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Outside money, inside money, and monetary policy : new evidence on the interactions between key monetary variables and output

Cezar Botel

To the Graduate Council:

I am submitting herewith a dissertation written by Cezar Botel entitled "Outside money, inside money, and monetary policy : new evidence on the interactions between key monetary variables and output." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Economics.

Jean Gauger, Major Professor

We have read this dissertation and recommend its acceptance:

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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OUTSIDE MONEY, INSIDE MONEY, AND MONETARY POLICY: NEW EVIDENCE ON THE INTERACTIONS BETWEEN KEY MONETARY VARIABLES AND OUTPUT

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Cezar Botel
August 2000

DEDICATION

This dissertation is dedicated to the memory of my father, Jorj Botel

Aceasta dizertatie este dedicata memoriei tatalui meu, Jorj Botel

ABSTRACT

This dissertation investigates the nature of the short run relationships between key monetary variables and output The question of whether or not money and monetary policy have significant short run effects on output represents the bone of contention in the long lasting debates between the competing schools of macroeconomic thought The empirical studies aimed to assess the relevance of the competing theories provide contradictory evidence It is argued in this dissertation that the majority of these studies fail to address properly a number of methodological issues required by the particularities of the relationships investigated These include the analytical distinctions *outside money vs inside money* and *monetary policy vs. changes in the money stock* Well documented in monetary theory, these distinctions are commonly neglected in the empirical literature In addition, many studies use econometric procedures that are not properly suited to investigate the short run monetary and macroeconomic dynamics The research here fills these gaps in the empirical literature To assess the nature of the interactions between the monetary variables and output, this study explicitly distinguishes between outside money and inside money and between money stock fluctuations and monetary policy actions The econometric methodology employed here allows proper identification and analysis of the *short run* macroeconomic dynamics, which are the critical issue generating theoretical controversies Given a more complete coverage than common in the existing literature, the results here provide more reliable evidence on monetary impacts in the economy. In addition, a new theoretical

interpretation of the observed pattern of monetary and output dynamics is proposed and empirically tested in this study

Parts Two through Four of this dissertation focus in turn on particular dimensions of the relationships between the monetary and the real sector In each part, the interactions between the key monetary variables and output are assessed by means of impulse response functions and forecast error variance decompositions, derived from structural vector error-correction models Additional information is provided by Granger-causality and superexogenity tests

Part Two focuses on the short run relationship between money and output The money stock is decomposed into outside money, created by the monetary authorities, and inside money (measured as the money multiplier), created by the fractional banking system Here, the main purpose is to evaluate the direction and the relative magnitude of mutual impacts among the two components of the money stock and output

Part Three switches the focus on the relationship between monetary policy and output Intentional monetary policy actions are identified as the proportion of non-borrowed reserves in total reserves of the banking system The investigation aims to assess the effectiveness of policy actions for output stabilization

In Part Four a theoretical hypothesis is formulated and subjected to empirical testing This hypothesis assigns portfolio redistributions among monetary assets an important role in explaining the observed pattern of monetary and output dynamics The empirical evidence on the interactions between outside money, the money multiplier, and output is reexamined in this enriched analytical framework

The general conclusions of this study are that monetary policy actions are likely to be ineffective for output stabilization, and that the interactions between the key monetary variables and output are weak. The analytical and econometric methodology used in this dissertation, its new empirical findings, and the theoretical hypothesis proposed here represent significant contributions to the monetary and macroeconomic literature

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PART ONE

GENERAL INTRODUCTION

Chapter One

General Introduction

1.1. Research Objectives

The nature of the short run relationship between money and output is a central topic of monetary and macroeconomics. One can hardly find another issue generating more vivid and long lasting debates between the competing schools of thought. In fact, the alternative positions regarding the role of money and monetary policy in the economy define one of the most relevant differences between macroeconomic paradigms. This is so because, justifiably or not, in many modern economies, monetary policy has become the single most important tool of macroeconomic policy.

