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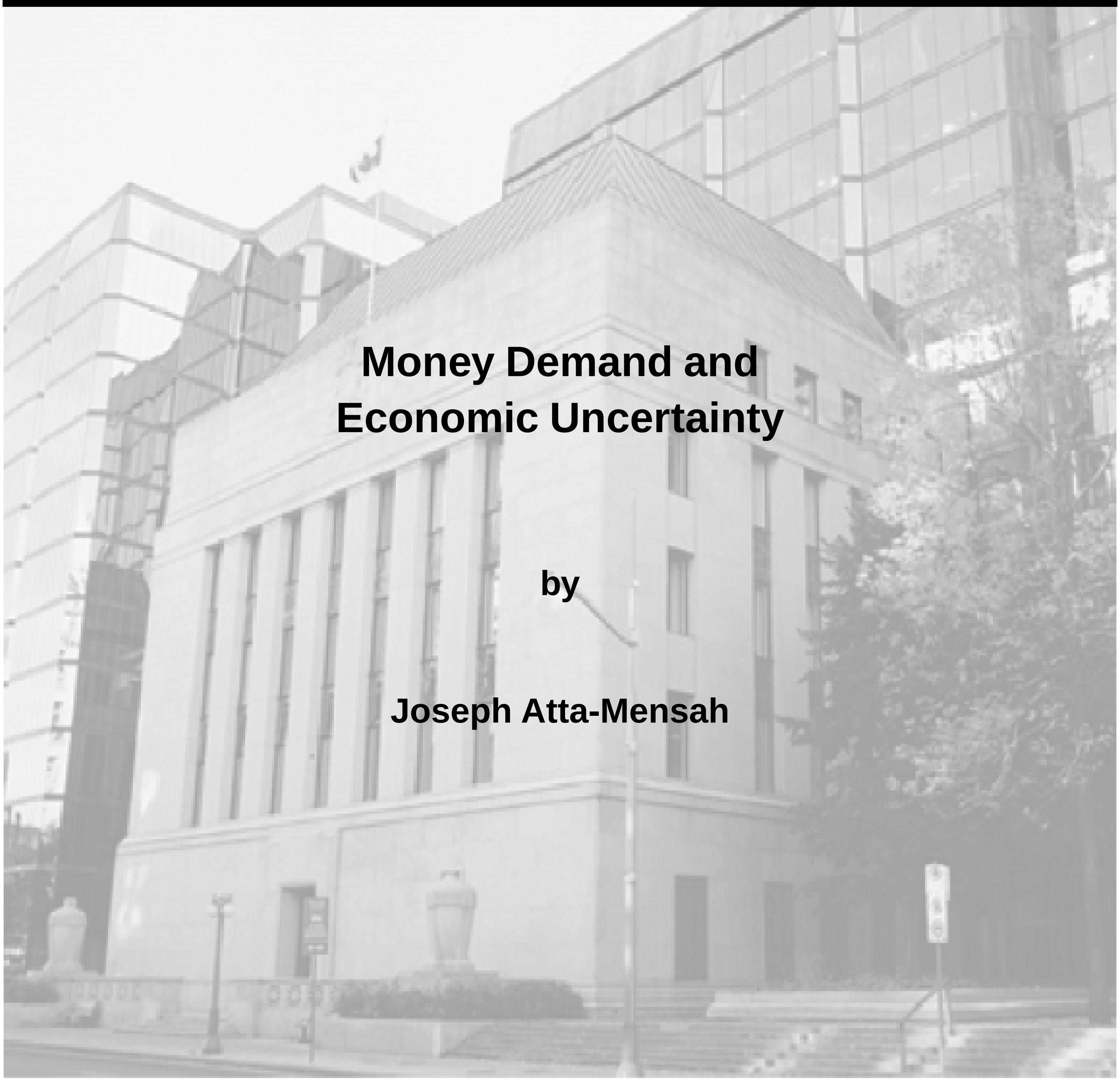

Money Demand and Economic Uncertainty

by

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Abstract

The author examines the impact of economic uncertainty on the demand for money. Using a general-equilibrium theory, he argues that in a world inhabited by risk-averse agents, who are constantly making portfolio decisions against a backdrop of macroeconomic uncertainty, the demand for money is a function of real income and interest rates, and an index of economic uncertainty. The author then uses the Johansen procedure of cointegration to estimate the long-run stationary relationships between a Canadian monetary aggregate (M1, M1++, and M2++) and the explanatory variables. Allowing for an index of economic uncertainty to enter the short-run dynamics of the estimated model, the author obtains empirical results that show that, in general, increased economic uncertainty leads, in the short run, to a rise in the desired M1 and M1++ balances that agents would like to hold. The impact of economic uncertainty on M2++ is, however, observed to be negative.

JEL classification: E41, E50
Bank classification: Monetary aggregates

Résumé

L’auteur examine l’incidence de l’incertitude économique sur la demande de monnaie. Partant d’un cadre d’équilibre général, il soutient que, dans un monde où les agents ont une aversion pour le risque et doivent prendre leurs décisions de placement dans un contexte d’incertitude au sujet de l’évolution de l’économie, la demande de monnaie est une fonction du revenu réel, des taux d’intérêt et d’un indice de l’incertitude économique. L’auteur fait appel au test de cointégration de Johansen pour estimer les relations stationnaires en longue période qui existent entre les agrégats monétaires canadiens (M1, M1++ et M2++) et les variables explicatives. Si un indice de l’incertitude économique est intégré à la dynamique à court terme du modèle estimé, les résultats empiriques montrent qu’en règle générale, une augmentation de l’incertitude économique donne lieu, à court terme, à un relèvement du niveau des encaisses entrant dans M1 et M1++ que les agents souhaitent détenir. L’incidence de l’incertitude économique sur M2++ se révèle quant à elle négative.

