

**THE LONG-RUN STRUCTURE OF THE M2 DEMAND RELATION
IN CANADA: A COINTEGRATION ANALYSIS**

By

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Title of Project *The Long-run Structure Of M2 Demand In Canada: A Cointegration Analysis*

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ABSTRACT

The paper examines whether M2 demand in Canada does not form a cointegrated system unless the effective exchange rate is included in the sample. I focus on testing the statistical significance of the coefficient on the effective exchange rate in the long-run equilibrium M2 demand relation. Empirical results indicate that it is significant at the 1% level, which suggests that the effective exchange rate is necessary for Canadian M2 demand cointegration in the sample period.

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I Introduction

The purpose of this paper is to examine whether inclusion of the exchange rate is important to long-run money demand in Canada. A significance test of the coefficient on the exchange rate in an estimated cointegrating vector is used to test this hypothesis.

The major results of this paper can be summarized briefly; (1) the effective exchange rate is necessary for M2 demand cointegration in Canada (2) The long-run effective exchange rate elasticity is positive; this result indicates that a depreciation of the Canadian dollar leads to an increase in Canadian M2 demand. (3) The loading coefficient for the long-run equilibrium M2 demand relation in the error correction model is statistically significant at the 2% level. The results imply that the M2 error correction model contains an error correction term for the long-run equilibrium M2 demand relation.

This paper is organized as follows. Literature review is in section II. In Section III I explain the data and introduce the econometric model. In Section IV I report the empirical findings. A summary and discussion are given in Section V.

II Literature Review

The assumption of a stable long-run relationship between the stock of real money and an interest rate has been an integral part of macroeconomic theory and applied analysis of monetary policy for over fifty years. For many years, the central proposition of monetarism has been the proposition of a stable long-run aggregate demand for real balances (Fridman, 1956). The body of empirical evidence on this issue is mixed. Poole (1988) constructs a static OLS estimate of the relationship between U.S. M1 velocity and

interest rates for selectively chosen long samples over which nominal interest rates have no trend. He concludes that there is a substantial interest elasticity of M1 velocity.

According recent development in the econometrics of nonstationary data, Hoffman and Rasche(1991) apply econometric techniques (Johansen, 1988,1991) designed to account for the nonstationarities that prevail in the variables that constitute money demand. They find a cointegrating relation among real M1 balances, short-term interest rates, and real personal income, using U.S. data at monthly intervals. Dennis Hoffman and Robert Rasche further provide strong evidence for the stability of the long-run demand function for narrowly defined money (M1) in five industrial countries (U.S., Japan, Canada, U.K. and West Germany) using post-war quarterly data.

However, instead of evidence of the stable relation exists between M1 (transaction money)(Dennis Hoffman and Robert Rasche), real income and interest rate, it is of little consequence for monetary policy since the relationship between the demand for real money balance and the transaction money is so unstable that the demand function for transactions money is of no practical consequence.

Traditional studies on demand for money have often ignored the influence of foreign monetary developments. However, the question of the monetary linkages among national economies is addressed in the literature on international capital mobility. The focus of discussion in this literature is on the impact of adjustments in international reserves on the domestic money supply, with the assumption that aggregate demand for money in the country is inelastic with respect to foreign monetary developments, such as changes in the exchange rate. (Sebastian Arango and M. Nadiri)

Sebastian Arango and M. Nadiri generalize traditional demand functions for money

to take account of foreign monetary developments, such as changes in the exchange rates. The demand function for real cash balances deduced from this model is shown to depend upon domestic variables such as real income, the interest rate, as well as actual and anticipated foreign monetary development. The model is estimated using quarterly time series data for the period 1960 to 1975 from three major industrialized countries: Canada, the United Kingdom, and U.S..

One of the results is that the exchange rate plays an important role in portfolio decisions concerning the degree of substitution between money and foreign assets. When it is omitted, the empirical results point to significant misspecification biases in the traditional demand functions for real cash balances.

