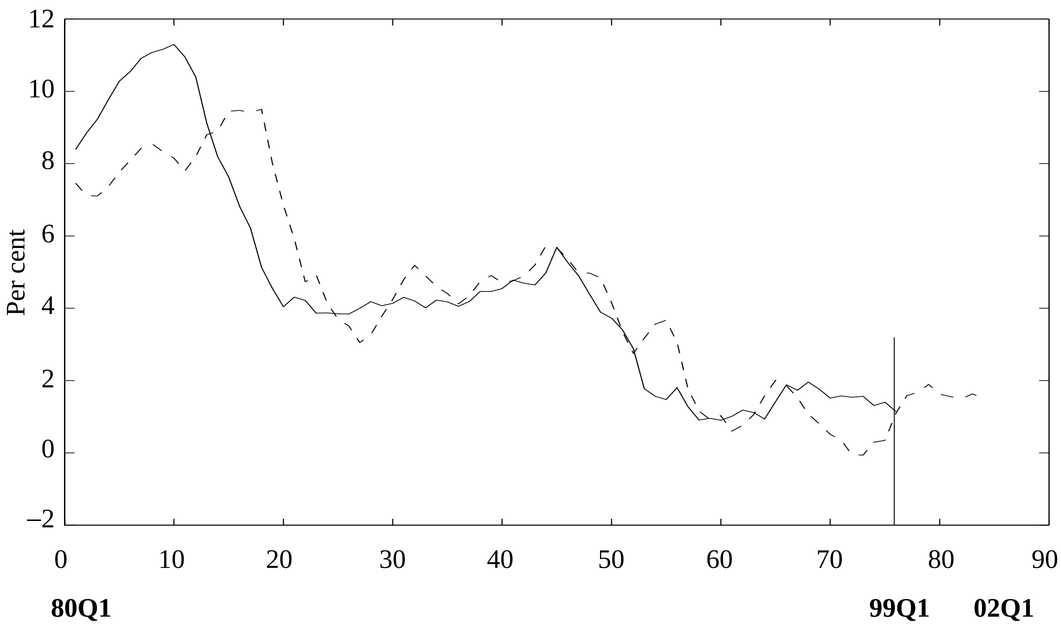


Figure 6
M2PP_Adj inflation forecasts

4-quarter horizon



8-quarter horizon



12 What Does It All Mean?

One model that has been used in the literature to explain empirical broad-money functions is the buffer-stock model. According to this characterization of the transmission mechanism, money temporarily held in excess of demand spills over to push up spending and put upward pressure on prices. Broad money is suitable as a buffer because it can be cheaply converted into a useful form in the event of a spending or income shock.

However, the results of this paper are not very encouraging to proponents of the buffer-stock hypothesis. While the results of section 6 indicate that money gaps help to explain inflation, the out-of-sample VECM results of Tables 9 and 10 show that money growth, not money gaps, accounts for much of broad money's power to explain inflation. That is, models that include money growth but exclude money gaps tend to forecast inflation as well as or better than models that include both money growth and money gaps.

Many conventional economic models could not predict money growth's ability to forecast inflation, even when output and interest rates are taken into account. This phenomenon is more in line with the standard quantity theory of money, a theory that tends to focus on the longer-run proposition that inflation is caused by past money growth but does not explain in detail the transmission mechanism nor rely on the importance of money gaps, as the buffer-stock theory emphasizes.

An additional explanation of why money growth forecasts inflation may arise through expectations. If money demand depends on current prices and on expected future prices, then higher expected inflation would generate an increase in money growth. To the extent that expectations were correct, the current increase in money growth would be validated by an increase in future inflation—that is, money growth would lead inflation. According to this motive it would be money growth rather than money gaps that would contribute to inflation forecasts, thus supporting the empirical evidence found here.

It may be that in the case of the narrow aggregates, the buffer-stock model is a valid explanation of money's role in the economy, whereas for broad money an explanation related to expectations is more suitable. Given that narrow money is held for transactions reasons while broad money's main function is as a savings vehicle, this should not be surprising.

Conclusion

In my introduction I asked whether broad money can be a useful monetary policy variable. The results of this paper suggest that it can.

The evidence of stability for the Johansen-Juselius estimates over the last 30 years suggests that one can be confident in the estimates of long-run money demand and what they imply—that a growth rate of about 6 per cent in real balances is consistent in the steady state with 2 per cent inflation. There is little evidence of instability in these relationships because of shifts in velocity or changing financial intermediation since the 1980s, as has been found in the U.S. case or for narrow-money aggregates in Canada.