Classification JEL : E41, E50
Classification de la Banque : Agrégats monétaires

1. Introduction

Traditionally, money-demand functions are estimated as relationships between real money balances, a scale variable (often represented by real income or real wealth), and the opportunity cost of holding real money (calculated as the yield on a risk-free short-term bond, or the difference between that yield and yields on the components of the monetary aggregate). Recent behaviour of the monetary aggregates, however, cannot be explained by this simple relationship. A general reason given for the breakdown of the relationship is financial innovations. Although innovation in the financial sector of the economy has had a major impact on the demand function, it is argued in this paper that other factors, such as economic uncertainty, play an important role in an economic agent's decision on the level of money holding. The focus of this paper is to examine the impact of economic uncertainty on the money-demand functions for Canadian monetary aggregates (M1, M1++, and M2++). It is hoped that, through this exercise, the factors that influence an economic agent's decision to hold money will be better understood.

Money is held by economic agents for transactions or as a store of value. General uncertainty in the economy could have an impact on the quantity of money that agents are willing to hold. For example, an increase in interest rate risk, in the form of volatility, also increases the risk of bearing fixed-term interest-paying securities. Economic agents in this environment substitute these securities for more money. In the same vein, an increase in inflation uncertainty makes all nominal assets riskier, because their value in terms of goods and services becomes less predictable. Thus, in an uncertain inflationary environment, economic agents could shift out of nominal assets, including money, into tangible assets such as gold or commodities. Another influencing factor that might affect the quantity of money that agents are willing to hold is the uncertainty surrounding the stock market. A large number of economic participants, either through mutual funds or directly, are exposed to equity markets. Heightened uncertainty surrounding stock markets could induce agents to hold more riskless assets, including money, and fewer assets that are exposed to the stock market.

This paper is organized as follows. Section 2 presents a simple model to illustrate the impact of uncertainty or shocks on the demand for money. Section 3 derives a theoretical money-demand function. Section 4 provides estimates of money-demand functions. Section 5 offers some conclusions.

2. A Model to Derive a Money-Demand Function

The main features of the model of the money-demand function are borrowed from Ireland (1997 and 2001), Dib (2003), Kim (2000), Choi and Oh (2003), and others.[1] The economy is made up of four representative agents: a household, a finished-goods-producing firm, a continuum of intermediate-goods producing, and a monetary authority. In this economy, the finished goods are sold to households and to an intermediate-goods-producing firm at a perfectly competitive price, p_t. Each intermediate-goods-producing firm produces its output with labour and capital supplied by households, and the output is sold on a monopolistically competitive market. Furthermore, the preferences of the representative household in this economy are defined over consumption of the finished good, leisure, and real money balances. This section focuses on the optimization decision of the household, to derive a conventional money-demand function.[2]

The representative household maximizes its utility by choosing consumption, c_t, real money balances, M_t/p_t, and leisure, $(1-h_t)$. The preference function of the household is summarized by the expected utility function of the form:

$$U_0 = E_o \sum_{k=0}^{\infty} \beta^t \left[\frac{\gamma}{\gamma-1} \log\left(c_t^{\frac{\gamma-1}{\gamma}} + b_t^{\frac{1}{\gamma}} \left(\frac{M_t}{p_t}\right)^{\frac{\gamma-1}{\gamma}} \right) + \eta \log(1-h_t) \right], \tag{1}$$

where $\beta \in (0, 1)$ is the discount factor, γ and η are positive structural parameters, M_t is total money balance in the economy, and h_t is labour hours. In this paper, the suggestion by Kim (2000) is followed that b_t summarizes the money-demand shocks and is assumed to evolve as:

$$\log(b_t) = (1-\rho_b)\log b + \rho_b \log(b_{t-1}) + \varepsilon_{bt}. \tag{2}$$

ε_{bt}, the serially uncorrelated shock, is normally distributed with a mean of zero and a standard deviation of σ_b and $\rho_b \in (-1, 1)$.

At the beginning of period t, the household holds k_t units of capital, M_{t-1} units of money, and B_{t-1} units of government discount bonds. The household supplies capital and labour to the intermediate-goods-producing firms in perfectly competitive markets. The amounts supplied to each individual intermediate firm, j, are given by k_{jt} and h_{jt}, where $j \in [-1, 1]$. Therefore, aggregate capital and aggregate labour satisfy $k_t = \int_0^1 k_{jt} dj$ and $h_t = \int_0^1 h_{jt} dj$, for all t. The

1. Atta-Mensah (2004) derives a continuous-time version of a money-demand function.
2. For the derivation of the optimization decisions of the other participants in the economy, see Ireland (1997 and 2001), Dib (2002), Kim (1995 and 2000), Choi and Oh (2003), and others.

household derives its income from rent from capital, labour income, dividends from intermediate-goods-producing firms, $D_t = \int_0^1 D_{jt} dj$, and a lump-sum nominal transfer, T_t, from the monetary authority. From its income, the household purchases output from the finished-goods-producing firm at the price p_t, part of which it consumes while the remainder is invested. Capital in the economy accumulates as follows:

$$k_{t+1} = (1-\delta)k_t + i_t, \tag{3}$$

where i_t is investment and $\delta \in (0, 1)$ is a constant capital depreciation rate.

Let R_t be the nominal interest rate (or return on the government bond) between periods t and $t+1$, r_{kt} the real rental rate of capital, and w_t the real wage. The household's budget constraint is:

$$c_t + k_{t+1} - (1-\delta)k_t + \frac{M_t + B_t/R_t}{p_t} \le \frac{r_{kt}k_t + w_t h_t + M_{t-1} + B_{t-1} + T_t + D_t}{p_t}. \tag{4}$$

