RESERVE REQUIREMENTS AND MONEY MULTIPLIER PREDICTABILITY: THE CANADIAN EXPERIENCE

Kam Hon Chu[1]

Abstract

An argument against abolishing legal reserve requirements is that money multipliers would become more volatile and unpredictable in the absence of reserve requirements, thus impairing the central bank's effectiveness in controlling money aggregates. This study examines the Canadian experience during 1970-2004, where a zero reserve requirement regime has become fully effective since June 1994. The findings show that all money multipliers, except the M1 multiplier, under this current regime have become less volatile than before. Furthermore, short- and medium-term *ex ante* forecasts based on the Holt-Winters exponential smoothing model indicate that the money multipliers have not become apparently more unpredictable. Overall, the findings do not lend strong support to the monetary control argument for reserve requirements.

Key words: Reserve Requirements, Money Multipliers, Monetary Control, Holt-Winters Exponential Smoothing.
JEL Classifications: E51, E52.

I. Introduction

Banking is undoubtedly one of the most heavily regulated industries, and legal reserve requirements are one of the major forms of regulation commonly observed in most banking systems. Against the secular trend of financial deregulation since the 1980s, some industrial countries, such as Australia, Canada, New Zealand, Sweden, Switzerland and the United Kingdom, have abolished legal reserve requirements. However, the majority of industrial countries and almost all emerging economies still maintain legal reserve requirements (see, for example, Dupuis *et al*., 2005). A main argument for legal reserve requirements is that they serve as a monetary policy instrument, enabling the central bank to control the money supply and hence to influence aggregate economic activity through changes in legal reserve ratios[2]. Moreover, the central bank's control over reserve-deposit ratios through reserve requirements can make the money multipliers more stable and hence the money aggregates more controllable (see, for example, Stevens, 1991; and Feinman, 1993). In a money multiplier framework, lower reserve requirements imply larger deviations of the actual money stock from its desired level when there are either money demand shocks or money supply shocks (Weiner, 1992). This argument is commonly known as the monetary control argument for reserve requirements[3]. But as Mishkin (2001, p. 459) correctly points out, the evidence for or against this proposition is limited and hence the desirability of abolishing reserve requirements remains an open question.

---

[1] I would like to thank Rod Hill, Mohammed Kabir and participants at a seminar held at the University of New Brunswick at Saint John, Canada, for their helpful comments on an earlier version of this paper. All errors are, however, my sole responsibility.

[2] The major arguments for reserve requirements include the maintenance of liquidity and financial stability, as a means to influence credit conditions, and as a supplementary monetary policy tool. Among the major arguments against reserve requirements is that non-interest bearing reserves act as a kind of special tax on banks and hence they distort the optimal allocation of financial resources. For details of these arguments, see Clinton (1997), Ely (1997), Feinman (1993), Goodfriend and Hargraves (1982), Sellon and Weiner (1996), among many others.

[3] Most central banks nowadays have shifted their focus away from monetary aggregates to short-term interest rates in their monetary policy operating procedures. Nonetheless, there is a closely related issue and concern that lower reserve requirements or their absence can potentially lead to greater volatility of short-term interest rates and impair the effectiveness of monetary policy (see, for example, Sellon and Weiner, 1997; and Bennet and Hilton, 1997). To make the scope of this paper manageable, this issue will not be examined in detail here.

The main objective of this paper is to fill this gap by verifying the validity of the above proposition in practice. Reserve requirements were imposed on Canadian chartered banks when the Bank of Canada was established in 1935 and since then have undergone several reforms. Following the Bank Act of 1992, legal reserve requirements were to phase out within two years. Since June 1994 a zero reserve requirement regime has become fully effective, under which chartered banks are no longer legally required to hold any reserves against their customer deposits. The Canadian experience provides a natural laboratory for us to examine whether money multipliers have become more unstable and unpredictable after reserve requirements are abolished.

The importance of stable money multipliers in controlling monetary aggregates has been a critical issue in the debate on the choice between the reserve aggregate approach and the money market conditions approach in both the theory and practice of monetary policy (e.g., see Cobham, 1991). There are two necessary conditions for the reserve aggregate approach or monetary base control approach: (i) the central bank can control the sources of the monetary base, and (ii) the money multiplier should be predictable with a reasonable degree of accuracy. Over the last two decades, many central banks have shifted their emphasis from targeting reserves to targeting short-term interest rates. Under interest-rate operating procedures, reserve requirements become irrelevant from a direct monetary control standpoint (Weiner, 1992).

Nevertheless, the relationship between reserve requirements and money multiplier stability remains highly relevant to the formulation and implementation of monetary policy under interest-rate targeting for at least several reasons. First, shocks to the money multiplier still affect short-term interest rates (say, the central bank's discount rate) unless the central bank completely commits to pegging the interest rate and does not tolerate any deviations from its target (Hagen, 1990). Second, while the central bank can determine the general level of interest rates, it may not do equally well in determining interest-rate differentials. Its ability to influence the degree of financial intermediation through its discount rate policy may be weakened, particularly in economies with less developed financial sectors or with relatively large informal financial sectors. This is why reserve requirements, though frequently used, remain one of the monetary policy instruments available to central banks (Dupuis, 2005)[1]. Third, monetary aggregates continue to serve as useful and informative intermediate targets even though short-term interest rates are used as central banks' operational targets. Finally, the central bank may find it necessary and appropriate to switch back to reserve-oriented targeting procedures if the economy is subject to frequent shocks in money demand disturbances emanating from changes in aggregate spending (see the seminal work by Poole, 1970). In any case, the stability of the money multiplier is not entirely irrelevant to the implementation of monetary policy.