The recursive VECMs suggest that broad money is a useful indicator of inflation at long horizons and thus a useful monetary policy tool. Long-horizon inflation forecasts that include broad money have lower RMSEs than do forecasts that exclude money. The usefulness of broad money in such forecasts appears to have persisted into the 1980s and 1990s.

The empirical results I have presented on the stability of long-run money demand and the usefulness of broad money for forecasting inflation hold for most of the definitions of broad money that I tested for. The results are robust and apply to more than just one or two specific cases. Nevertheless, according to the criteria used here, M2P_Adj and, especially, M2PP_Adj, which consist of M2P together with CSBs and mutual funds, are apparently the most reliable of the broad-money aggregates I considered.

How the best of the broad aggregates performs over time should be monitored. Shifts, such as the recent shift out of M2P towards mutual funds (a shift internalized within M2PP_Adj), are possible in the future. The optimal definition of broad money could evolve.

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Discussion

Alain Paquet

On the Motivation for and Relevance of Finding Monetary Aggregates' Place in Monetary Policy

A broad consensus in economics is that in the long run, core inflation is a monetary phenomenon, and money is neutral with respect to real quantities and relative prices. The focus on core inflation is to distinguish an ongoing general rise in the price level from transitory upward or downward jumps resulting from short-run sluggishness in price adjustments and from changes in major relative prices that feed into the price level.[1]

In fact, the theoretical underpinning of core or fundamental inflation as a monetary phenomenon rests solely on the equilibrium precept that all money in circulation is willingly held; i.e., there is an equilibrium between money supply and money demand:

$$\frac{M_t^S}{P_t} = \frac{M_t^D}{P_t} = L(Y_t, i_t^c, \ldots), \tag{1}$$

where M_t is the quantity of money, P_t is the price level, Y_t is real GDP, i_t^c is the nominal interest rate on a competing asset, and $L(\cdot)$ represents the demand function for real balances. From the total derivative of this

1. As an illustration, an OPEC-induced oil-price increase that underlies an increase in the observed general price level should not trigger per se a shift towards a more restrictive anti-inflation monetary policy. Nor should it lead to an accommodative monetary policy that seeks to increase real economic activity. To the extent that a central bank cares about core inflation, what matters is to be transparent about it and to pursue a monetary policy that is consistent with the inflation target.

equilibrium relationship we see that inflation results from the excess growth rate of money supply relative to its real demand:

$$\pi_t = \Delta M_t^S - \Delta L(Y_t, i_t^c, \ldots) . \tag{2}$$

This fundamental result does not impose any specific working of the labour or goods markets, nor that the long-run demand for money be the same as the short-run demand for money.

While the long-run view is largely accepted, there is more debate about the effects of money in the short run, with possibly a majority of economists believing that money is not neutral in the short run. Non-neutrality may arise because of a combination of nominal (or real) rigidities in prices or wages, incomplete information, and/or a limited-participation constraint interacting with the way money is injected into the economy. Consensus is still lacking on which of these dominates. Empirically, uncertainty exists about how important the transitory real effects are on economic fluctuations and how long they last. There is also the issue that these effects mostly stem from unanticipated changes in monetary policy. Ultimately the only guaranteed eventual effect is on the price level. These uncertainties underlie the view that it is not desirable to use monetary policy to attempt to stabilize real economic activity—a view that is now largely shared by economists and central bankers.

A difficult task—that the economic profession has not completed despite progress in clarifying what we still do not understand—is to link the theoretical concept of money to a satisfactory and encompassing empirical counterpart.

Lucas (1977, 232–3) pretty much summed up the issue:

> In the "long run," general price movements arise primarily from changes in the quantity of money. Moreover, cyclical movements in money are large enough to be quantitatively interesting. . . . The direct evidence on short-term correlations between money, output, and prices is much more difficult to read. . . . In general, however, the link between money and these and other variables is agreed to be subject, in Friedman's terms, to "long and variable lags."
>
> . . . *why* monetary effects work with long and variable lags. On this question little is known. It seems likely that the answer lies in the observation that a monetary expansion can occur in a variety of ways, depending on the way the money is "injected" into the system, with different price response implications depending on which way is selected. This would suggest that one should describe the monetary "state" of the

> economy as being determined by some *unobservable* monetary aggregate, loosely related to observed aggregates over short periods but closely related secularly.