In each period $t = 0, 1, 2,...$, the household chooses c_t, h_t, M_t, B_t, and k_{t+1}, to maximize the utility function given by equation (1) subject to equation (4). Given λ_t, as the Lagrangian multiplier, the first-order conditions for the household's maximization problem are:

$$\frac{c_t^{-\frac{1}{\gamma}}}{c_t^{\frac{\gamma-1}{\gamma}} + b_t^{\frac{1}{\gamma}}(M_t/p_t)^{\frac{\gamma-1}{\gamma}}} - \lambda_t = 0, \tag{5}$$

$$\frac{\eta}{1-h_t} - \lambda_t w_t = 0, \tag{6}$$

$$\frac{b_t^{\frac{1}{\gamma}}(M_t/p_t)^{\frac{-1}{\gamma}}}{c_t^{\frac{\gamma-1}{\gamma}} + b_t^{\frac{1}{\gamma}}(M_t/p_t)^{\frac{\gamma-1}{\gamma}}} - \lambda_t + \beta E_t\left(\frac{p_t \lambda_{t+1}}{p_{t+1}}\right) = 0, \tag{7}$$

$$\frac{1}{R_t} - \beta E_t\left(\frac{p_t \lambda_{t+1}}{p_{t+1}\lambda_t}\right) = 0, \tag{8}$$

$$\lambda_t - \beta E_t\left[\lambda_{t+1}\left(\frac{r_{kt+1}}{p_{t+1}} + 1 - \delta\right)\right] = 0. \tag{9}$$

Equations (5) and (6) imply that the marginal rate of substitution between consumption and labour is equal to the real wage. Given that λ_t is the marginal utility of consumption, equation (8) indicates that the price of the government discount bond ($1/R_t$) is equal to the expected discounted value of the intertemporal marginal rate of substitution for consumption. Equation (9) equates the marginal utility cost of an additional unit of investment during period *t* with the discounted expected marginal utility value of its return during period *t*+1.

Next, using equation (8), equation (7) can be expressed as:

$$\frac{b_t^{\frac{1}{\gamma}}(M_t/p_t)^{\frac{-1}{\gamma}}}{c_t^{\frac{\gamma-1}{\gamma}} + b_t^{\frac{1}{\gamma}}(M_t/p_t)^{\frac{\gamma-1}{\gamma}}} = \lambda_t\left(1-\frac{1}{R_t}\right). \tag{10}$$

Combining equations (6) and (10) yields:

$$\left(\frac{b_t c_t}{M_t/p_t}\right)^{\frac{1}{\gamma}} = 1-\frac{1}{R_t}. \tag{11}$$

Let $r_t = R_t - 1$ denote the net nominal interest rate between *t* and *t*+1. $1/R_t \approx 1 - r_t$ can then be approximated and equation (11) rewritten as:

$$\log(M_t/p_t) \approx \log(c_t) - \gamma\log(r_t) + \log(b_t), \tag{12}$$

where γ is the interest elasticity of real money demand and b_t represents a serially correlated money-demand shock. Equation (12) clearly demonstrates that shocks to the economy do have an impact on the quantity of money that economic agents are willing to hold. The source of the money-demand shocks could come from a variety of areas in the economy: monetary and fiscal policies, financial markets, economic activities, and technological changes.

In this paper, it is postulated that these uncertainties are summarized by log(*b*) in equation (2), referred to here as the *n* index of economic uncertainty. The assumption of unitary income elasticity is relaxed. Furthermore, given that consumption is a fraction of income, c_t in equation (12) could be replaced with a measure for income.

3. Measuring the Sources of Economic Uncertainty

To empirically estimate a demand function summarized by equation (12) requires the knowledge of the risks or volatilities of the respective macroeconomic variables that cause the money-demand shocks. However, measuring risk or uncertainty in economics is a delicate task.[3] In this paper, it is assumed that risk and uncertainty are the same and will be proxied by a measure of volatility.

It is also assumed that the six main sources of economic uncertainty are the level of economic activity, the mood of the stock market, inflation uncertainty, exchange rate uncertainty, long-term interest rates, and short-term interest rates. It is argued that shocks to these variables, which serve as an index of economic activity, have a strong impact on the portfolio decision processes of economic agents, and therefore have a significant bearing on the quantity of money held by households.

Several different measures of conditional volatility have been proposed in the literature. A common measure is a generalized autoregressive conditional heteroscedasticity (GARCH) model. Bollerslev (1986), who proposed the GARCH model, suggests that the conditional variance of a time series depends upon the squared residuals of the process. By modelling the conditional variance in this manner, Bollerslev introduces heteroscedasticity to the conditional variance. Extending his earlier work, Bollerslev, Chou, and Kroner (1992) introduce a time-varying conditional variance, which they call GARCH(p, q). A macroeconomic variable, y_t, can be modelled as GARCH (p, q), as follows:

$$y_t = \mu_t + \varepsilon_t , \tag{13}$$

$$\varepsilon_t | \Omega_t \sim N(0, h_t) , \tag{14}$$

$$h_t = \sigma + \sum_{i=1}^{p} \beta_i h_{t-i} + \sum_{j=1}^{q} \alpha_j \varepsilon_{t-j}^2 , \tag{15}$$

where μ_t is the mean of y_t, conditional on the information set Ω_{t-1}. To ensure that the conditional variance, h_t, is positive, the following inequality restrictions are imposed: $\sigma > 0$, $\beta_i \geq 0$, and $\alpha_j \geq 0$.

3. Knight (1921) distinguishes between risk and uncertainty. Risk is assumed to be present if economic agents can assign numerical probabilities to random events. These probabilities may either be objectively specified, as with lottery tickets, or reflect the agent's own subjective beliefs. On the other hand, random events to which agents cannot assign probabilities are said to involve uncertainty.

The size and significance of α_j indicate the presence of an ARCH process in the residuals. In this paper, the volatilities, or the conditional variances, h_t, are estimated from a GARCH(1, 1) model.

Engle and Bollerslev (1986) suggest that if $\alpha_1 + \beta_1 = 1$ in a GARCH(1, 1) model, then there will be persistence of the estimated conditional variance over all finite horizons, and an infinite variance for the unconditional distribution of ε_t. Thus, the current shock persists indefinitely in conditioning the future variance. A model with $\alpha_1 + \beta_1 = 1$ is referred to as the integrated GARCH (IGARCH) model. Testing for the presence of IGARCH is equivalent to testing for unit roots in the conditional variance. Note that if the sum of α_1 and β_1 approaches unity, then the persistence of shocks to volatility (conditional variance) is greater and the decay rate of the shocks is slower.