In the literature, there is also other empirical evidence. McNown and Wallace (1992) conclude that the effective exchange rate is necessary for M2 demand cointegration in the United States, using quarterly data from 1973:2 to 1988:4. Following McNown and Wallace (1992), Bahmani-Oskooee and Shabsigh (1996) give empirical evidence for this hypothesis with regard to the Japanese economy using quarterly data from 1973:1 to 1990:4. Bahmani-Oskooee and Shabsigh (1996) conclude that the effective exchange rate is necessary for M2 demand cointegration based on the fact that there is no evidence for M2 cointegration without the effective exchange rate, but there is evidence for M2 cointegration when the effective exchange rate is added. H.Yamada(1998) further tested if a relationship from the effective exchange rate to M2 money demand exists, and the empirical results indicate that the effective exchange rate is necessary for Japanese M2 demand cointegration. The purpose of this paper is to examine if the effective exchange rate is necessary for M2 demand cointegration in Canada during the sample period.

III Data and Econometric Model

I test the hypothesis using the following four variables: (a) real demand of money $M2+$ (m), (b) real personal income (y), (c) the nominal interest rate (r) (the 91-day Treasury bill rate), and (d) the nominal effective exchange rate (e).

A review of previous analyses showed a variety of different measurements regarding the definition of money. The lack of close correspondence between the theoretical variables and the observed variables makes it difficult a priori to know which definition of money is the most appropriate for an $M2$ demand relation. However, based on the literature, $M1$ (transaction money) is of little interest in this paper. I choose $M2+$ (chartered bank assets and liabilities and monetary aggregates) to measure real money balances. It is consistent with Sebastian Arango and M. Nadiri's paper (the demand for real money balance). $M2+$ is deflated by personal income deflator (p); the deflator is constructed as the ratio of current personal income to real personal income in 1992. (The time series of deflator is constructed by using the time series of current personal income dividing the time series of real personal income)

The nominal interest rate is the 91-day Treasury bill rate. In much of the traditional literature a short-term rate seems to be preferred. The nominal exchange rate (e) is a Canadian dollar index against C-6 currencies.

Monthly data such as the 91-day Treasury bill rate and $M2$ are transformed by averaging over the three months within the quarter. Real personal income, personal income deflator, and nominal $M2+$ are seasonally adjusted. All data are obtained from the 'Cansim' site and IMF site. The sample period used in this study is from 1980:1 to 2001:4.

The variables used in the model are: The natural log of deflated M2+ ($\ln(m/p)$); The natural log of deflated real personal income ($\ln(y/p)$); The natural log of 91-day Treasury bill rate ($\ln(i)$); and The natural log of nominal exchange rate ($\ln(e)$).

I identify the order of integration of each variable in the study using unit root tests. The details of the test are in the next part. It appears that the level of each series is nonstationary but the first difference of each series is stationary. This result supports the notion that each series is integrated of order one over the sample period used in the study.

I use the Johansen approach to estimate the model. A priori all of the variables in vector must be stochastic and therefore should be statistically modeled. I define

$x_t (m_t ; y_t ; r_t ; e_t) : (m_t - \ln(m/p); y_t - \ln(y/p); r_t - \ln(i); e_t - \ln(e))$ and specify the conditional VAR model as the basic statistical model.

The purpose of the cointegration test is to determine whether a group of non-stationary series is cointegrated or not. As explained below, the presence of a cointegrating relation forms the basis of the VEC specification.

Write this VAR as (equation1)

$$\Delta x_t = \mu + \delta t + \sum \Gamma_1 \Delta x_{t-1} + \Pi x_{t-k} + u_t \quad (1)$$

$$u_t \sim \text{i.i.d. } N(0, \Sigma u), t=1, \dots, T$$

Where the coefficient matrix Π conveys the long-run information in the data. When $0 < \text{rank}(\Pi) < p$, Π can be written $\Pi = \alpha \beta'$. Where β may be interpreted as a matrix of cointegrating vectors and α as matrix of error correction parameters. The constant μ allows for the possibility of deterministic drift in the data.