While economics still struggles with identifying money's empirical counterpart in the data, by their avowed practices central banks also seem to have given up on monetary aggregates. At the very least, many of them have to a great extent de-emphasized an explicit role for monetary aggregates, so much so that, in the language of central bankers, output gaps are the pre-eminent indicators of inflationary pressures. Analyses refer more readily to aggregate demand/aggregate supply than to money. It almost seems that we have forgotten the equivalence, in a general-equilibrium sense, between excess growth of aggregate demand relative to aggregate supply resulting from excess money creation and excess money creation itself as described by equation (2).

There is another way in which money's place in monetary policy has been reduced. Most countries have chosen to focus on a very short-term interest rate (e.g., the overnight rate in Canada and the federal funds rate in the United States) as the operational target in preference to a narrow aggregate such as the monetary base.[2] This is sometimes motivated by the presumed and often documented instability in monetary aggregates, especially in an era of significant financial innovations that have changed the empirical meaning of money. Later I will discuss whether this has necessarily been warranted.

McPhail aims to make some significant progress regarding the empirical relevance of money to monetary policy on the basis of a broad econometric investigation in cointegrated systems. As she states, "The purpose of this paper is not to characterize the optimal definition of broad money from a theoretical viewpoint, but to determine from an empirical standpoint which measures of broad money appear useful" (page 56).

While I will raise some econometric issues—in the light of recent developments in modern macroeconometrics—I find that her paper makes a contribution with respect to its avowed goal. In particular a few results stand out as revealing a relevant place for broad monetary aggregates in the conduct of monetary policy. As a by-product of my comments, I will point out some paths for future research.

My discussion of McPhail's paper is organized as follows: First, I briefly present what I believe to be her main conclusions, then I organize my comments in two sets. The first set directly addresses the paper's execution

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2. For a review and analysis of the recent conduct of monetary policy in various countries, see Bernanke et al. (1999).

and conclusions. The second set pertains to the implications of the results and issues for monetary policy and future research.

The Empirical Evidence

Having presented various alternative empirical definitions of broad monetary aggregates, McPhail first aims at identifying a long-run money demand that, she argues, might encompass one or more stationary relationship(s) between the quantity of money (*m*), the price level (*p*), real GDP (*y*), a measure of real wealth (*w*), the own rate of return on the aggregate (i^o), and a competing rate of return (i^c). All variables but the rates of return are expressed in logs. The sample of quarterly data covers the 1970Q1–1998Q4 period. There are 12 definitions of broad money and 2 alternate measures of real wealth (total wealth and non-human wealth).[3]

From ADF *t*-ratio tests conducted at the 5 per cent significance level McPhail generally concludes that, over the whole sample, all variables are at least I(1), with most nominal and real monetary aggregates being I(1) and the price level being I(2). However, the evidence regarding the order of integration is neither invariant nor apparently consistent when considering different degrees of broadness of the monetary aggregates. For instance, while her results suggest that 6 out of 12 so-called nominal broad aggregates are I(1), M2P, M2PALLQ, M2PP, M3β, LLβ, and M5 are I(2). Also, 9 out of 12 real monetary aggregates are I(1), but *r*M3β and *r*LLβ would be I(2) and *r*M2PALLQ would be stationary.

At the next stage, McPhail estimates by full-information maximum likelihood, different VECMs for each monetary aggregate in order to investigate the existence, the dimension, and the properties of the cointegrating space that would arise from the long-run relationships between the variables of interest. As she rightly acknowledges, one has to be careful in giving a structural interpretation to the estimated vectors spanning the cointegrating space. Unless some identification restriction(s) are imposed, a wrong interpretation could be given to these vectors. Focusing on real balances—by imposing price-level homogeneity in the monetary equilibrium relationship—is akin to estimating a long-run real money demand equation between the variables of interest, provided that there is a single cointegrating vector or that the other cointegrating vector(s) can be identified, if needed.

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3. McPhail's Table 1 provides a precise definition of the various aggregates that were considered. The sequence of mnemonics moves from the narrowest to the broadest concept of broad money: M2, M2P, M2PFIQ, M2PALLQ, M2P_Adj, M2PP_Adj, M2PP, M2PPFIQ, M2PPALLQ, M3β, LLβ, and M5.