In this paper, it is assumed that the factors that contribute to an uncertain economic environment in Canada, with the proxied variables in parentheses, are: the stock market (TSE index), the bond market (long-term interest rate), monetary policy uncertainty (90-day commercial paper rate), external shocks (the bilateral exchange rate between Canada and the United States), and economic activity (real GDP at factor cost). The volatilities of these variables are extracted by the GARCH technique described above. The economic uncertainty index (EUI) is then constructed as a weighted average of the estimated volatilities, with each of the volatilities standardized as the deviation from its mean and divided by the standard deviation. The measure of the EUI is therefore defined as:

$$EUI = \sum_i^n \lambda_i \left(\frac{vol_i - \overline{vol_i})}{\sigma_{vol}} \right), \tag{16}$$

where vol_i is the volatility of the factor that contributes to the source of uncertainty, $\overline{vol_i}$ is the average volatility, σ_{vol} is the standard deviation of volatility, and λ_i is the weight attached to each factor.

Quarterly data are used and the estimation interval is from 1960Q1 to 2003Q4. Table 1 reports the results from the GARCH(1, 1) model for the variables. For each variable, the estimate of the coefficient of the lagged error term is less than unity, which suggests that the shocks to volatility are not explosive. However, the measure of persistence ($\alpha_1 + \beta_1$) is high, which indicates that the shocks to volatility could persist and that the half-life of the initial shocks can be reached very quickly.[4]

4. Engle and Bollerslev (1986) define the half-life of a shock to volatility as $1 - [\log(2)/\log(\alpha_1 + \beta_1)]$. A half-life measures the period of time (number of quarters) over which a shock to volatility reduces to half of its original size.

The EUI is constructed based on equation (16). For simplicity, the components of the EUI are weighted equally. Figure 1 graphs the EUI. It shows that increased volatility of GDP, around periods of economic recession or slowdown (1972, 1982, 1991, and 2001), contributed to increased economic uncertainty (Figure 2). Also, increased variability of interest rates in the late 1970s and part of the 1980s, periods that coincide with high-level and volatile inflation plus excessive money growth, played a role in the rise in economic uncertainty around that period (Figures 3 to 5.) Supported by Figures 6 and 7, the EUI is also seen to capture the crash of the stock market in 1987, the "Asian crisis" of the autumn of 1998, and the "correction" of the market (or the bursting of the technology bubble) in late 2000 and early 2001. On average, the EUI appears to perform well, capturing most of the periods where the economy experienced heightened levels of economic uncertainty.

4. Estimates of Money-Demand Functions

In section 3, a theoretical money-demand function was derived. Based on equation (12), the money-demand functions are postulated as:

$$\frac{M_t}{P_t} = \beta_0 + \beta_1 y_t + \beta_2 r_t + \beta_3 EUI_t + \varepsilon_t , \tag{17}$$

where M is nominal money, P is the price level, y is real income, r is the interest rates, EUI is the proxy for economic uncertainty, ε is the error term, and βs are coefficients to be estimated.

Having estimated an EUI, an estimate is obtained of the demand functions for selected monetary aggregates (M1, M1++, and M2++). M1 and M1++ represent money used by agents for the transaction of goods and services; M2++, the broadest Canadian monetary aggregate, represents a saving vehicle for Canadian households. Besides the monetary aggregates, the variables used to estimate the money-demand functions are the 90-day commercial paper rate (R90) and real GDP. The monetary aggregates are all deflated by the CPI. With the exception of the interest rate, all the variables are in logarithm. The data used are quarterly and the estimation period is from 1968Q1 to 2003Q4.

To begin the empirical exercise, the Augmented Dickey-Fuller (ADF) diagnostic test is used to determine whether the variables being used are stationary. Table 2 reports the ADF results. The results show that, with the exception of EUI (the measure of economic uncertainty), all the variables have unit roots. This result suggests that EUI and the I(1) variables cannot be cointegrated, which implies that the long-run money-demand functions for the monetary aggregates cannot include EUI.

Based on the unit-root tests, the methodology of Johansen and Juselius (1990) is used to estimate the demand functions for the monetary aggregates. The general form of the estimated equation is as follows:

$$\Delta Y_t = \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + \ldots + \Gamma_p \Delta Y_{t-p+1} + \alpha\beta' Y_{t-1} + \delta EUI_{t-j} + \varepsilon_t, \quad (18)$$

where Y is a vector of a monetary aggregate, real GDP, and R90. The long-run cointegration parameters are summarized by the matrix β, and the coefficients of adjustment (or loadings) are summarized by the matrix α. Γ_i is a matrix of parameters that captures the model's short-run dynamics. Equation (18) implies that EUI is excluded from the long-run money-demand function, but present in the short-run dynamics. Hence the impact of economic uncertainty on the demand function is assessed by the statistical significance of δ.

An optimal lag-length for each of the aggregates is selected according to Akaike's Information Criterion (AIC). It should also be noted that the demand function is assumed to be homogeneous of degree one in prices. Tables 3 to 5 report the eigenvalues, λ-max, and trace test statistics for the cointegration analysis, and the critical values of Osterwald-Lenum (1992).[5] The results indicate that there is at most one cointegrating vector for each monetary aggregate. Table 6 reports estimates of the long-run demand functions for the monetary aggregates,[6] and estimates of the coefficient for the EUI, which were lagged 4 quarters to avoid contemporaneous regression problems.