The empirical literature on the predictability or stability of the money multiplier can be traced back to Burger, Kalish and Babb (1971). The most widely adopted approach is the aggregate forecasting approach put forward by the seminal work of Bomhoff (1977), followed by Cesar and Haan (1989), Hafer and Hein (1984), Zaki (1995), among others. These studies apply the Box and Jenkins (1976) time-series technique to model and forecast the aggregate money multipliers. Another approach is the component approach advocated by Johannes and Rasche (1979, 1987), which applies the Box-Jenkins framework to model the various components of the money multiplier, i.e., the currency-deposit and reserve ratios; and the component forecasts are then used to generate money multiplier forecasts. By using more disaggregated information, this approach aims at providing more accurate forecasts than the aggregate method[2]. However, these studies did not explic-

---

[1] For instance, while the People's Bank of China sets interest rates on deposits and proposes a range for interest rates on loans by financial institutions, it raised the legal reserve ration in 2003 and 2004 in order to curb the rapid increase in liquidity in the financial sector.

[2] However, Hafer and Hein (1984) find that the aggregate approach forecast as well as the component approach, based on forecasts of US M1 multiplier for the period of January 1980 through December 1984; whereas Zaki (1995) find that, for the case of Egypt, the aggregate approach provided satisfactory forecasts but the component approach did not.

itly examine the variability and predictability of the money multipliers due to abolishment of legal reserve requirements.

This paper adopts the aggregate approach to examine the impacts of changes in legal reserve requirements on the predictability of the money supply multipliers in Canada. It differs from the above studies in that the Holt-Winters exponential smoothing technique rather than the Box-Jenkins technique is used to generate *ex ante* forecast of the money multipliers. Section III discusses the reasons for our choice of empirical technique. Our findings suggest that the money multipliers have not become more variable since the zero reserve requirement regime became effective in June 1994. On the contrary, all the money multipliers, except the M1 multiplier, have become less volatile. Nor have they become more unpredictable based on the forecasting performance of the exponential smoothing models (see Section III for details).

The outline of this paper is as follows. To facilitate the understanding and interpretation of the empirical work to follow, the next section briefly describes the history and institutional arrangements of reserve requirements in Canada, with a focus on the zero reserve requirements introduced in 1994. Section III discusses briefly the empirical procedures and reports the results. The last section concludes with the implications of our findings for reform of reserve requirements.

II. Reserve Requirements in Canada

Following the establishment of the Bank of Canada in 1935, chartered banks in Canada were legally required to maintain daily cash reserves in the form of Bank of Canada notes and deposits held at the Bank of Canada equal to 5% of their deposit liabilities from customers. Since then, the legal reserve requirements had undergone several reforms such as changes in the legal reserve ratios and the methods of calculation. The major reforms during the period under study included lagged reserve accounting introduced in 1980 and the weighting system for reserve calculations introduced in June 1986 (see, for example, Appendix 17A in Binhammer and Sephton, 2001, for details). But the most interesting and dramatic reform is the abolishment of legal reserve requirements following the Bank Act of 1992, which has significant and profound implications for both banking stability and the implementation of monetary policy.

A main objective of zero reserve requirements is to reduce volatilities in both settlement balances and short-term interest rates so as to enhance the effectiveness of monetary policy. Canada's current payments system consists of the large value transfer system (LVTS) and the Automated Clearing Settlement System (ACSS). The former is a real-time, electronic fund transfer settlement system for large-value, wholesale transactions over $50,000, whereas the latter is essentially paper-based and handles non-LVTS transactions like cheques. Although chartered banks are no longer legally required to hold reserves, participants in LVTS or direct clearers in the ACSS are required to maintain non-negative clearing balances with the Bank of Canada[1].

Under LVTS, participants are able to track in each trading day their LVTS receipts and payments in real time, thus eliminating most of the uncertainty in predicting the end-of-the-day settlement balances under the old payments system. The LVTS closes for client transactions at 6 p.m., followed by a pre-settlement trading period of half an hour in Bank-of-Canada clearing balances among participants themselves. This pre-settlement trading is expected to achieve a zero settlement balance for each participant because participants with surplus settlement balances would lend to those with deficit balances. At the end of the settlement day (at 8 p.m. or earlier), a participant with a debit (negative) balance has to take a collateralized overdraft loan from the Bank of Canada at the Bank Rate, whereas one with a credit balance is paid interest at the Bank Rate less 50 basis

[1] There are 13 LVTS participants who maintain a settlement account at the Bank of Canada. All other members of the Canadian Payments Association arrange LVTS payments through the LVTS participants. Similarly, there are 11 direct clearers in the ACSS who participate directly in the clearings and maintain settlement balances with the Bank of Canada; other members are known as indirect clearers are represented by the direct clearers in the clearing and settlement processes. All the eight largest chartered banks are LVTS participants and direct clearers.

points[1]. As long as the overnight bid-ask spreads in the interbank market are within the operating band announced by the Bank of Canada, participants should find it more profitable to resolve their nonzero clearing balances among themselves during the pre-settlement period than to have non-zero settlement balances at the Bank of Canada (see Clinton, 1997, for details about how the system operates). As a result, this framework motivates the banking system to target zero settlement balances at the Bank of Canada.

Similarly in the ACCS, direct clearers with net negative clearing balances on a settlement day make interest payments at the Bank Rate plus 150 basis points for their loans from the Bank of Canada for settlements. On the other hand, direct clearers with net positive clearing balances receive interest payments at the Bank Rate less 150 basis points. The large rate spread of 300 basis points provides incentives for direct clearers to resolve their non-zero clearing balances among themselves in an overnight interbank market in retroactive ACSS clearing balances.

In sum, the current institutional arrangements of the Canadian payments system essentially impose a penalty cost on chartered banks with negative clearing balances and an opportunity cost on those with excess settlement balances. Such costs provide incentives for chartered banks to target their clearing balances to zero, or as close to zero as possible, even though they are not legally subject to any legal reserve requirements.

III. Variability and Predictability of Money Multipliers

In Canada there are four basic money supply definitions: from the narrowest M1, which includes currency in public circulation and demand deposits held at chartered banks, to other broader ones like M2, M3 and M2+[2]. Based on these definitions, the multipliers are computed accordingly. All data are seasonally unadjusted (see the Data Appendix for more details) because our empirical technique will take care of seasonality. Our sample covers monthly observations for the period of January 1970 through December 2004 and is divided into four subsamples – 1975.01-1979.12, 1980.01-1986.06, 1986.07-1994.06, 1994.07-2004.12 – each representing a different reserve requirement regime[3].