Johansen (1988) derives the maximum likelihood estimates for α , β , Γ_1 and a test statistic for the hypothesis that there are at most r cointegration vector, and develops

hypotheses test regarding individual elements of α , β .

According to Yamada(1992), δ is assumed to be zero, because the inclusion of the linear trend in Equation 1 implicitly assumes that variables possibly contain a quadratic time trend. Although Bahmai-Oskooee and Shabsigh (1996) report results both with and without a constant term (μ), Yamada deals only with the case with a constant term. This is because the exclusion of a constant term implicitly assumes that there is no linear trend in macroeconomic variables such as money balance and real income, and that there is no intercept term in the cointegrating relation, and this specification appears to be incorrect.

Theory suggests the expected signs are

coefficient of $\ln(y/p)$ and $\ln(e)$ are positive; coefficient of $\ln(i)$ is negative.

The direction of effects of income and interest rate on real cash balance is well known and therefore needs no further discussion. However, it would be useful to comment briefly on the direction of the effect of the exchange rate on desired stock of real money balance.

It can be explained in terms of portfolio rebalancing. After the C\$ depreciates the share of US\$ assets is higher than before. To get back to the original portfolio composition Canadians must increase their demand for C\$ assets. The crucial assumption is that people don't expect future C\$ depreciations. If they did, then they would want to reduce their C\$ holdings.

IV Empirical Results

4.1. Stationarity test

In order to examine the stationarity of the variables and the cointegrating relation among the variables, one must select an appropriate lag length k for the test and for the VAR model (Equation 1). I selected k using such model selection criteria as the Akaike Information Criterion (AIC) and the Hannan-Quinn Criterion (HQC), setting the maximum lag at 8 and the minimum at 1. Note that, since I set the maximum lag at 8, the first quarter of 1982 corresponds to $t = 1$ in Equation 1. As a result, for the sample period, AIC and HQC selected $k=3$. For these reasons, I set the lag length as three.

The results for the cointegration test do not necessarily represent the long-run equilibrium relation among the variables. This is because the number of cointegrating relations increases for each stationary variable included, as stated in Hansen and Juselius (1995, p.65). If there is one stationary variable in our system, then order-one cointegrating relations are trivial and there is no long-run equilibrium M2 demand relation. As a consequence, we conducted stationarity tests on each variable in the system using the ADF test.

The unit root test strategy must determine if an intercept, an intercept plus a time trend, or neither an intercept nor a time trend, should be included in the regression. On the basis of theoretical considerations and by looking at a plot of data against time, it is possible to simplify the test strategy, especially for macroeconomic data, as discussed in John Elder and Peter E. Kennedy (Testing for unit root). For example, by plotting the

data, I find that all of the variables are growing over time; So I choose the strategy, which is a t test $\rho = 1$ when estimating equation 1, which include intercept and trend.

Also in order to identify the order of integration, I test the variables both in log-levels and the log first differences. The result appears in table1 with the values of the test statistic in the top half of the table obtained from the log-levels of each series and the value of test statistics in the bottom half obtained from the log first differences of each series.

Variables	ADFTest Statistic	10%Critical Value	5% Critical Value	1% Critical Value	Test Result
Log-level of each series					
ln(y/p)	-0.252276	-2.5846	-2.8955	-3.5082	Fail to reject unit root
ln(m/p)	0.072015	-2.5846	-2.8955	-3.5082	Fail to reject unit root
ln(i)	-0.640916	-2.5846	-2.8955	-3.5082	Fail to reject unit root
ln(e)	-0.479550	-2.5846	-2.8955	-3.5082	Fail to reject unit root
First log-differences of each series					
ln(y/p)	-3.633584	-2.5846	-2.8955	-3.5082	a unit root
ln(m/p)	-3.430694	-2.5846	-2.8955	-3.5082	a unit root
ln(i)	-3.503499	-2.5846	-2.8955	-3.5082	a unit root
ln(e)	-3.50980	-2.5846	-2.8955	-3.5082	a unit root