First, if we consider the whole sample available and the most general set of variables (i.e., $[rm, y, w, i^{o}, i^{c}]'$) from which McPhail wants to obtain so-called unrestricted money-demand estimates, the evidence from both the Johansen and Juselius (1990) trace and the maximum eigenvalue statistics often suggests that there are two cointegrating vectors. Provided that one of them arises from a long-run relationship between the two rates of return, the other one might well be a money-demand equation. In some instances, however, when we consider *r*M2P, *r*M2P_Adj, and *r*M2PP_Adj, the evidence points out to only one cointegrating vector, but tests with *r*LLβ suggest that there are three cointegrating vectors. As she points out, it is disquieting that such a great variability exists across the alternative systems for each aggregate in the point estimates of the coefficients associated with real income, wealth, and interest rates.

A second set of VECMs is subsequently estimated, with McPhail considering fewer variables (namely $[rm, y, w, i^{c}]'$) in order to uncover a so-called restricted money demand. In this case, consistent evidence across all aggregate measures of broad money is found in support of a single cointegrating vector with the point estimates of the cointegrating vector, normalized with respect to real balances, being much similar. Furthermore, evidence—from estimates over two periods (from 1970Q1 to 1984Q4 and from 1982Q1 to 1998Q4) and the application of a Chow-type test—supports the stability of the restricted long-run money demand.

Focusing on an individual dynamic price equation and taking into account that the inflation rate may be I(0) during the later period also suggest that broad money is significant.

Finally, McPhail considers the information content of monetary aggregates in forecasting inflation. Recursive VECM indicators were used to construct 1-, 2-, 4-, and 8-period-ahead forecasts of inflation. The RMSEs of the forecasts were found to be lower when accounting for movements in broad money. More specifically, M2P_Adj and M2PP_Adj performed statistically best in forecasting inflation.

Comments on the Econometrics

While McPhail's econometric treatment is applied systematically, some issues deserve further consideration to ensure the robustness of the results.

Regarding the data measures that were employed, it would have been useful had McPhail discussed her reasons for her use of the CPI as the empirical counterpart of the price level rather than using a concept of core inflation (e.g., CPI excluding food, energy, and effects of indirect taxes).

As her empirical approach rests on evidence about the order of integration of the variables, some comments about the execution of the unit-root tests and the interpretation of their results are in order. First, it has been shown that the ADF unit-root test is not very powerful because of the need to estimate deterministic components (e.g., a constant and a linear trend). These are nuisance parameters that affect the distribution of the ADF test and make it more difficult to reject the null hypothesis of integration. Recently Elliot, Rothenberg, and Stock (1996) have developed a procedure, the Dickey-Fuller generalized least-squares (DF-GLS) unit-root test, that is much more powerful. Essentially their proposed test is constructed after the deterministic components are estimated on the basis of a quasi-difference of the original series so that the alternative hypothesis is more precisely defined. This test is becoming more widely used, and it might help in assessing evidence about the order of integration in the monetary aggregates. As it stands, McPhail's paper does not provide much detail on which specifications were retained for the deterministic regressors.

Second, the results of ADF (and DF-GLS) unit-root tests are dependent on the selection of the lag length on the first difference of the series in the empirical model that is estimated to compute the statistics. Too long a lag length will lead to a drop in the test's power, and too short a lag length will bias the test against the unit-root hypothesis. The use of Akaike's information criterion (AIC) to select this lag length has been known to be problematic. Ng and Perron (1995) found that this and other traditional information criteria tended to select models that were too parsimonious, thus leading to serious size distortions. Instead, they advocate the use of the data-dependent procedure, first suggested by Campbell and Perron (1991), according to which the lag length is selected on the basis of a recursive *t*-statistic procedure. More recently, Ng and Perron (1997) have also recommended, based on Monte Carlo experiments, the use of a modified AIC that takes into account the possible dependence of the estimated autoregressive parameter on the number of lags in the first difference of the series.

Third, one must be careful about the existence of negative moving-average components in the underlying data-generating processes (DGPs) of integrated time series. These are known to distort the size of usual unit-root tests (e.g., Schwert 1989 and DeJong et al. 1992) unless an appropriate method of estimation is used (e.g., Pantula and Hall 1991).

Fourth, given the indirect evidence of a change in the underlying DGP of inflation, I would have found it helpful had some empirical assessment of the unit-root hypothesis been reported for different subsamples. Also, a top-down approach to test for more than one unit root (e.g., Dickey and Pantula 1987) might well be advised and be preferable to a sequence of two separate unit roots on the level and the first difference of the series. I would also recommend that a recursive testing of the two unit roots be performed by varying the sample period in order to more systematically assess the possibility of a change in the underlying DGP of the aggregates.