The alternative contemporary macroeconomic theories assign different degrees of importance to monetary impulses in the economy. Monetary theories of business cycles (Keynesian, Monetarist, and New Keynesian economics) maintain that fluctuations of monetary variables can have significant impacts on the real sector. In contrast, Real Business Cycles (RBC) theory argues that changes in the real economy are independent of the monetary sector.

The purpose of this dissertation is to assess the degree to which these alternative theories are consistent with the empirical evidence. The study investigates the short run relationships between money, monetary policy, and economic activity, in a multivariate dynamic framework. Many studies and articles have previously investigated these relationships The empirical results are mixed, leaving room for continued debate. However, most of the previous empirical research neglected some important

methodological issues suggested by theory It is therefore likely that the results previously obtained offer an incomplete picture of the complex relationships between the monetary and the real sector of the economy Specifically, the existing empirical literature frequently overlooks two important distinctions documented in theoretical studies: *outside money vs. inside money* and *changes in money supply vs. monetary policy actions.* This dissertation maintains in the empirical investigation these distinctions indicated as important in the theory. Given the more complete coverage, the results here provide more reliable evidence on monetary impacts in the economy.

The distinction between outside money, created by the monetary authorities, and inside money, created by the banking sector, was first pointed out by Gurley and Shaw (1960). The assertion is that the heterogeneous components of monetary aggregates may have different effects on economic activity. It is therefore essential to maintain this distinction in theoretical or empirical investigations.

The majority of recent theoretical studies agree, at least to some degree, that inside money (that is, bank created money) is not primarily policy determined, being substantially influenced by the real sector of the economy. However, the effects of outside money on output are still subject to unsettling arguments. Monetary theories of business cycles still assert that outside money can have significant effects on economic activity, at least in the short run. In contrast, Real Business Cycle (RBC) theory argues that outside money can only affect the price level.

Although the distinction between outside and inside money is clearly defined by the theory, the vast majority of empirical studies do not appropriately account for it. A major contribution of this study is to conduct the analysis of the relationship between

money and economic activity, maintaining an explicit distinction between outside money and inside money (measured here as the money multiplier for the monetary aggregate M2). This allows for potentially different impacts from the heterogeneous components of money. This investigation is undertaken in Part Two of the dissertation. Its main goals are to assess the sign and the relative magnitude of the interactions between outside money and output, between the money multiplier and output, and between outside money and the money multiplier.

The second relevant distinction considered here is that between money and monetary policy. Earlier theoretical and empirical studies regarded monetary policy actions as broadly equivalent with changes in monetary aggregates. More recent studies (for instance, Meulendyke, 1989, Eichenbaum, 1991, and Strongin, 1995) suggest that this is an oversimplification, bound to obscure, rather than explain, the connections between policy variables, monetary variables, and the rest of the economy. Monetary policy actions clearly influence the monetary aggregates. However, changes in monetary aggregates can also be caused by changes in variables that are not controlled by policy makers. Thus, the relationship between policy and money is neither simple nor invariant to specific policy instruments and distinct components of the money stock. To single out the actual impacts of policy on output, a proper identification of the *intentional* policy actions is necessary. In this study, intentional monetary policy actions are identified as the proportion of non-borrowed reserves in total reserves of the banking system. Strongin (1995) showed that, in contrast to alternative policy measures, this solution eliminates to a large extent the confusion between supply and demand shocks on the market for bank reserves (that is, the Federal funds market) Bank

reserves represent the basis of money creation in the banking system. Therefore, the supply shocks to bank reserves, i.e. the changes engineered by the central bank in the proportion of non-borrowed reserves in total reserves, properly identify the policy actions intended to accelerate or slow down the process of money creation. Based on this identification, the empirical investigation in Part Three of the dissertation aims to evaluate the importance of monetary policy actions on output.