Table1-stationarity test

The tests reveal convincingly that the first difference of each series is stationary about its mean. This conclusion remains regardless of the lag length or the test considered. The result support the notion that each serie is integrated of order one over the sample period used in my study. ($m_t - \ln(m/p)$; $y_t - \ln(y/p)$; $r_t - \ln(i)$; $e_t - \ln(e)$)

4.2. Cointegration test

Most macroeconomic time-series behave in a nonstationary manner. When the empirical model is estimated with data that are nonstationary in levels we discuss identification of the long-run structure, i.e., identification of the cointegrating relation.

By using the ADF test, I find that all variables are nonstationary. Hence, the standard VAR(k) model equation 1 can be transformed into a vector error correction model. In order to determine the cointegrating rank r , I utilized LRTs such as the trace test (Trace) and the maximum eigenvalue test (L-max), proposed in Johansen (1991).

The series have nonzero means and deterministic trends. Similarly, the cointegrating equations may have intercepts and deterministic trends. As a result, the asymptotic distribution of the LR test statistic for cointegration does not have the usual distribution and depends on the assumptions made with respect to deterministic trends. Therefore, in order to carry out the test, I need to make an assumption regarding the trend underlying the data.

For trending series, I use case 3 (intercept in VAR and CE) if all trends are stochastic; if some of the series are trend stationary, use case 4 (intercept and trend in CE and not trend in VAR). So here I use case 3 to test for cointegration. Table 2 reports the results. The hypotheses that stationary linear combinations exist among the log of real money balance, real personal income, the short-run interest rate and exchange rate are examined in table 2. The test results in this table generally reject the hypothesis of zero cointegration vectors and fail to reject the hypothesis of one cointegrating vector. The results for the cointegration test indicated that the cointegration rank is one.

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
Rank=0**	0.320251	55.26550	47.21	54.46
Rank=1	0.148856	22.83887	29.68	35.65
Rank=2	0.094865	9.300283	15.41	20.04
Rank=3	0.010986	0.927890	3.76	6.65

Trace test indicates 1 cointegrating equation(s) at both 5% and 1% levels

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
Rank=0**	0.320251	32.42662	27.07	32.24
Rank=1	0.148856	13.53859	20.97	25.52
Rank=2	0.094865	8.372392	14.07	18.63
Rank=3	0.010986	0.927890	3.76	6.65

Max-eigenvalue test indicates 1 cointegrating equation(s) at both 5% and 1% levels

Cointegrating	R=1	R=2	R=3
Log likelihood	957.8906	964.6599	968.8461

Table2-Trace test

4.3. Testing significance of effective exchange rate in VECM

From the results indicating the stationary cointegration, I further estimated the VECM by imposing the restrictions $B(1,1)=1$ to normalize the $\ln(m/p)$.

Table 3 reports estimates of the long-run equilibrium M2 demand relation for the sample. The value in parentheses represents the value of the wald test statistic for the

significance of parameters. In this table, '*' signifies that the corresponding parameter is statistically significant at the 1% level. Standard errors is in () .

$(m_t ; y_t ; r_t ; e_t) : (m_t - \ln(m/p); y_t - \ln(y/p); r_t - \ln(i); e_t - \ln(e))$			
$m_t = -12.81445 + 1.602157 y_t - 0.389060 r_t + 1.149567 e_t$			
	(0.11940)	(0.04730)	(0.19451)
	[13.4186]	[- 8.22600]	[5.91004]
	*	*	*

Table3-VECM unrestricted

The wald tests suggest that the coefficient of each variable in the cointegration vector is significant, which insure that the vector includes the entire menu of variables. The estimated coefficients of the cointegration vector of exchange rate are of considerate interest. First the wald test of the coefficient is significant at the 1% level. These results indicate that the effective exchange rate is necessary for M2 demand cointegration in Canada during the time period. Furthermore this result implies that the absence of the effective exchange rate in the system leads to no empirical evidence surporting M2 demand cointegration. I find no cointegration in the m2 demand when exchange rate is excluded. The result is reported in table 4.