Following the definition of variability by Christ (1986), Table 1 reports the variability of the money multipliers under different reserve requirement regimes. While the variability of the M1 multiplier has noticeably increased under the zero reserve requirement regime than it was in the previous regimes, all other multipliers have become apparently less variable almost across the board[4]. The findings suggest that zero reserve requirements have not resulted in a higher degree of uncertainty as far as the variability of the broader multipliers is concerned.

Following Bryant (1983), the monthly changes in the monetary aggregates are decomposed into changes in the monetary base and changes in the money multipliers. Table 2 shows the contributions of changes in the monetary base and those of the money supply multipliers to changes in the monetary aggregates under different reserve requirement regimes. Once again, the M1 multiplier differs from its broader counterparts. Under the current zero reserve requirement regime, the average monthly growth rates for M1, the monetary base and the M1 multipliers are respectively 0.85%, 0.37% and 0.48%. Thus, changes in the multiplier account for about 56% of the changes in M1. This percentage contribution is higher than the corresponding figures in the previous re-

---

[1] The Bank Rate is the interest rate charged by the Bank of Canada on its loans to members of the Canadian Payments Association. The Bank Rate is set at the upper band of the overnight rate.

[2] The precise definitions of money supply can be found in any monthly issue of *Bank of Canada Banking and Financial Statistics*. The Bank of Canada has recently introduced new money measures called M1+, M1++ and M2++ in response to financial innovation. These are modifications to the traditional money supply definitions M1 and M2+. To avoid excessive statistical reporting, we focus on the four traditional money measures here.

[3] Observations for the period of 1970.01-1974.12 are used to initialize the estimation rather than for forecasting evaluation.

[4] The only exception is the M2 multiplier, which was less variable during the period of 1975-1979 than it is under the current zero reserve requirement regime.

gimes. By contrast, the other money multipliers contribute less to changes in the monetary aggregates than before, not to mention that the M2 and M2+ multipliers have on average declined under the current zero reserve requirement regime. Overall, Table 2 suggests that in most cases the monetary base rather than the money multipliers is the main source for changes in the monetary aggregates.

Although a high degree of variability is often associated with a high degree of uncertainty, it has been correctly recognized that variability is not necessarily equivalent to unpredictability. As Christ (1986, p. 157) correctly points out, "it is not economic variability per se that creates risk and uncertainty; it is inability to forecast what will happen". In the following paragraphs, we examine whether the money multipliers have become more or less unpredictable after under zero reserve requirements. In the literature, both the aggregate approach (e.g., Bomhoff, 1977) and the component approach (e.g., Rasche and Johannes, 1979, 1987) have applied the Box-Jenkins method to examine the predictability of money multipliers. Post-sample *ex ante* forecast based on ARIMA models fitted for the sampling periods are generated and the root mean squared errors (RMSE) based on the residuals are commonly used as a criterion to evaluate the forecasting performance.

Instead of applying the Box-Jenkins technique, this study employs another widely-used forecasting method in practice – the Holt-Winters exponential smoothing technique (Holt, 1957; Winters, 1960; and Chatfield and Yar, 1988). For the purpose of our study, there are several reasons to justify our choice of the Holt-Winters technique over the Box-Jenkins technique. First, in practice parameters can be unstable because of regime changes (Hagen, 1990). But this important issue has not been explicitly considered by the empirical studies on money multiplier predictability[1]. As Figures 1-4 suggest, the money multipliers in Canada are nonstationary and have undergone shifts because of changes in economic conditions including changes in reserve requirements[2]. Second, apart from parameter instability, the ARIMA technique is likely to be subject to small sample bias if the entire sample is broken down into several sub-samples according to regime changes. Although the exponential smoothing technique is sometimes criticized for being *ad hoc* because of its unknown underlying data generating process, this *ad hockery* can be in practice a virtue rather than a vice when regime or structural changes are frequent. Third, exponential smoothing has shown to be equivalent to ARIMA models in some cases and to provide optimal forecasts (Bowerman and O'Connell, 1993; Abraham and Ledolter, 1986), even though our objectives are not to compare the forecasting performance of different forecasting techniques and to find the "optimal" forecast. For the purpose of our study, it suffices so long as if we can find *at least one* forecasting technique that predicts the money multipliers reasonably well after the abolishment of the legal reserve requirements. Ironically, our results (see later) show that the forecasting performance of exponential smoothing is not inferior to, in fact better than, its counterpart using more sophisticated econometric or time series techniques[3]. In short, exponential smoothing is simple and easy to implement and update on one hand and provides satisfactory forecasts on the other.

In our study, the Holt-Winters exponential smoothing model with trend and multiplicative seasonal variations is first applied to generate k-period ahead *ex ante* forecasts[4]. The forecasts are *ex ante* in the sense that the smoothing parameters are estimated using the observations available only up to the time when the k-period ahead forecasts are made. For example, the realizations of M1 and the monetary base up to May 1978 are used to compute the M1 multiplier, a model is fitted by

---

[1] Take the Netherlands as an example. Bomhoff (1977), Fase (1980) and Cesar and Haan (1989) draw different conclusion about the predictability of the money multipliers because different periods are examined.

[2] For illustration, Figures 1-4 show the actual money multipliers and their one-year ahead forecasts. As expected, the shorter term (one month, three months, and six months) forecasts are better than the one-year forecast. For brevity, however, the figures for these forecasts are not included here .

[3] Most, if not all, of the empirical studies using the Box-Jenkins technique do not produce superior results based on the commonly used forecast evaluation criteria such as mean absolute error and RMSE. For instance, Zaki (1995) finds that in the case of Egypt the RMSE of the multiplier forecasts range from 0.0603 to 0.5325 using the aggregate approach and from 0.1170 to 0.6800 using the component approach.