The first column of Table 6 provides parameter estimates for a demand equation for M1. The results clearly show that increased economic uncertainty leads to an increase in the demand for M1 balances. An explanation for this result is that economic agents (households and firms) increase the level of M1 balances they hold in periods of heightened economic uncertainty for precautionary reasons, because production and the supply of goods and services tend to be uncertain in this period. Firms also build up their cash holdings in these times. The results show

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5. The critical values generated in Johansen and Juselius (1990) were obtained from asymptotic distributions. However, empirical analyses, by their nature, deal with finite samples, and therefore the quality of the asymptotic approximations to critical values in finite samples is very important. Work by Godbout and van Norden (1996), Cheung and Lai (1993), and others finds that asymptotic critical values are biased towards finding cointegration. For these reasons, critical values computed by Osterwald-Lenum (1992) are used to determine the number of cointegrating vectors.

6. Because all the variables in equation (18) are endogenous, caution must be used in interpreting the cointegrating vectors as traditional elasticities of money-demand functions.

that the income elasticity (0.52) and the interest semi-elasticity (–0.25) are close to those found in the literature. The Baumol model suggests that the income elasticity for transactions money is close to 0.5.

Estimates for the demand for M1++ are reported in the second column of Table 6. As expected, results show a positive relationship between the EUI and M1++. It is suggested that, as with M1, economic agents build up their M1++ balances as a precaution to circumvent unforeseen expenditures. Moreover, increased volatility of financial markets in periods of economic uncertainty causes economic agents to flee the stock market and pack their money in safer assets, such as M1++. The income elasticity of M1++ is estimated as 1.18 and the semi-interest elasticity is –0.033. By the standard of the Baumol model, the income elasticity of M1++ may be high for a transaction monetary aggregate.

Estimates for the demand function for M2++ are provided in the last column of Table 6. The results show a negative relationship between the EUI and M2++, which supports the view that, in times of increased economic uncertainty, economic agents find real assets more attractive than nominal assets. Furthermore, in times of heightened economic uncertainty, financial markets tend to be unstable, forcing risk-averse economic agents to move out of mutual funds, the major component of M2++, and use safer assets as vehicles for savings. The estimated elasticities for income and interest rates conform to those obtained in the literature.

The stability of the parameter estimates of the demand functions is also examined. Using the methodology of Johansen and Juselius, the hypothesis of structural stability is tested recursively by examining the constancy of the parameters of the cointegrating vectors. Figures 8, 9, and 10 show the results of the test regarding the constancy of the cointegration space for the functions estimated.[7] The figures show that the functions have been stable since 1985.

7. There are two graphs in each figure: BETA_Z and BETA_R. The two graphs capture two methods of evaluating parameter constancy (or stability) in a cointegrated VAR model. BETA_Z is the plot of the χ^2 test statistic obtained when all the parameters in the model are estimated recursively. In the case of BETA_R, all the short-run parameters are fixed, whereas the long-run parameters are estimated recursively. In a sense, one can interpret BETA_Z and BETA_R, respectively, as a strong and weak test of the parameter constancy of the cointegrating vector. Therefore, it is argued that, if one is interested in only the stability of the demand functions, then a test conducted with BETA_R is sufficient. However, if one is to use the estimated vector-error-correction model (VECM) for forecasting variables, such as inflation or money growth, then BETA_Z is necessary. Note that, in the figures, the χ^2 test statistic has been normalized so that unity represents a test with a 5 per cent significance level.

5. Conclusion

This paper has examined the impact of economic uncertainty on the money-demand functions. In carrying out this task, an EUI was constructed using GARCH techniques. This exercise was undertaken in the belief that the traditional specification of money-demand functions as relationships between real money balances, a scale variable, and an opportunity cost of holding real money is very restrictive. It has been argued that, by specifying the demand function in this form, one is assuming that money is held only for transactions purposes. Two reasons have been proposed as to why the traditional demand function is very restrictive. First, if economic agents' decisions to hold money stems from finding the proper mix for their investment portfolio, then the optimal level of money held by them will be influenced by both the level and volatilities (variances) of the scale variable and the opportunity costs. Second, rational economic agents are generally risk-averse and do require compensation for any additional risk they take. This suggests that the general level of economic uncertainty does play an important role in the quantity of money demanded by risk-averse economic agents.

Using general-equilibrium theory, the demand for money has been derived as a function of real income and short-term interest rates, and as an EUI. The Johansen and Juselius procedure of cointegration was then used to estimate the long-run stationary relationships between a Canadian monetary aggregate (M1, M1++, and M2++) and the explanatory variables. Allowing for an EUI to enter the short-run dynamics of the estimated model, further empirical results showed that, in general, increased economic uncertainty leads, in the short run, to a rise in the desired M1 and M1++ balances that agents would like to hold. The impact of economic uncertainty on M2++ was, however, observed to be negative. This result supports the view that general economic uncertainty reduces agents' appetites for risky assets. In this environment, agents substitute riskier assets (equities and mutual funds) for safer assets (guaranteed investment certificates and money market mutual funds). In addition, uncertainty surrounding the production and the supply of goods and services in periods of increased economic uncertainty induces agents to increase their level of money holding for precautionary reasons. Furthermore, in periods of economic uncertainty, real assets, such as houses and precious metals, are more attractive than nominal assets. All these factors contribute to increasing the level of transaction balances (M1 and M1++) and to reducing M2++.

References

Atta-Mensah, J. 2004. "The Demand for Money in a Stochastic Environment." Bank of Canada Working Paper No. 2004-7.

Bollerslev, T. 1986. "Generalized Autoregressive Conditional Heteroscedasticity." *Journal of Econometrics* 31: 307–27.

Bollerslev, T., R. Chou, and K. Kroner. 1992. "ARCH Modelling in Finance." *Journal of Econometrics* 52: 5–59.

Cheung, Y-W. and K. Lai. 1993. "Finite-Sample Sizes of Johansen's Likelihood Ratio Tests for Cointegration." *Oxford Bulletin of Economics and Statistics* 55: 313–28.

Choi, W.G. and S. Oh. 2003. "A Money Demand Function with Output Uncertainty, Monetary Uncertainty, and Financial Innovations." *Journal of Money, Credit and Banking* 35: 685–709.

Dib, A. 2003. "An Estimated Canadian DSGE Model with Nominal and Real Rigidities." *Canadian Journal of Economics* 36(4): 949–72.