Fifth, another issue pertaining to the stability of the DGP of the series is that of shifts or breaks in the mean and/or in the deterministic trend of a series. Such shifts may wrongly lead one to conclude that unit roots are present. Perron and Rodriguez (1998) have extended Elliot, Rothenberg, and Stock's DF-GLS test to account for the deterministic part of the process changing at an unknown time.

Taking these points into account may remove what might seem to be inconsistencies in results of unit-root tests of different measures of broad money.

When modelling the VECM systems, McPhail selected lag lengths on the basis of the FPE criterion. Yet no discussion is provided on the properties of the residuals of each respective equation. At the very least, tests of no serial correlation would be warranted. This is not a trivial issue to identify the dimension of a VECM, since both under- and over-parameterization of the system will distort inferences about cointegration. The former will lead to biases and inconsistencies in the estimator of a system's parameters and possibly a spurious finding of cointegration. The latter will lead to power problems and hence a tendency to find too little evidence of cointegration.

Some cautions are also warranted when inferring the dimension of the cointegrating space on the basis of the trace and maximum eigenvalue statistics, particularly with large systems in finite samples. In a sample of near or less than 100 observations, as is the case in McPhail's paper, the tabulated asymptotic critical values may be inappropriate. One solution is to correct the statistics for the numbers of estimated parameters. Reimers (1992) has proposed such an adjustment to the maximum eigenvalue statistic, and Reinsel and Ahn (1992), and Pitarakis (1995) have proposed corrections to the trace test.

McPhail mentions that Chow-type tests were performed to assess the evidence of breaks in the estimated money-demand functions, but provides few details. Her results also indicate variability in the estimates across various aggregates. I believe that, given its importance, the issue of stability would have deserved a more systematic and formal treatment and that more details would have been useful. In particular, an empirical assessment of stability of both the cointegrating rank and cointegrating space could have been conducted (as per Hansen and Johansen 1993).

To document whether broad money contributes significantly to price dynamics, individual error-correction models (ECMs) for prices were also estimated for two subsamples as well as for the whole sample. Hansen's (1992) test could have been useful to formally evaluate the stability of the ECM equations. One issue, however, pertains to the QPM measure of the output gap, which was included amongst the regressors in these equations. If this measure was obtained from a multivariate H-P filter, the estimator would be inconsistent. Furthermore, as shown by Orphanides and van Norden (1999), estimates of output gaps are typically very imprecise.

I very much like McPhail's idea of checking the information content of monetary aggregates in ECM price equations or/and in VECMs, especially in their recursive versions. The study of the money block's impact on the RMSE of inflation forecasts is particularly revealing. An interesting and useful addendum would have been the decomposition of the RMSE in terms of its bias proportion, its variance proportion, and its covariance proportion, this last representing the unsystematic forecast errors. Other dimensions of its forecasting ability could also have been considered, such as monetary aggregates' contribution to predicting the direction of change in inflation.

Another avenue would have been to test the significance of the contribution of monetary aggregates relative to that of other variables by applying Granger non-causality tests. Such tests could then be interpreted as a formal testing of the statistical significance of the information content of the various variables. However, we have to be careful about issues pertaining to the distribution of this test in the presence of unit roots and cointegrating relationships (see Toda and Phillips 1994).

Finally, the results may be interpreted as evidence that broad money does not act as a buffer stock. However, one cannot test this just on the basis of VECMs, which are reduced forms, with the dynamics being modelled jointly with the long-run relationship.

Implications of the Results and Issues for Monetary Policy and Future Research

The paper's title enticed me to expect a substantiation that broad money can guide monetary policy. This worthy goal goes beyond the paper's contribution, as the way money can be used as a guide is not addressed. Still, as McPhail argues, "If better forecasts of inflation can be obtained by including money, then a policy strategy that includes money has a higher chance of meeting the inflation targets and keeping inflation within the target bands" (pages 51–2).

Subject to some checking for robustness, McPhail's results suggest that broad money contains relevant inflation-forecasting information. It is therefore appropriate for the Bank of Canada to be explicitly concerned with the evolution of broad money in the conduct of the Bank's monetary policy, as far as it aims to pursue an inflation rate within the announced target band.

What would be useful now is to more precisely establish money's place in the conduct of monetary policy. One could conclude from McPhail's paper that broad money is arguably a relevant indicator for conducting monetary policy, broad money carrying useful information about the state of the economy that may signal future directions in inflation. For this reason alone, the Bank of Canada might want to reconsider whether it is paying enough attention to broad money, relative to other indicators (including the output gap).