[4] The forecasts generated by the multiplicative model do not differ significantly from those of the additive model. For brevity, we focus on the former model. See the Mathematical Appendix for more details about the model.

the Holt-Winters method. Based on the estimated parameters, a one-month ahead forecast is computed to generate a forecast of the M1 multiplier for June 1978. This forecast is then compared with the actual value realized in June 1978 to generate the forecast error. The model is then re-estimated using the data up to June 1978 to generate the forecast and forecast error for July 1978, so on and so forth. The forecast errors are then used to evaluate the predictability of the money multipliers under different reserve requirement regimes. These procedures are repeated to generate three-month, six-month and one-year ahead *ex ante* forecasts to analyze the predictability of the money multipliers in both short- and intermediate terms. We use several criteria to evaluate the forecast results. The evaluation based on RMSE is tabulated as Table 3. Except in the case of the M1 multiplier, the values of the RMSE are not considerably higher after the implementation of the zero reserve requirement regime. Table 4 reports the results based on the RMSE in percentage form to take into account the scaling effect, i.e., the RMSE may also increase because the multipliers have increased in value over time. Except in certain few cases, the RMSE in percentage terms for the zero reserve requirement regime are in general slightly higher than those in the previous regimes. However, the differences are in general so small that they are of little, if any at all, material significance in practice.

Finally, Tables 5-8 report Theil's (1966) Inequality Coefficient and the decomposition of the mean squared errors (MSE) into the bias, regression and disturbance proportions. For a perfect forecast, the value of Theil's Inequality Coefficient is zero. The first two proportions of the decomposition are sometimes called "systematic errors". A large value of U^M, say above 0.1 or 0.2, means that the average predicted value deviates substantially from the average actual value, suggesting a systematic bias. For the optimal predictor, the values of U^M and U^R tend to zero. As the results indicate, the Holt-Winters model provides quite satisfactory *ex ante* forecasts for the money multipliers because the Theil's inequality coefficients all are less than 0.05, except in a couple of case, say, the one-year ahead forecast for the M1 multiplier, which has the highest value of 0.065. Furthermore, the forecasts based on the exponential smoothing model are better than the no-change forecasts (i.e., the *k* period-ahead forecast at time *t* is the same as the realization at time *t*) because the Theil's inequality coefficients are all less than one. It thus pays to use the Holt-Winters model to forecast the money multipliers because it provides more accurate forecasts than using the no-change forecasts. However, the bias and regression proportions show that there is room for improvement because they exceed 0.2 in value in some cases, particularly for the longer term forecasts. Overall, the above empirical results suggest that the abolishment of legal reserve requirements has little significant adverse impact on the variability and predictability of the money multipliers, except marginally in the case of M1.

IV. Conclusion

Some economists argue against abolishing legal reserve requirements because the money multiplier would become more volatile and unpredictable in the absence of reserve requirements, thus impairing the central bank's effectiveness in controlling money aggregates. However, this study has examined the Canadian experience and found that under the current zero reserve requirement regime all money multipliers, except the M1 multiplier, have become less volatile than before. Nor do the *ex ante* forecasts based on the Holt-Winters exponential smoothing model indicate that the money multipliers have become practically more unpredictable than before. Overall, our findings do not support the monetary control argument for reserve requirements.

These findings alone, however, by no means imply the abolishment of legal reserve requirements. Besides variability in money multipliers, some economists argue against abolishing reserve requirements because of their interest-rate smoothing effect (Bennett and Hilton, 1997; and Feinman, 1993). Interestingly, Bank of Canada's stated objective for introducing the zero reserve requirement regime is to reduce volatilities in both short-term interest rates and the demand for Bank of Canada balances so as to enhance its control of monetary policy. In fact, casual empiricism suggests that the volatility in short-term interest rates is reduced under the zero reserve requirement regime: the computed variance in the short-term interest rate is 2.2% for the period of

1994.07-2004.12, lower than 2.8% for 1975.01-1979.12, 11.9% for 1980.01-1986.06, and 7.8% for 1986.07-1994.06[1]. Whether interest rate volatilities are lowered under the zero reserve requirement regime deserves further research by its own right, but these findings are consistent with Bank of Canada's stated objective. More detailed case studies of Canada, New Zealand and the United Kingdom also show that the central bank can adopt appropriate mechanisms, like the institutional changes in the payments system in Canada, for providing liquidity to reduce interest rate volatility without the use of reserve requirements (Sellon and Weiner, 1997). In sum, our findings indicate that the abolishment of reserve requirements has led to less volatility in both money multipliers and short-term interest rates in Canada. It should be pointed out, however, that Canada's successful experience can be attributable to its oligopolistic banking structure that facilitates the Bank of Canada to gauge the demand for monetary base.

Admittedly, the implementation of monetary policy should not be the sole factor in determining the abolishment or reform of legal reserve requirements. Other factors should be taken into consideration as well. In particular, reserve requirements as taxes have important policy implications for financial development. The abolishment of reserve requirements removes the distortions due to such a tax, because banks no longer need to expend their resources to minimize their reserve holdings or to pass the tax burden to their customers in the form of lower deposit rates and higher loans rates. Therefore, the abolishment of reserve requirements not only creates a level playing field for all depository institutions but also lowers the operating efficiency of the banking industry. Similarly from a perspective of financial globalization, it discourages the relocation of business centers with lower or even zero reserve requirements and allow banks to compete more efficiently in the global financial markets. More than three decades ago, McKinnon (1973) and Shaw (1973) correctly pointed out that financial underdevelopment or repression in less developing countries is largely due to ill-conceived government interventions like interest-rate ceilings, high reserve requirements and directed credit programs. More recently, there is ample empirical evidence showing the positive relationship between financial development and economic growth across countries (see, for example, King and Levine, 1993; World Bank, 2001; and Goodhart, 2004, among many others).