Engle, R. and T. Bollerslev. 1986. "Modelling the Persistence of Conditional Variance." *Econometric Review* 5: 1–50.

Godbout, M.-J. and S. van Norden. 1996. "Unit Root Tests and Excess Returns." Bank of Canada Working Paper No. 96-10.

Ireland, P.N. 1997. "A Small, Structural, Quarterly Model for Monetary Policy Evaluation." *Carnegie-Rochester Conference Series on Public Policy* 47: 83–108.

———. 2001. "Sticky-Price Models of the Business Cycle: Specification and Stability." *Journal of Monetary Economics* 47: 3–18.

Johansen, S. and K. Juselius. 1990. "Maximum Likelihood Estimation and Inference on Cointegration — with Application to the Demand for Money." *Oxford Bulletin of Economics and Statistics* 52: 169–210.

Kim, J. 2000. "Constructing and Estimating a Realistic Optimizing Model of Monetary Policy." *Journal of Monetary Economics* 45: 329–59.

Knight, F.H. 1921. *Risk, Uncertainty, and Profit*. Boston, MA: Hart, Schaffner and Marx; Houghton Mifflin Company.

Osterwald-Lenum, M. 1992. "A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics." *Oxford Bulletin of Economics and Statistics* 54: 461–72.

Table 1: GARCH (1, 1) Test Results[a]

$$y_t = \mu_t + \varepsilon_t$$

$$h_t = \sigma + \beta h_{t-1} + \alpha\varepsilon_{t-1}^2$$

	CPI	RGDP	R90	RLT	EXR	TSE
μ	0.003 (22.408)	0.003 (12.297)	0.028 (3.038)	0.011 (2.266)	0.001 (2.175)	0.020 (4.207)
σ	0.0002 (13.439)	0.0006 (11.467)	0.006 (10.887)	0.001 (4.448)	0.0002 (29.000)	0.103 (2.056)
β	0.252 (16.538)	0.158 (6.382)	0.220 (31.052)	0.177 (17.632)	0.061 (4.343)	0.130 (2.547)
α	0.652 (67.185)	0.639 (33.485)	0.614 (22.435)	0.632 (27.004)	0.694 (78.454)	0.694 (5.855)

a. *t*-statistics in parentheses.

Table 2: ADF Test for Unit Roots (1968Q1 to 2003Q4)[a]

Variable	***k***	t_ρ	**Outcome**	**Order of integration**
M1	5	0.2785	Accept H_0	I(1)
ΔM1	4	–84.1390	Reject H_0	I(0)
M1++	9	–1.0515	Accept H_0	I(1)
ΔM1++	8	–54.3557	Reject H_0	I(0)
M2++	7	–1.2996	Accept H_0	I(1)
ΔM2++	6	–27.8634	Reject H_0	I(0)
Real GDP	4	–0.5734	Accept H_0	I(1)
ΔReal GDP	3	–92.4727	Reject H_0	I(0)
CPI	8	–1.2635	Accept H_0	I(1)
ΔCPI	7	–28.5168	Reject H_0	I(0)
R90	1	–11.0087	Accept H_0	I(1)
ΔR90	0	–111.8748	Reject H_0	I(0)
EUI	1	–21.2771	Reject H_0	I(0)

a. The tests are based on the Augmented Dickey-Fuller Z-test. The critical value at the 5 per cent significance level is 14.0.

Table 3: Cointegration Analysis for M1 (3 lags)[a]

H0: *r*	Eigenvalue	λ-max	Critical value (95%)	Trace	Critical value (95%)
0	0.3034	49.53	27.07	63.05	47.21
1	0.0928	13.35	20.97	13.52	26.79
2	0.0013	0.17	14.07	0.17	13.33

a. Critical values are obtained from Osterwald-Lenum (1992).

Table 4: Cointegration Analysis for M1++ (4 lags)[a]

H0: *r*	Eigenvalue	λ-max	Critical value (95%)	Trace	Critical value (95%)
0	0.1256	18.25	27.07	27.74	47.21
1	0.0672	9.46	20.97	10.60	26.79
2	0.0002	0.03	14.07	0.03	13.33
3	0.0000	0.00	3.76	0.00	2.69

a. Critical values are obtained from Osterwald-Lenum (1992).

Table 5: Cointegration Analysis for M2++ (4 lags)[a]

H0: *r*	Eigenvalue	λ-max	Critical value (95%)	Trace	Critical value (95%)
0	0.3334	37.18	27.07	58.75	47.21
1	0.1096	15.36	20.97	19.57	26.79
2	0.0360	5.17	14.07	5.21	13.33
3	0.0002	0.03	3.76	0.03	2.69

a. Critical values are obtained from Osterwald-Lenum (1992).

Table 6: Estimates of Long-Run Money-Demand Functions

	M1	**M1++**	**M2++**
Real GDP	0.516	1.181	1.409
R90	–0.246	–0.033	–0.014
Estimates of economic uncertainty index (*t*-statistics in parentheses)			
EUI	0.004 (2.927)	0.002 (2.253)	–0.003 (–2.948)