Broad money could also play a more formal role as an intermediate target. If that were the case, the Bank of Canada could then seek, by acting on its operating targets, to keep broad money along a growth path consistent with the Bank's ultimate inflation objective. McPhail's evidence does not rule out that broad money could play such a role, especially since there seems to be evidence of a stable long-run demand for an appropriately defined measure of broad money. However, she does not clearly establish this role. Further research in this regard would be welcome.[4]

Another issue goes beyond the scope of McPhail's paper but, I believe, has been too readily dismissed by many central banks even though it pertains directly to money's place in the conduct of monetary policy (see McCallum 1999). Most central banks have opted to use a short-term or overnight interest rate as an operating target in place of a particular measure of the private banks' reserves or the monetary base.

If the monetary base were the operating target, a central bank would determine this aggregate's path in a way that the resulting growth path of a broad monetary aggregate would be consistent with the inflation objective for a given expected growth rate of real money demand and a given money multiplier. Expected changes in either real money demand and/or the money multiplier would lead to adjustments in the operating target.

With the overnight nominal interest rate as the operating target, a central bank must affect the path of this very short-term interest rate for long enough so that, along the yield curve, it affects the nominal interest rate that enters the real money demand function. This way, monetary policy must be

4. Even though the Canadian experience in the late 1970s and early 1980s with M1 as an intermediate target was unsatisfactory (mainly because of the extent of financial innovations at that time), a broader monetary aggregate could play a successful role as an intermediate target.

conducted so that the resulting path of broad-money growth is compatible with the ultimate inflation objective. Here, too, expected changes in real money demand resulting from changes in the expected growth rate of real economic activity and in the cost of financial intermediation will require adjustments to the operating target.

As shown in the appendix to my paper, the success of the monetary base as an operating target would depend on the uncertainty about the money multiplier relative to the overall uncertainty about money demand and on the uncertainty about the control of the relevant nominal interest rate. A sufficient condition for the superiority of the monetary base as an operating target is that the overall uncertainty about money demand be larger than the uncertainty about the money multiplier. This result is further reinforced when acknowledging a central bank's imperfect control over the relevant nominal interest rate, an even more imperfect control in the case of a small open economy with high capital mobility.

It is not because most central banks have resolved to use the nominal interest rate as the operating target that it is automatically the best one. Clearly this is an empirical matter that deserves additional work.

To conclude, I find McPhail's paper to be a very good invitation to further research. Such work is needed to better define the place of a broad monetary aggregate either as an indicator or as an intermediate target and to better identify its relationship with operational targets. It might also be worth reinvestigating how the use of a very narrow aggregate, such as the monetary base, as the operational target could fare relative to the performance of the overnight interest rate.

Appendix
Effects of Various Sources of Uncertainty on the Choice of an Operating Target

The following model is adapted from McCallum (1989) by adding uncertainty relative to a central bank's control of the relevant short-term interest rate.

Let real money demand be represented by

$$m_t = p_t + a_0 + a_1 y_t - a_2 i_t^c + \varepsilon_t , \tag{A1}$$

where m_t is the log of the broad-money aggregate, p_t the log of the price level, y_t the log of real GDP, i_t^c the nominal interest rate that enters the money-demand function, and ε_t is a white-noise random variable that summarizes the uncertainty about real money demand. Here, for discussion purposes, we can think of i_t^c as the 3-month nominal interest rate.

Taking the total derivative of equation (A1), we can see that, in equilibrium, inflation arises from the excess growth rate of the money supply relative to that of real money demand.

Let the supply of broad-money aggregate be represented by

$$m_t = b_0 + b_1 \ h_t + b_2 \ i_t^c + \zeta_t , \tag{A2}$$

where h_t is the log of the monetary base and ζ_t is a white-noise random variable that summarizes the uncertainty about the money multiplier, with variance $\sigma_\zeta{}^2$.

Let us define a combined expectations-error/money-demand disturbance as

$$z_t = p_t - p_t^e + y_t - y_t^e + \varepsilon_t , \tag{A3}$$

with variance σ_z^2.