To conclude, the empirical findings of this paper demonstrate that the abolishment of legal reserve requirements does not necessarily have any significant adverse impact on monetary control. After all, changing the legal reserve ratios is nowadays rarely used in practice as an instrument of monetary policy, not to mention that, even if used, its effectiveness is eroded by the existence of other non-bank financial intermediaries as well as financial innovation. Compared with other monetary policy instruments, it is at best an inflexible and discriminatory instrument. In practice, legal reserve requirements are not a completely indispensable tool for monetary control. On the other hand, reserve requirements have undesirable impact on financial development and allocation of financial resources. While both theory and the Canadian experience are not in favor of reserve requirements, we do not advocate uncritically the abolishment of reserve requirements. Undeniably, there is no one-size-fits-all policy recommendation in the reform of reserve requirements. Policymakers should take all the relevant factors into consideration and weight their costs and benefits, which vary from country to country, before they make the final decision in the reform process.

References

1. Abraham, B., and J. Ledolter (1986) "Forecast Functions Implied by Autoregressive Integrated Moving Average Models and Other Related Forecast Procedures", *International Statistical Review* 54: 51-66.

[1] The 7-day average of the overnight money market financing rate (CANSIM label V121753) is used as a proxy for short-term interest rates and weekly data are used in the computation.

2. Bennett, P., and S. Hilton (1997) "Falling Reserve Balances and the Federal Funds Rate", Federal Reserve Bank of New York, *Current Issues in Economics and Finance*, Volume 3, Number 5 (April): 1-6.
3. Binhammer, H.H., and P. Sephton (2001) *Money, Banking and the Canadian Financial System*, 8th edition. Scarborough: Nelson.
4. Bomhoff, E.J. (1977) "Predicting the Money Multiplier", *Journal of Monetary Economics* 3: 325-46.
5. Bowerman, B., and R. O'Connell (1993) *Forecasting and Time Series: An Applied Approach.* Belmont: Duxbury Press.
6. Box, G.E.P., and G.M. Jenkins (1976) *Times Series Analysis, Forecasting and Control*. San Francisco: Holden Day.
7. Bryant, R. (1983) *Controlling Money: The Federal Reserve and its Critics.* Washington, D.C: Brookings Institution.
8. Burger, A., L. Kalish and C. Babb (1971) "Money Stock Control and its Implications for Monetary Policy", *Federal Reserve Bank of St. Louis Review* (October): 6-22.
9. Cesar, H., and J. de Haan (1989) "Predicting the Money Multiplier in the Netherlands Once More", *Empirical Economics* 14: 215-27.
10. Chatfield, C., and M. Yar (1988) "Holt-Winters Forecasting: Some Practical Issues", *The Statistician* 37: 129-40.
11. Christ, C. (1986) "Accuracy of Forecasting as a Measure of Economic Uncertainty", pp. 154-60, in C.D. Campbell and W.R. Dougan (eds.) *Alternative Monetary Regimes*. Baltimore: Johns Hopkins University Press.
12. Clinton, K. (1997) "Implementation of Monetary Policy in a Regime with Zero Reserve Requirements", Working Paper 97-8, Bank of Canada.
13. Cobham, D. (1991) "The Money Supply Process", as Chapter 2, pp. 44-78, in C.J. Green and D.T. Llewellyn (eds.) *Surveys in Monetary Economics* Vol. 2. Oxford: Basil Blackwell.
14. Dupuis, F., *et al* (2005) *Guide to Monetary Policy of the Main Industrialized and Emerging Countries*, 2nd edition. Montreal: Desjardins Group Economic Studies.
15. Ely, B. (1997) "Time to Abolish Reserve Requirements", *The Golembe Reports*, Vol. 1997-7.
16. Fase, M.M.G. (1980) "Monetary Base Control: A Useful Alternative for the Netherlands?" *De Economist* 128: 189-204.
17. Feinman, J (1993) "Reserve Requirements: History, Current Practice and Potential Reform", *Federal Reserve Bulletin* 79: 569-89.
18. Goodfriend, M., and M. Hargraves (1982) "A Historical Assessment of the Rationales and Functions of Reserve Requirements", *Annual Report* of the Federal Reserve Bank of Richmond: 5-23.
19. Goodhart, C.A.E. (ed.) (2004) *Financial Development and Economic Growth: Explaining the Links*. New York: Palgrave Macmillan.
20. Hafer, R.W., and S. Hein (1984) "Predicting the Money Multiplier: Forecasts from Component and Aggregate Models", *Journal of Monetary Economics* 14: 375-84.
21. Hagen, J. von (1990) "Operating Targets and Information Variables in Money Multiplier Forecasting", *Weltwirtschaftliches Archiv*: 643-61.
22. Holt, C.C. (1957) "Forecasting Seasonals and Trends by Exponentially Weighted Moving Averages," unpublished research report, Carnegie Institute of Technology, Pittsburgh.
23. King, R.G., and R. Levine (1993) "Finance and Growth: Schumpeter Might Be Right", *Quarterly Journal of Economics* 108: 717-37.
24. Johannes, J., and R. Rasche (1979) "Predicting the Money Multiplier", *Journal of Monetary Economics* 5: 301-25.
25. Johannes, J., and R. Rasche (1987) *Controlling the Growth of Monetary Aggregates*. Boston: Kluwer Academic Publishers.
26. McKinnon, R.I. (1973) *Money and Capital in Economic Development.* Washington, D.C.: Brookings Institution.
27. Mishkin, F. (2001) *The Economics of Money, Banking and Financial Markets,* 6th edition. Addison-Wesley.

28. Poole, W. (1970) “Optimal Choice of Monetary Policy Instruments in a Simple Stochastic Macro Model”, *Quarterly Journal of Economics* 84(2): 197-216.
29. Sellon, G.H., Jr., and S. Weiner (1996) “Monetary Policy Without Reserve Requirements: Analytical Issues”, *Economic Review of the Federal Reserve Bank of Kansas City* 81(4): 5-24.
30. Sellon, G.H., Jr., and S. Weiner (1997) “Monetary Policy Without Reserve Requirements: Case Studies and Options for the United States”, *Economic Review of the Federal Reserve Bank of Kansas City* 82(2): 5-30.
31. Shaw, E.S. (1973) *Financial Deepening in Economic Development*. New York: Oxford University Press.
32. Theil, H. (1966) *Applied Economic Forecasting.* Rand McNally & Company.
33. Weiner, S. (1992) "The Changing Role of Reserve Requirements in Monetary Policy", *Economic Review of the Federal Reserve Bank of Kansas City* 77(4): 45-63.
34. Winters, P.R., (1960) “Forecasting Sales by Exponentially Weighted Moving Averages”, *Management Science*: 324-42.
35. World Bank (2001) *Finance and Growth: Policy in a Volatile World.* New York: Oxford University Press.
36. Zaki, M. (1995) “Forecasting the Money Multiplier and the Control of Money Supply in Egypt”, *Journal of Development Studies* 32: 97-111.