Figure 1: Economic Uncertainty Index

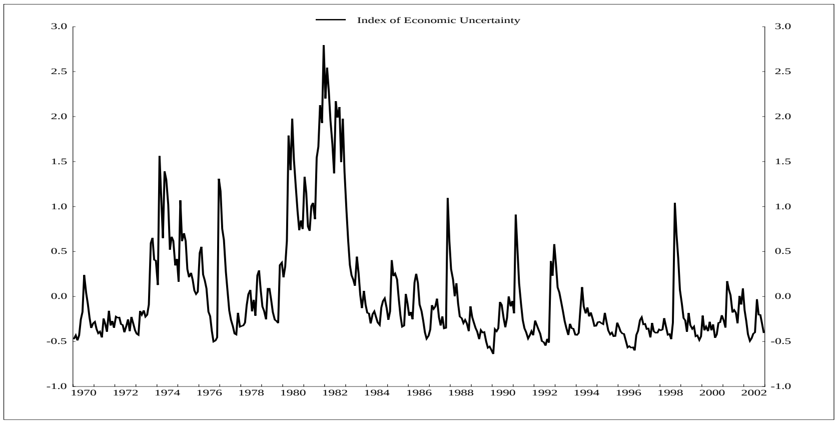


Figure 2: Volatility of Real GDP

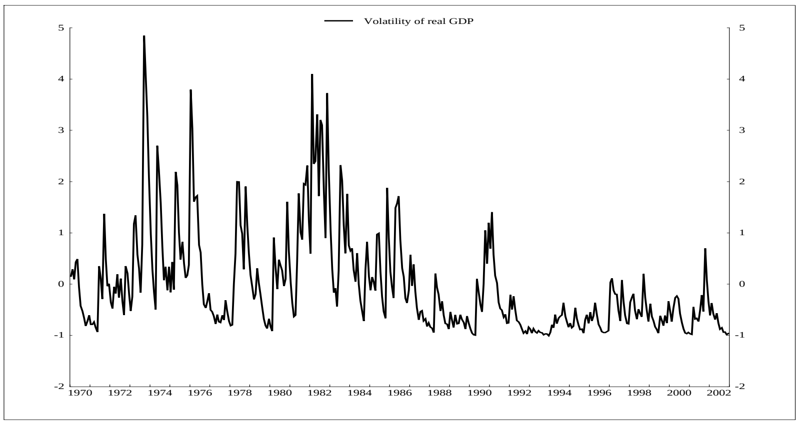


Figure 3: Volatility of CPI

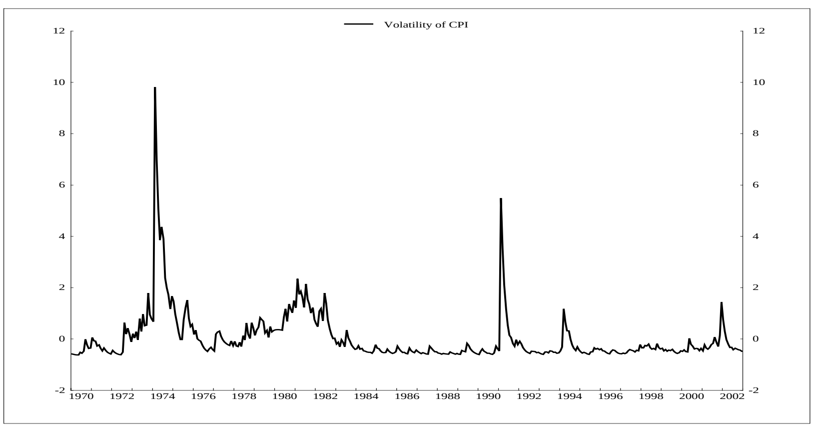


Figure 4: Volatility of Commercial Paper Rate

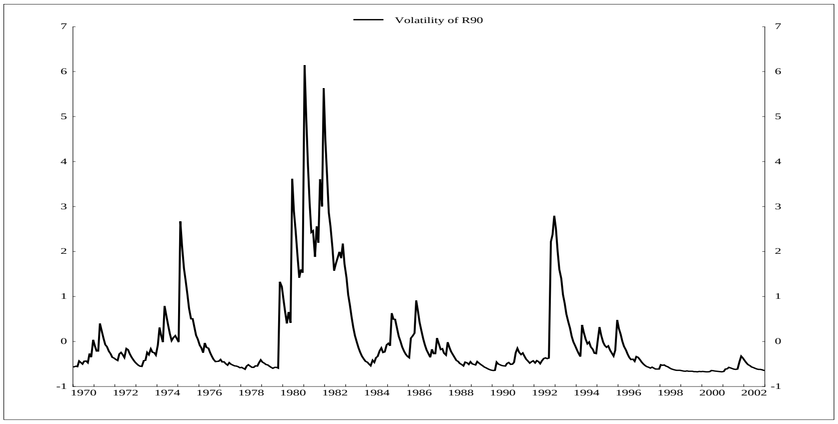


Figure 5: Volatility of Long-Term Bond Rate

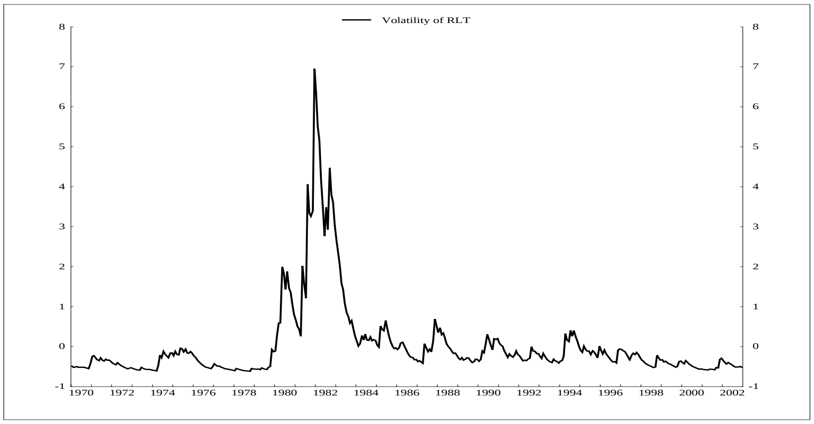


Figure 6: Volatility of the TSE