Suppose that m_t^* is the quantity of broad money compatible with a growth rate in line with the central bank's inflation target. It can be shown that if the central bank were to choose the path of the monetary base as its operating target, the mean-squared error of inflation would be given by

$$E(m_t - m_t^*)^2 \Big|_{base} = \frac{a_2^2 \sigma_\zeta^2 + b_2^2 \sigma_z^2}{(a_2 + b_2)^2} . \tag{A4}$$

Instead, if the central bank uses the overnight interest rate as its operating target, it would like to establish the rate's value to yield a 3-month nominal interest rate that would in turn lead to a path for broad money compatible with the inflation objective. Let an imperfect control of the 3-month nominal interest rate along the yield curve be reflected as in

$$i_t^c = \bar{i}_t^c + \eta_t , \tag{A5}$$

where $\bar{i}_t^c$ is the target 3-month interest rate and η_t is a white-noise random variable that summarizes the uncertainty about the control of the interest rate, with variance σ_η^2. In this case it can be shown that the mean-squared error for inflation would be given by

$$E(m_t - m_t^*)^2 \Big|_{i^c} = \sigma_z^2 + a_2^2 \sigma_\eta^2 . \tag{A6}$$

This model implies that a sufficient, but not necessary, condition for the monetary base to be a superior operating target relative to the nominal interest rate is that the overall uncertainty about money demand be larger or equal to the uncertainty about the money multiplier. This would be true even if there were no uncertainty about controlling the 3-month nominal interest rate. For the overnight interest rate to dominate the money base in terms of mean-squared error, the uncertainty about the money multiplier would have to be large relative to the overall uncertainty about money demand, the elasticity of money demand relative to the interest rate would have to be relatively high (i.e., a_2 be large relative to b_2), and the uncertainty about the control of the nominal interest rate would have to be relatively small.

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Discussion

Tony S. Wirjanto

In her paper Kim McPhail addresses two important questions on the relationship between money and inflation in Canada. In particular she inquires whether stable long-run demand functions exist for broad money and whether broad money helps forecast inflation at the 4- and 8-quarter horizons after controlling for output and interest rate. After a somewhat exhaustive data search she concludes affirmatively for both questions, in particular when M2P with CSBs and mutual funds are used as the definitions of broad money.

In my discussion I will focus on her search for stable long-run money-demand functions, since that is a precursor to the second question her paper poses and will be somewhat technical. But in my conclusion I will attempt to look beyond the technical aspects of her paper and put it in a proper perspective, highlighting its potential contribution to the policy arena.

Most of what I will say is motivated by the results reported for the unrestricted long-run money-demand equations, from which her specification search takes off. In total, 12 empirical definitions of broad money are used in the study, ranging from the relatively more liquid aggregate (M2) to the relatively less liquid aggregate (M5), using quarterly data from 1970Q1 to 1998Q4 for the first six definitions and from 1970Q1 to 1996Q4 for the last six definitions. The Johansen-Juselius VECM is used as an organizing tool in the specification search from an unrestricted long-run money-demand specification to restricted ones that are thought to be data congruent.

My first comment inquires whether McPhail has included a drift term in her VECMs consistently throughout the specification search and if she has not, whether there is a strong argument for excluding it. I raise this question because allowing for a drift term in the VECM may dramatically alter the results obtained from a VECM without a drift term, including the nature of its stability or instability. Also, given the size of the data set used, it seems prudent to use some scheme to correct for a finite-sample bias of the test statistics used in the specification search, in particular the trace statistic, to minimize the frequency of over-rejections of no cointegration. There are a number of schemes available in the literature, and some of them are relatively straightforward to implement and some are not.

My second comment notes that while most inferential statements she makes are admirably done in a formal way, some, in particular those assessing the stability of the VECM estimates across the different definitions of broad money, lack formalism. It would be a good idea to adopt some formal way of discriminating between these various VECMs in terms of their in-sample stability performances in the absence of any theoretical underpinnings for these definitions. However, we can afford to forego this particular exercise if we are not searching for an optimal specification of money demand.

My third comment relates to the empirical modelling of VECM in general. The popularity of the VECM in recent years has largely to do with its ability to allow researchers to duck the issue of exogeneity in the modelling process. Unfortunately, this flexibility comes at a cost of compounding the issue of identification in an unrestricted VECM with more than one cointegrating vector. Many discussions on this issue, and hence on how to move from an unrestricted specification to a restricted one, have been made over the years, largely on the theoretical front. However, many of the proposed solutions, I am afraid, are either difficult or impossible to implement with a limited data size (such as 112 observations), a large number of variables (such as 5 or more), and longer lags for each of the variables (such as 3 or more), unless we first take a stance on the issue of exogeneity. The absence of an empirically tractable solution almost certainly will hamper an effective evaluation of the structural behaviour, including researchers' efforts to establish whether any structural changes have taken place within the sample—a possibility that has become the focus of investigation in McPhail's paper.