Data Appendix

All money supply data used in this study are seasonally unadjusted monthly data from the Canadian Socio-economic Information Management System (CANSIM II) database. The CANSIM II series labels for the monetary base, M1, M2, M3 and M2+ are respectively V37253, V37200, V37198, V37197 and V37216. The overnight money market financing rate is the average rate on a weekly basis and the CANSIM II series label is V121753.

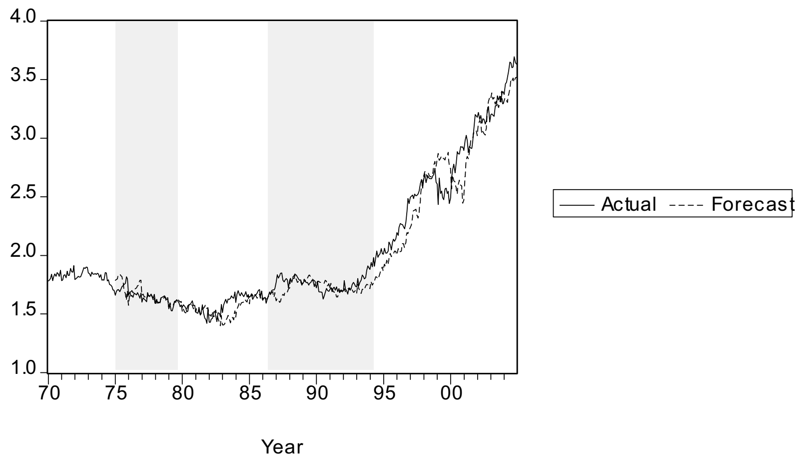

Fig. 1. M1 Multiplier and One-Year Ahead Forecast

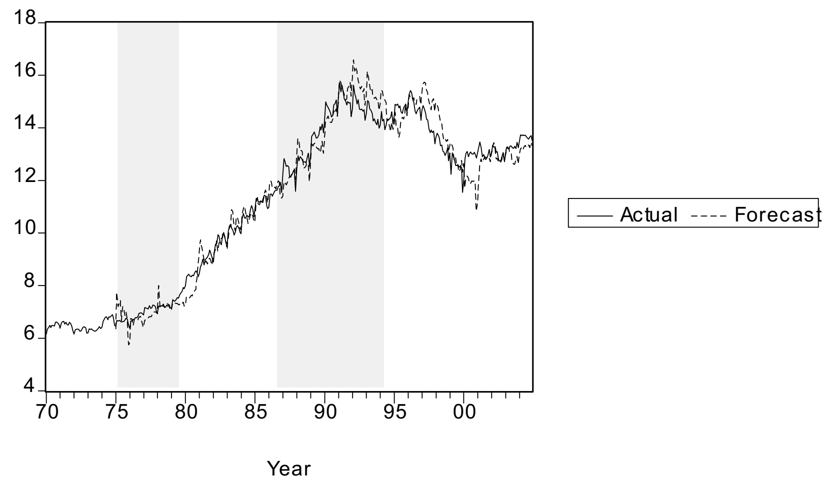

Fig. 2. M2 Multiplier and One-Year Ahead Forecast

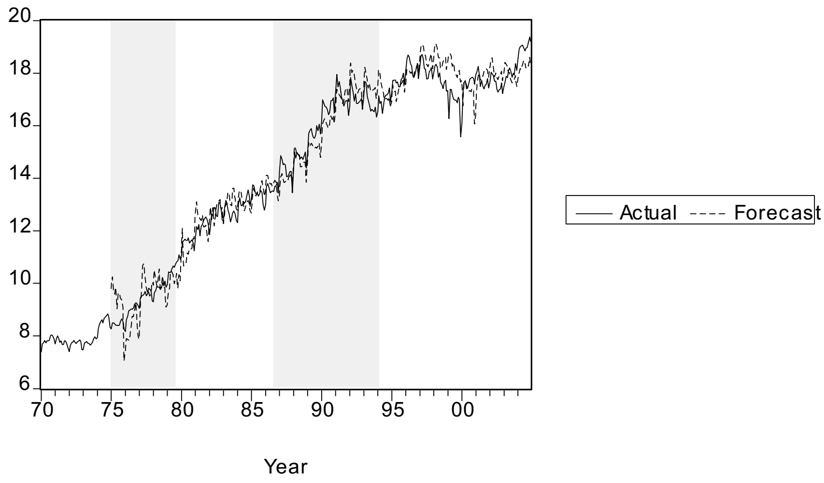

Fig. 3. M3 Multiplier and One-Year Ahead Forecast

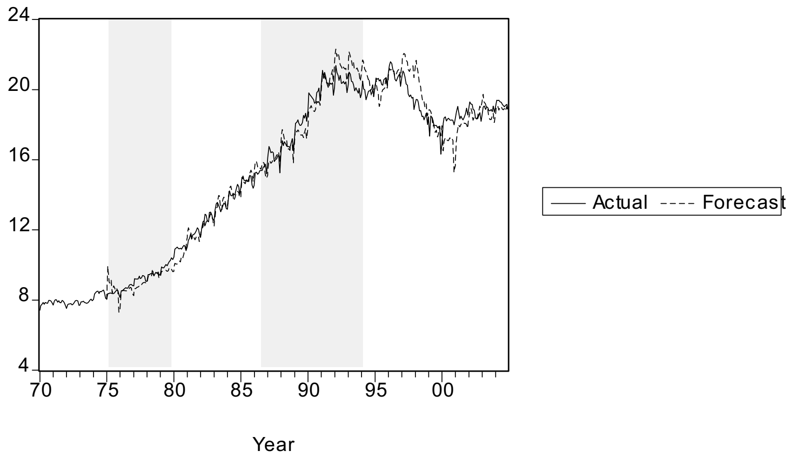

Fig. 4. M2+ Multiplier and One-Year Ahead Forecast

Table 1

Variability of the Money Multipliers

Period	Multiplier			
	M1	M2	M3	M2+
94.07-04.12	29.85	3.46	1.20	2.82
86.07-94.06	1.54	7.05	6.29	10.1
80.01-86.06	2.47	11.30	2.95	12.70
75.01-79.12	1.28	2.60	6.85	4.44

Notes:
1. Variability is defined as the variance of the logarithm of the level of the multiplier.
2. All entries are to be multiplied by 10^{-3}.