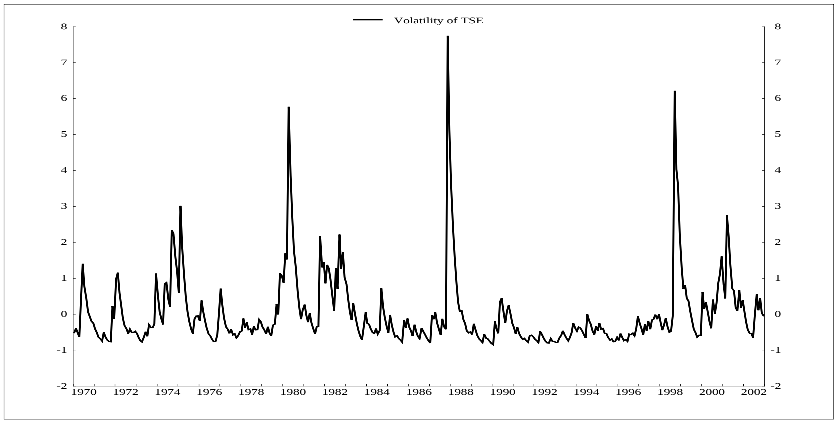


Figure 7: Volatility of the Exchange Rate

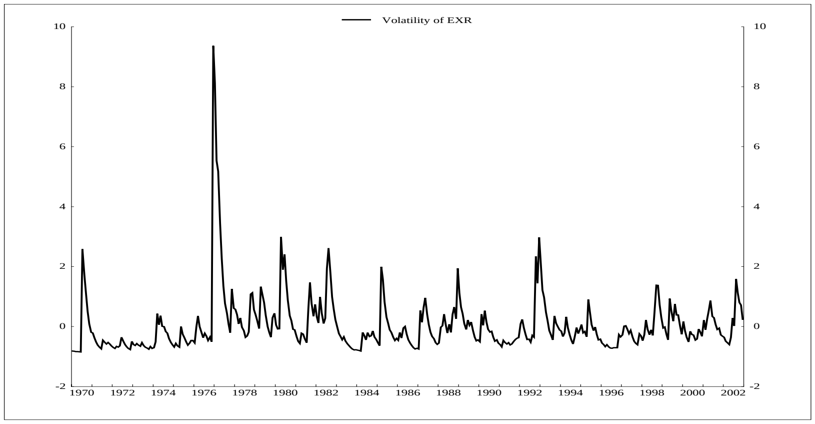


Figure 8: Testing the Stability of M1

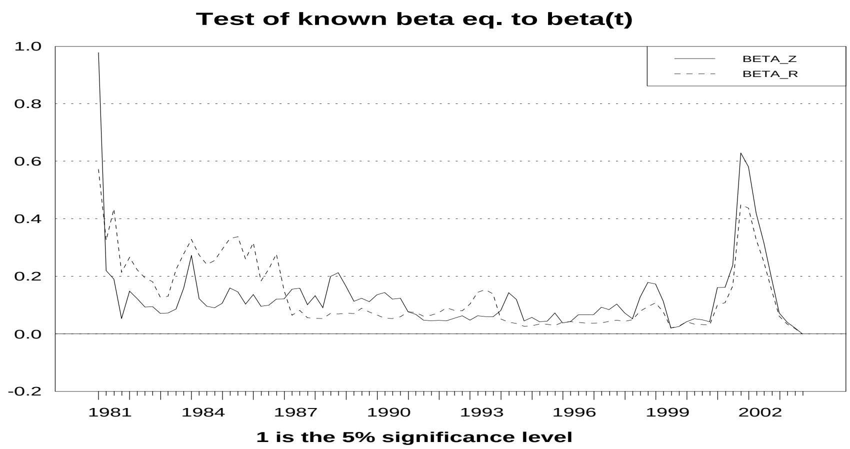


Figure 9: Testing the Stability of M1++

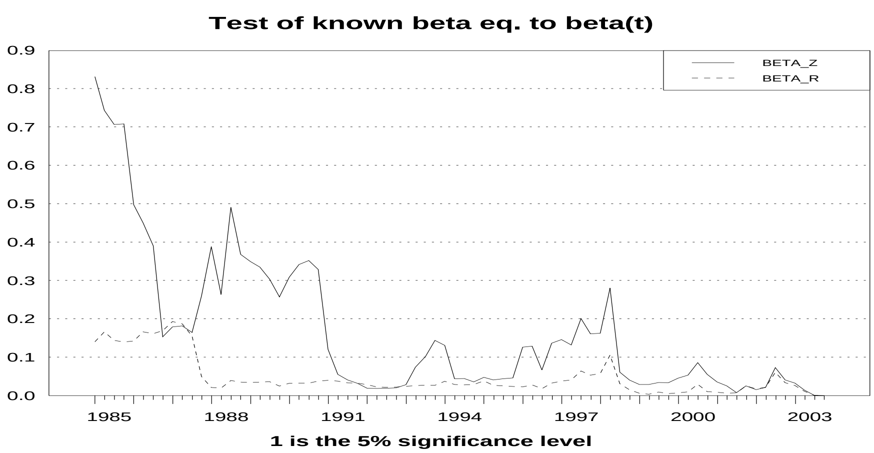
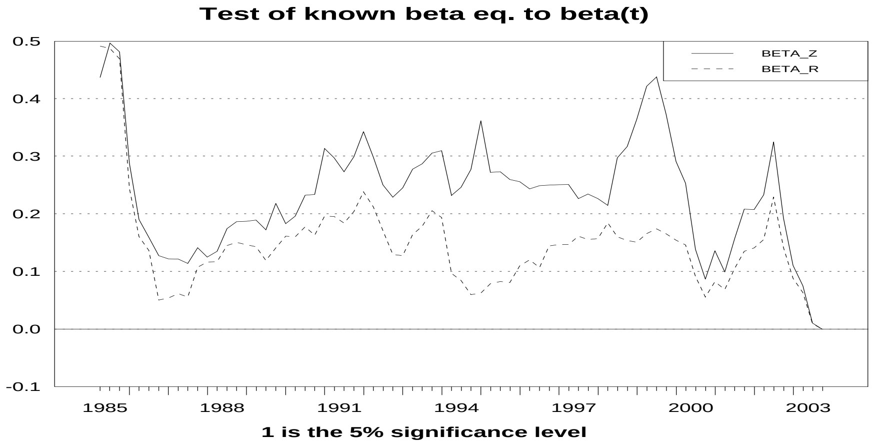


Figure 10: Testing the Stability of M2++



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