For example, if there are 5 variables and 3 lags for each variable in the unrestricted VAR model, we need to estimate, using only 112 observations, a total of 75 parameters. But if we treat 2 of the 5 variables as being weakly exogenous, the number of parameters to be estimated in the VAR would be reduced to 30. Clearly, in the absence of extra identifying assumptions, determining the correct number of cointegrating vectors is likely to be difficult and at best unreliable. This in turn will complicate the search for a correct specification of the structural VECM. It is desirable to classify variables in the VECM into exogenous and endogenous at the initial stage of the modelling, considerably reducing the number of parameters in the system and hence improving the performance of the tests for the number of cointegrating vectors. As a next step we can impose a set of just-identifying restrictions on the cointegrating vectors and enter these vectors in the VECM unrestrictedly, so that each equation for the endogenous variable will have all the cointegrating vectors included in it. As the cointegrating vectors are tested, not only can the model's dynamics be simplified and estimated, but also the model's causality can be established by eliminating inappropriate cointegrating vectors from each equation.

This brings me to my concluding remarks. My discussion of the technical aspects of McPhail's paper should not obscure its basic message: There are stable long-run demand functions for broad-money aggregates in Canada and these aggregates have good forecasting properties. For this statement alone she should be highly commended; her paper contributes to the argument that broad-money aggregates can play a role in forming monetary policy in Canada. To be sure, by itself the fact that no evidence of in-sample instability has been uncovered in the long-run demand functions for some of the broad-money aggregates she studied is no guarantee that these aggregates will be stable ever after. Nor do we expect this to be the case as the financial market evolves over time. However, their questionable stability is not a good enough reason for excluding them from being considered as an informal intermediate target of monetary policy; in particular it is possible to observe shifts when they occur and hence make proper allowances for their effects, and it is possible to use more than one aggregate in this role.

In closing, while the issue of the stability of broad monetary aggregates is important in assessing whether they are fit for use as an informal intermediate target of the monetary policy, it certainly should not be treated as a key issue. It seems to me that the central issue in this matter is how well these aggregates can be "controlled" by the monetary authority. And this issue of "controllability" by the monetary authority needs to be further studied and clarified in the near future.

General Discussion

David Laidler argued that the cointegrating relationships and the negative loading on the rate of interest on competing assets appeared to be consistent with a liquidity effect working through the structure of interest rates rather than an expectations effect. If it were simply a matter of expectations, he would have expected an excess of supplies of broad money and a positive increase of interest rates on competing assets. Instead, the evidence is consistent with an active-money story for broad aggregates working in a traditional textbook way. For example, an increase in money would drive down the nominal rates of return on competing aspects.

McPhail agreed that this interpretation may be possible, noting that the effects of the money gap on the interest rate are consistent across specifications and seem to be empirically important. Alain Paquet remarked that the two interpretations can be compatible. Since VECMs are reduced forms, even if interest rates are not significant, a change in interest rates may allow an interpretation consistent with Laidler's explanation.

Graeme Wells noted that money demand is unlike demand for real products. He suggested a specification whereby a VECM with adjusting nominal money balances is transformed into a model in which people adjust real money balances and inflation is a term on the right-hand side with a negative sign. This type of specification was tried in the 1970s and early 1980s and proved inconclusive, but may be worth revisiting and could possibly explain some of the inflation-forecasting results.

McPhail explained that in the approach Wells suggests, expected inflation is thought of as leading to a reduction in the level of money balances through a shift in the opportunity cost of holding money relative to competing assets. Her model contains a rate-of-return variable that captures

* Prepared by Carol Ann Northcott.

returns on assets, such as housing, that compete with broad money and are closely tied to inflation. Therefore an increase in this rate of return would lead to a decrease in real money balances.

Robert Jones observed that some of the measures of broad money include treasury bills or bonds, the stocks of which vary with fiscal positions. He wondered whether the forecasting value of broad-money aggregates might stem from the fiscal policy stance, which the model does not otherwise include as a variable. McPhail responded that this would not be a large concern empirically because the amount of government debt in the relevant measures is relatively small.

Finally, Stefan Gerlach from the Bank for International Settlements, made two suggestions to further the model. McPhail agreed that both suggestions were useful. First, in models such as this, where prices and money growth are I(2), a common parameterization is to include the real money stock and the inflation rate. Since inflation is nonstationary, it can be included in the VECM, and this would provide a direct test of whether the money gap feeds into inflation. His second suggestion was to include a time trend that might be cointegrated with the level of output. Detrended output would be a measure of the output gap, and one could then directly test if the output gap is more important than the money gap in driving inflation.