The investigation in Part Four extends the analysis of Part Two, based on the inside money vs. outside money distinction, and is strongly motivated by some interesting results obtained in both Part Two and Part Three. These results include the negative relationships (found in Part Two) between outside money and output, and between outside money and the money multiplier, as well as a negative relationship (found in Part Three) between the total reserves of the banking system and output. More specifically, the findings show that, as a general pattern for the U.S. economy over the period of investigation (1960.1-1997.4), increases in the output and the money multiplier growth rates are associated with decreases in the growth rates of outside money and total reserves. These empirical results are new in the literature. A complete analysis of these findings requires a plausible interpretation To this purpose, a theoretical hypothesis consistent with these patterns is formulated. The main premise of the hypothesis is that the revealed patterns obtain if the short-run fluctuations in output are regularly associated with portfolio redistributions within the monetary aggregate M2. This theoretical hypothesis is subjected to empirical testing in Part Four. In addition, the investigation in Part Four is aimed to complete the evaluation of the short run interactions between outside money, output, and the money multiplier. In light of

the ongoing macroeconomic debates, the result of primary interest here is the relative magnitude of the impacts of changes in outside money on output fluctuations. This result can be brought to bear in resolving the theoretical controversy regarding the neutrality or otherwise of outside money.

As the issues outlined above indicate, the relationships between the monetary and the real sector of the economy are complex and multidimensional. In Parts Two through Four of this dissertation, various relevant dimensions are in turn investigated. Assembled together, the results provide answers to the broader questions of the study. Why focusing on separate issues, in several steps, rather than analyzing all key issues in a single comprehensive model? The choice of a multiple-step analysis is motivated by the usual limitations of the econometric procedures. It is well known that the number of observations available limits the number of variables included in a multivariate dynamic analysis (such as a VAR). Hence, it is practically impossible to include all the relevant variables in a single-step analysis. However, most of the conclusions regarding monetary/macro relationships in the literature are based on one-step analyses employing a limited set of variables (usually 4-6). Across these narrow studies, it is difficult to corroborate the results, since their authors use different measures for the same theoretical concepts, different modeling strategies, and different econometric procedures. A major contribution of this research is to undertake *a multi-step analysis* of the relationships between the monetary and the real sector of the economy using a *common methodology*. As the final results will show, this approach is able to reveal complexities in monetary/macro relationships that current studies neglect.

As explained above, this study emphasizes the analytical distinctions between outside money and inside money, and between monetary policy and money stock changes Another feature that distinguishes the investigation here from previous studies is the econometric modeling approach adopted. A set of common procedures is used across all three investigations. The analytical concepts and the main procedures of this approach are presented in the next section. In Parts Two through Four, the discussion will focus on the specific use of these concepts and procedures, as required by the particularities of each issue investigated.

1.2. The Econometric Modeling Approach

An important feature differentiating this study from previous research is the econometric modeling methodology adopted. In what follows, the main components of this methodology are presented The exposition will also show why alternative approaches are likely to overlook relevant aspects of the monetary and macroeconomic interactions.

The primary goal of this study is to assess the nature of the effects of monetary shocks on output. The signs and the relative magnitude of these effects are evaluated by means of impulse response functions (IRFs) and forecast error variance decompositions (FEVDs), derived from multivariate dynamic models. The modeling strategy adopted here involves a series of procedures aimed at identifying the appropriate specification of the models that are used to generate the IRFs and FEVDs. Across Parts Two through Four of this dissertation, common attributes of this strategy are: an econometric modeling approach that moves from general to specific; formal exogeneity modeling,

isolating the short run dynamics from the long run relationships between the variables of interest, by means of cointegration analysis and vector error-correction models (VECM); identifying the structural innovations of the system using the Sims-Bernake procedure. Each of these is addressed in turn.

The *general-to-specific approach* to econometric modeling was mainly developed by individuals associated with the London School of Economics. Grounded in the research of Sargan (1964), it was elaborated in the works of his students (Davidson et al., 1978; Hendry and Mizon, 1978; Hendry, 1993). The most representative figure of this tradition today is David Hendry.