Table 2

Contributions to Changes in the Monetary Aggregates

Period	Monetary Base	Multiplier			
		M1	M2	M3	M2+
94.07-04.12	0.3725	0.4819	-0.0339	0.1076	-0.0313
		56.40	-10.01	22.41	-9.17
86.07-94.06	0.4125	0.1863	0.2042	0.2267	0.2552
		31.11	33.12	35.47	38.22
80.01-86.06	0.3102	0.0629	0.4451	0.2717	0.5114
		16.86	61.48	46.69	62.24
75.01-79.12	0.8983	-0.1287	0.3252	0.4498	0.4022
		-16.72	26.58	33.37	30.93

Notes:
1. All figures are in percentage (%).
2. For each period, the entries in the first row are the average monthly changes whereas those in the second row are the contributions of the multipliers to changes in the monetary aggregates.
3. The percentage change in the money supply (M) is decomposed into the percentage change in the money multiplier (m) and the percentage change in the monetary base (H) using the equations M = m H, and dlog x = dx/x for.

Table 3

RMSE of the Money Multiplier Forecasts

Forecast	Period	Multiplier			
		M1	M2	M3	M2+
1-Month	94.07-04.12	0.0639	0.2093	0.2802	0.2945
	86.07-94.06	0.0379	0.2057	0.2290	0.2637
	80.01-86.06	0.0341	0.1269	0.1855	0.1625
	75.01-79.12	0.0254	0.0655	0.0990	0.0758
3-Month	94.07-04.12	0.0930	0.2912	0.4028	0.4090
	86.07-94.06	0.0511	0.3151	0.3703	0.3870
	80.01-86.06	0.0453	0.2008	0.2931	0.2475
	75.01-79.12	0.0368	0.1183	0.1980	0.1324
6-Month	94.07-04.12	0.1274	0.4074	0.4885	0.5644
	86.07-94.06	0.0723	0.4572	0.5046	0.5451
	80.01-86.06	0.0588	0.2765	0.3391	0.3027
	75.01-79.12	0.0477	0.1875	0.3565	0.2128
1-Year	94.07-04.12	0.1811	0.6634	0.6767	0.9037
	86.07-94.06	0.0895	0.6307	0.5606	0.7630
	80.01-86.06	0.0837	0.4126	0.4738	0.4233
	75.01-79.12	0.0631	0.3608	0.7722	0.4216

Table 4

RMSE (%) of the Money Multiplier Forecasts

Forecast	Period	Multiplier			
		M1	M2	M3	M2+
1-Month	94.07-04.12	2.3810	1.6166	1.6446	1.6174
	86.07-94.06	2.1375	1.5338	1.5320	1.4677
	80.01-86.06	2.1915	1.2780	1.4844	1.2407
	75.01-79.12	1.5280	0.9074	1.0184	0.8162
3-Month	94.07-04.12	3.3818	2.1933	2.3217	2.1936
	86.07-94.06	2.8692	2.3079	2.3293	2.1017
	80.01-86.06	2.9162	2.0958	2.3580	1.9220
	75.01-79.12	2.2201	1.6381	2.0855	1.4291
6-Month	94.07-04.12	4.6536	3.0248	2.8114	2.9855
	86.07-94.06	4.0197	3.3373	3.1867	2.9488
	80.01-86.06	3.7348	3.0229	2.7661	2.4507
	75.01-79.12	2.8631	2.6314	3.8669	2.3277
1-Year	94.07-04.12	6.9421	4.9245	3.9061	4.7778
	86.07-94.06	4.9076	4.4511	3.4491	3.9456
	80.01-86.06	5.2340	4.5848	3.8450	3.4903
	75.01-79.12	3.7160	5.1960	8.6235	4.7735

Table 5

Evaluation of One-Month Ahead Forecasts

Period		Multiplier			
		M1	M2	M3	M2+
94.07-04.12	U_1	0.0229	0.0154	0.0157	0.0153
	U^M	0.0088	0.0020	0.0002	0.0019
	U^R	0.0107	0.0755	0.0496	0.0964
	U^D	0.9883	0.9304	0.9582	0.9097
86.07-94.06	U_1	0.0214	0.0148	0.0149	0.0140
	U^M	0.0178	0.0060	2.3×10^{-5}	0.0066
	U^R	0.0515	0.0703	0.0741	0.0654
	U^D	0.9408	0.9343	0.9364	0.9384
80.01-86.06	U_1	0.0215	0.0127	0.0146	0.0124
	U^M	0.0163	0.0014	0.0056	3.2×10^{-5}
	U^R	0.0428	0.0054	0.0384	0.0083
	U^D	0.9534	1.0061	0.9689	1.0046
75.01-79.12	U_1	0.0154	0.0093	0.0104	0.0083
	U^M	1.9×10^{-4}	0.0872	0.0224	0.1207
	U^R	0.0110	0.0072	0.0012	0.0025
	U^D	1.0058	0.9210	0.9929	0.8917

Notes:
1. In Tables 5-8, U_1 is Theil's Inequality Coefficient, whereas U^M, U^R, and U^D are respectively the bias proportion, regression proportion and disturbance proportion from the decomposition of MSE.
2. The sum of bias, regression and disturbance proportions may not be exactly equal to one because of rounding.