From table 3, I also find that the elasticity of the long-run effective exchange rate is positive. The result indicates that increase in exchange rate (depreciation of the Canadian dollar) leads to an increase in M2 demand. This result is consistent with the analysis above. In addition, I find that estimates of the long-run elasticity of exchange rate are close to 1 during the sample time period.

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
Rank=0**	0.170522	23.16859	29.68	35.65
Rank=1	0.075594	7.464048	15.41	20.04
Rank=2	0.010202	0.861361	3.76	6.65

Trace test indicates no cointegration at both 5% and 1% levels

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.170522	15.70454	20.97	25.52
Rank=1	0.075594	6.602687	14.07	18.63
Rank=2	0.010202	0.861361	3.76	6.65

Max-eigenvalue test indicates no cointegrating equation(s) at both 5% and 1% levels

Table4-Trace test without exchange rate

In addition to estimating the long-run M2 demand relation, I also estimate the loading coefficient for long-run M2 demand relation in the M2 error correction model.

Table6 shows the result.

Error Correction:	D(LM)	D(LY)	D(LI)	D(LE)
CointEq1	-0.027520	-0.025285	-0.785979	0.116878
	(0.01369)	(0.01565)	(0.26242)	(0.03362)
	[-2.10978]	[-1.61548]	[-2.99507]	[3.47627]

Table6-Estimation of loading coefficient

α_{11} represents the (1,1) element of α in Equation 2. p -values for the significance test of α_{11} are less than 2% for the sample. These results indicate that the M2 error correction model contains the error correction term for the long-run equilibrium M2

demand relation. Combined with the fact that the effective exchange rate elasticity is marginally significant at 1% level, this result implies that the effective exchange rate causes M2 demand in Granger's sense.

Finally, I exam the coefficient in the cointegration. The income elasticity is 1.6; it is lager than the income elasticity in Hoffman and Rasche's paper (however they use M1 as the definition of money and the exchange rate is excluded). The coefficient of interest is between 0.3 and 0.4. This is consistent with the literature.

V Summary and Discussion

This paper has examined whether the effective exchange rate is necessary for M2 demand to form a cointegrated system in Canada. I examined quarterly data from 1980:1 to 2001:4,

My empirical findings may be summarized as follows:

- (i) The long-run effective exchange rate elasticity is significant at the 1% level in the sample. These results indicate that the effective exchange rate is necessary for M2 demand cointegration in Canada. In fact, I cannot find cointegration of M2 demand without the effective exchange rate in the sample.
- (ii) The long-run effective exchange rate elasticity is positive; this result indicates that an increase in the exchange rate leads to an increase in M2 demand.
- (iii) The loading coefficient for the long-run equilibrium M2 demand relation in the M2 error correction model is statistically significant at the 2% level in

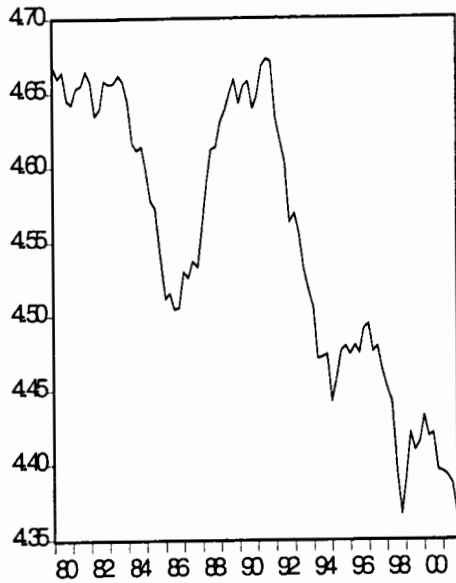
the sample. Combined with result (i), it implies that the effective exchange rate causes M2 demand in Granger's sense