The traditional econometric approach, labeled by Hendry as *specific-to-general,* starts with a specification, believed to be true, derived from the economic theory. Then the estimated model is tested for violations of the classical assumptions. The researcher tries to improve the models by various transformations, such as adding lags of the existing variables or new regressors. In contrast to this approach, *the general-to-specific* modeling starts with a very general hypothesis that is accepted by all competing theories and proceeds to narrow it down, by looking for simplifications that are acceptable in the context of the available data.

At the center of the general-to-specific approach lies the concept of *data generating process* (DGP) (Hendry et al., 1984), which is simply a general statement of the joint probability distribution of all variables of interest. For the analysis of time series data, the DGP is usually described, in its general form, as an autoregressive distributed lag model of the form:

$$a(L)y_t = b(L)x_t + \varepsilon_t \qquad (1\ 1)$$

where L denotes the lag operator, *a* and *b* are polynomials in L, and ε_t is white noise. This model is subsequently transformed by performing a battery of tests for restrictions and well-behaved errors. In this study, the main types of restrictions tested on the general DGP include. lag structure restrictions, cointegrating restrictions, weak exogeneity restrictions, and restrictions on the contemporaneous correlations between the structural innovations of the system. Further details will shortly clarify the meaning of these restrictions. The final DGP specification, i.e. the 'specific form' embedding the restrictions accepted by tests, is estimated and used to generate IRFs and FEVDs. This approach has the advantage of reducing, as much as possible, the *a priori* assumptions employed in empirical modeling. A smaller number of priors embedded in the empirical model reduce the risks of circular reasoning when assessing the consistency between the empirical evidence and theory

Formal *exogeneity modeling* is an essential stage of the general-to-specific approach. Exogeneity modeling can be seen as a middle ground between the traditional (Cowles Commission's) structural econometric modeling and the standard VAR approach The former assumes *a priori* an exogenous-endogenous division of the variables of interest, whereas in a VAR system there are no exogenous variables. Exogeneity modeling still allows for some *a priori* restrictions to be imposed in order to control for the size of the model (i.e. selecting the variables of interest). However, the endogenous- exogenous distinction is no longer given *a priori*. It becomes, instead, a testable hypothesis.

For exogeneity to be tested, first it has to be precisely defined. A terminology frequently employed in the literature distinguishes between predetermined and strictly exogenous variables. A variable is predetermined in an equation of interest if it is independent of the current and future errors of that equation. If the variable is also independent of the past errors of the equation, then it is strictly exogenous (Charemza and Deadman, 1997). However, Engels, Hendry, and Richard (1983) argue that this classification of variables is not precise enough, since it does not rigorously specify *for what precisely* a variable of interest is exogenous. They show that the status (i.e. exogenous/endogenous) of a variable can change drastically, depending on which parameters of a model are of interest. The authors propose an alternative set of definitions aiming to eliminate the ambiguities in the treatment of econometric variables. The relevant concepts of this terminology, adopted in this study, include weak exogeneity, strong exogeneity, and superexogeneity.

The concept of weak exogeneity is related to the problem of static inference in an econometric model, i.e. with the estimation of the model. A variable z_t is weakly exogenous for some set ψ of parameters of interest if the process generating z_t contains no useful information for the estimation of ψ or, put another way, ψ needs not be known for inferences on the process generating z_t (Charemza and Deadman, 1997) Those variables of interest that are not weakly exogenous are statistically endogenous for the system.

The practical implication of weak exogeneity is that the system can be estimated conditional on the weakly exogenous variables. There are two advantages of estimating a multivariate system by conditioning on weakly exogenous variables. First, if these

variables exhibit some data problems, conditioning on them will ensure that the rest of the system (i.e. the conditional process) will have better stochastic properties. Secondly, when a VECM is estimated, the number of variables in the short run model is reduced, rendering a more parsimonious model (Harris, 1995).