Table 6

Evaluation of Three-Month Ahead Forecasts

Period		Multiplier			
		M1	M2	M3	M2+
94.07-04.12	U_1	0.0332	0.0214	0.0226	0.0213
	U^M	0.0271	0.0026	0.0031	0.0004
	U^R	0.0206	0.1697	0.1418	0.1994
	U^D	0.9601	0.8357	0.8631	0.8081
86.07-94.06	U_1	0.0289	0.0226	0.0231	0.0206
	U^M	0.0644	0.0159	2.1×10^{-6}	0.0162
	U^R	0.0811	0.1710	0.1453	0.1589
	U^D	0.8643	0.8235	0.8653	0.8352
80.01-86.06	U_1	0.0436	0.0201	0.0231	0.0188
	U^M	0.0970	0.0019	0.0100	8.6×10^{-5}
	U^R	0.1013	0.0338	0.0876	0.0361
	U^D	0.8720	0.9772	0.9153	0.9767
75.01-79.12	U_1	0.0223	0.0167	0.0208	0.0145
	U^M	0.0005	0.1606	0.0231	0.2662
	U^R	0.0344	0.0025	0.0172	0.0051
	U^D	0.9823	0.8511	0.9763	0.7411

Table 7

Evaluation of Six-Month Ahead Forecasts

Period		Multiplier			
		M1	M2	M3	M2+
94.07-04.12	U_1	0.0456	0.0299	0.0274	0.0294
	U^M	0.0630	0.0049	0.0136	4.5×10^{-5}
	U^R	0.0350	0.2680	0.1283	0.3100
	U^D	0.9095	0.7350	0.8659	0.6979
86.07-94.06	U_1	0.0409	0.0328	0.0315	0.0290
	U^M	0.0966	0.0256	4.9×10^{-5}	0.0235
	U^R	0.1790	0.2490	0.1874	0.2329
	U^D	0.7339	0.7356	0.8231	0.7540
80.01-86.06	U_1	0.0370	0.0277	0.0268	0.0230
	U^M	0.0905	0.0002	0.0196	0.0037
	U^R	0.1382	0.1421	0.1677	0.1361
	U^D	0.7831	0.8707	0.8254	0.8583
75.01-79.12	U_1	0.0290	0.0265	0.0375	0.0232
	U^M	0.0066	0.1512	0.0090	0.3063
	U^R	0.1330	0.0025	0.0592	0.0068
	U^D	0.8772	0.8606	0.9486	0.6986

Table 8

Evaluation of One-Year Ahead Forecasts

Period		Multiplier			
		M1	M2	M3	M2+
94.07-04.12	U_1	0.0648	0.0487	0.0379	0.0470
	U^M	0.1225	0.0079	0.0414	7.5×10^{-5}
	U^R	0.0977	0.4452	0.2522	0.5080
	U^D	0.7869	0.5548	0.7141	0.4999
86.07-94.06	U_1	0.0507	0.0453	0.0350	0.0406
	U^M	0.1629	0.0743	0.0003	0.0487
	U^R	0.2491	0.4393	0.3771	0.4190
	U^D	0.5968	0.4962	0.6331	0.5423
80.01-86.06	U_1	0.0527	0.0413	0.0374	0.0322
	U^M	0.1986	0.0063	0.0511	0.0334
	U^R	0.1710	0.4005	0.3192	0.3846
	U^D	0.6408	0.6062	0.6420	0.5945
75.01-79.12	U_1	0.0383	0.0510	0.0812	0.0460
	U^M	0.1019	0.0474	0.0006	0.1407
	U^R	0.3744	0.2750	0.3055	0.0535
	U^D	0.5389	0.6937	0.7109	0.8204

Mathematical Appendix

To make the paper self-contained, this appendix explains the Holt-Winter exponential smoothing model and the Theil's Inequality Coefficient. More details can be found in the original papers as listed in the references.

For the Holt-Winter model, the k period ahead forecasts from time t, denoted as $m_{p,t}(k)$, are given by the following equation:

$$m_{p,t}(k) = (L_t + kT_t)I_{t-12+k}\,, \tag{1}$$

with the following updating equations:

$$L_t = \alpha\frac{m_t}{I_{t-12}} + (1-\alpha)(L_{t-1} + T_{t-1})\,, \tag{2}$$

$$T_t = \gamma(L_t - L_{t-1}) + (1-\gamma)T_{t-1}\,, \tag{3}$$

and

$$I_t = \delta(\frac{m_t}{L_t}) + (1-\delta)I_{t-12}\,, \tag{4}$$

where m_t is the new observation available at time t, L_t, T_t, I_t are respectively the local level, trend and seasonal indexes, and α, γ, and δ are the corresponding smoothing parameters estimated by minimizing the sum of squared residuals over a fitting period for which historical data are available.

For forecast evaluation, the Theil's Inequality Coefficient is defined as:

$$U_1 = \sqrt{\frac{MSE}{\sum m_{a,t}^2 / T}}, \tag{5}$$

where $m_{a,t}$ is the actual value of the money multiplier at time t, and T is the number of observations in the sample period. In the case of perfect forecasts, this measure is equal to zero. For the decomposition of the MSE, the bias proportion, U^M, is given as:

$$U^m = \frac{(\overline{m_p} - \overline{m_a})^2}{MSE}, \tag{6}$$

where m_a is the mean of the actual values of the multiplier and m_p is the mean of the predicted values. The regression proportion, U^R, is given as:

$$U^R = \frac{(\sigma_p - r_a)^2}{MSE}, \tag{7}$$

where σ_p is the standard deviation of the predicted values of the money multiplier, σ_a is the standard deviation of the actual values of the money multiplier, and r is the correlation coefficient between the actual and predicted values. Lastly the disturbance proportion, U^D, is given as:

$$U^D = \frac{(1 - r^2)\sigma_a^2}{MSE}. \tag{8}$$

The sum of the above three proportions is equal to one. The first two proportions are sometimes called “systematic errors” because a large value of U^M, say above 0.1 or 0.2, means that the average predicted value deviates substantially from the average actual value, suggesting a systematic bias.