Also there is a debate about the nominal interest rate in the model. In much of the traditional literature a short-term rate seems to be preferred. Poole (1988) argues for a long-term rate. If interest rates are cointegrated across the term structure, then the inclusion of a second-rate in the regression increase the dimensionality of the cointegration space. In order to identify individual cointegrating vectors sufficient exclusion restrictions must be provided by economic theory. If two-interest rate are cointegrated, then it is irrelevant which interest rate is excluded from the equilibrium specification. The estimated interest and income elasticity are invariant to the choice of the excluded rate (see Dennis Hoffman and Robert Rasche, 1994.) Further study on the term structure is needed to support the selection of the short-term interest rate.

Whether the conclusions of this project are important to policy makers depends on whether the cointegrating relationship is stable over time. Investigation of this issue is a subject for further research.

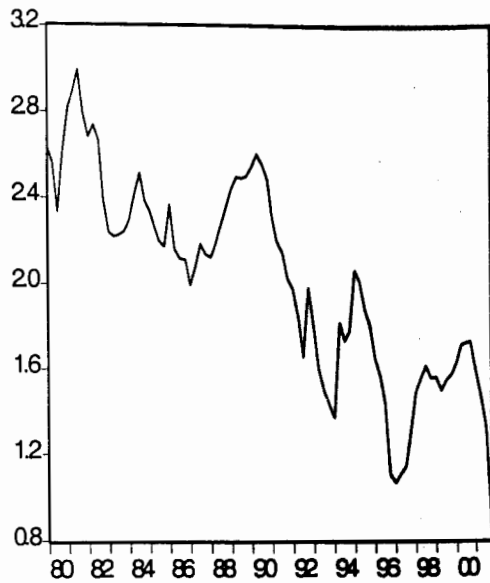
Appendix

$e_t - \ln(e)$



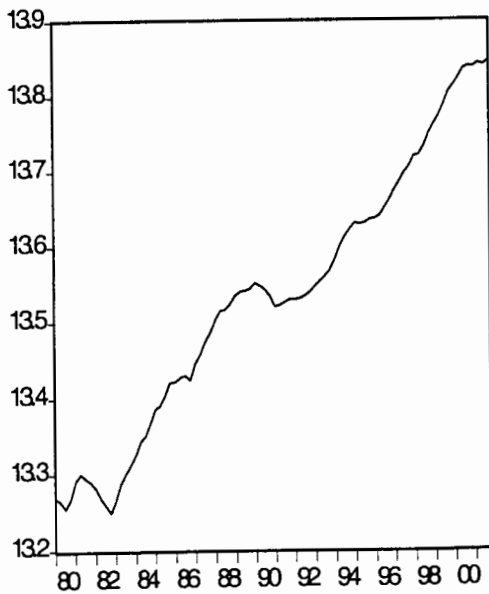
— LE

$r_t - \ln(i)$



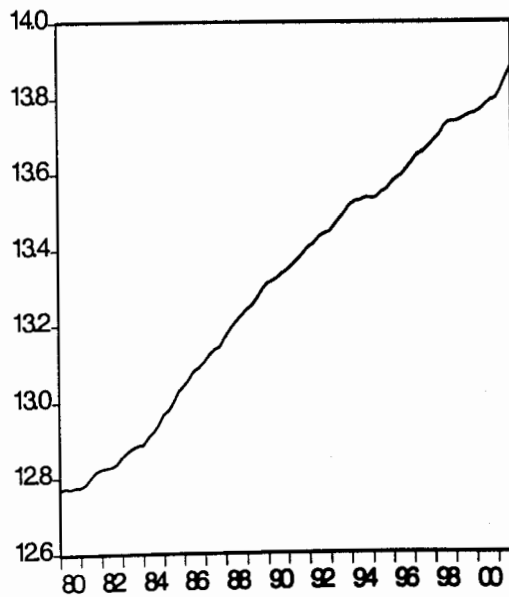
— U

$y_t - \ln(y/p)$



— LY

$m_t - \ln(m/p)$



— LM

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