The concept of strong exogeneity adds a dynamic aspect to exogeneity and it is mainly related to the possibility of forecasting conditional on the exogenous variables. Conditional forecasting requires that the exogenous variables be influenced neither by contemporaneous nor by past values of endogenous variables. Therefore, a variable z_t is strongly exogenous with respect to the parameters of interest ψ if z_t is weakly exogenous for ψ, and, in addition, endogenous variables do not Granger-cause z_t. In practice, strongly exogenous variables may represent useful leading indicators for the endogenous variables.

Finally, the concept of superexogenity is related to the 'Lucas critique'. Lucas (1976) argued that structural econometric models used for policy evaluation and design are wrongly assuming that the behavioral (structural) parameters of the models are invariant. In reality, the behavior of the economic agents, and therefore the structural parameters, change as a result of policy regime changes, due to adjusted expectations. Therefore, econometric models assuming invariant structural parameters fail to predict accurately the effects of proposed policy measures.

In light of this critique, a variable can be safely used as a policy instrument only if changes in the mean and variance of this instrument do not induce changes in the parameters of interest, i.e. if the variable is superexogenous. Notice that weak exogeneity is a prerequisite for superexogeneity.

An alternative interpretation of superexogeneity is suggested by Engle et al (1983). The authors argue that superexogenity "seems to satisfy the requirement for causality," defined by Zellner (1979) as "predictability according to a law." Under this interpretation, if a variable z_t is superexogenous for the parameters of another variable y_t, then z_t causes y_t.

In this study, superexogeneity tests are employed to assess the effectiveness of the proportion of non-borrowed reserves in total reserves as a policy variable, and to question if changes in outside money may cause changes in output.

Another important feature of the modeling approach here is the use of *cointegration analysis* and *vector error-correction models*. The majority of recent empirical studies found that many macroeconomic time series behave as non-stationary random variables. A common practice in dealing with these variables is to difference them until stationary series are obtained However, it is possible that some linear combination of non-stationary variables is stationary, i.e that the variables are cointegrated. It is now well known that, if a set of non-stationary variables is cointegrated, then simply replacing a VAR in levels with a VAR in differences is not an appropriate solution. In its general form, an unrestricted VAR model can be written as:

$$y_t = A_1 y_{t-1} + \ldots + A_k y_{t-k} + u_t \qquad (1.2)$$

where y_t is a vector of n variables, A_i is an (n x n) matrix of parameters, and u_t is a vector of n error terms. This model can be reformulated in a VEC form, as:

$$\Delta y_t = \Gamma_1 \Delta y_{t-1} + \ldots + \Gamma_{k-1} \Delta y_{t-k+1} + \Pi y_{t-k} + u_t \qquad (1.3)$$

where $\Gamma_i = -(I - A_1 - \ldots - A_i)$, $(i = 1, \ldots, k-1)$, $\Pi = -(I - A_1 - \ldots - A_k)$, I is an identity matrix of order n, and Δ denotes first differences.

Now, if the variables in y_t are cointegrated, then the correct specification of the DGP is equation (1.3). Estimating the system as a VAR in first differences (i.e. omitting the term Πy_{t-k}) involves a misspecification (Enders, 1995). In fact, as Engle and Granger (1987, 1991) proved, there is a strict correspondence between cointegration (CI) and error-correction models (ECM): any cointegrated series have an ECM representation (the "Granger Representation Theorem") and CI is a necessary condition for ECM to be valid. Concisely, CI $\Leftrightarrow$ ECM.

Moreover, as Swanson (1998) shows, standard F-tests or Wald tests for Granger causality become severely biased when multivariate models are using only differenced data without accounting for cointegrating relationships.

Finally, the advantage of the ECM or VECM formulation is that it combines the flexibility of short run dynamic specification with information regarding the long run relationships between the variables of interest. Specifically, the term Πy_{t-k} in equation (1.3) expresses the long run relationships between variables in y_t, whereas the rest of the model, i.e. the differenced variables, represents the short run component. The possibility of isolating the short run dynamics is particularly useful when assessing, as in this study, the empirical relevance of the competing business cycle theories. In a VECM framework, IRFs and FEVDs are derived from the coefficients in matrices Γ of equation (1.3), whereas in standard VAR models they are derived from the coefficients in matrices A of equation (1.2). It is clear that A's represent combinations of the short run

parameters Γ's and long run parameters Π. Therefore, the IRFs and FEVDs from VARs in levels reflect a mixture of short run and long run dynamics.

The last type of restrictions tested is related to the identification of the structural innovations affecting the variables of interest. The error-terms u_t in equation (1.3) are linear combinations of the structural innovations, i.e. the error terms of the underlying structural model. An economically meaningful interpretation of the IRF and FEVD results requires the recovery of the structural innovations. The relationship between the structural and reduced-form innovations is given by:

$$u_t = \Lambda^{-1} v_t \tag{1.4}$$

where u_t is the (5x1) vector of reduced-form innovations in equation (1.3), v_t is the (5x1) vector of the structural innovations, and Λ is a (5x5) matrix of the contemporaneous relationships between the variables of interest. Whereas the reduced-form innovations are correlated across equations, it is assumed that the structural innovations are uncorrelated (orthogonal).

The identification of v_t's requires restrictions on the matrix Λ. The most commonly used procedure to restrict Λ is the so-called Choleski decomposition. This method requires that a particular causal order be imposed for the variables of interest. Matrix Λ is then modeled in triangular form, with zeros above the main diagonal and ones on and below the diagonal. This particular form is consistent with a causal pattern where the first variable causes all the others, the second variables causes the next variables, and so on. This rigid causal pattern, that excludes mutual causation between variables, represents an important weakness of the Choleski method. The procedure

elaborated by Sims (1986) and Bernake (1986) avoids this drawback, allowing practically any structure of the matrix Λ. The zero restrictions on Λ are distributed according to theoretical priors regarding the contemporaneous correlations between the structural innovations. However, Sims (1980) warned against the "incredible restrictions" implied by any a priori structure imposed on a simultaneous equations system. It is therefore important that the Sims-Bernake decomposition procedure allows empirical tests of the restrictions on matrix Λ, if the number of restrictions imposed is larger than needed for a just (strict) identification[1]. This possibility to test for overidentifying restrictions is not available with a Choleski decomposition, since the latter invariably involves a strict identification. The Sims-Bernake procedure, adopted here, is consistent with the general-to-specific approach where the final DGP is chosen through a battery of tests. In addition, this type of decomposition allows more flexible assumptions about the possible causal connections between the variables of interest

The final, specific form of the multivariate DGP, "tested down" from the initial general DGP, is used to derive the impulse response functions (IRFs) and the forecast error variance decompositions (FEVDs). The IRFs provide information about the sign of the relationship between variables, whereas the FEVDs evaluate the relative magnitude of these interactions The IRF and FEVD results therefore help assess the nature of the short run relationships between the monetary variables and output.

The foregoing discussion of the main objectives of this dissertation and of the methodology adopted makes clear the gaps in the literature that this study fills. The

[1] The number of restrictions necessary for just identification is $n(n-1)/2$

explicit distinction between measures of inside and outside money in a multivariate analysis of the money-output relationship is employed in very few empirical studies (Manchester, 1989 is a rare exception). With the exception of Strongin (1995), the previous studies employ measures of monetary policy actions inappropriate for singling out the intentional actions of the policy makers Many studies do not undertake cointegration analysis and therefore exclude the possibility of using a VECM, an observation made also by Swanson (1998). Davis and Tanner (1997), while testing for and finding cointegration between money and income, ignore the long-run relationship in the subsequent estimation procedure, using a standard VAR in first differences. The same type of model is used by Manchester (1989), who completely neglects the cointegration analysis. Various studies use the exogeneity concepts in a rather loose way and, with the exception of Litterman and Weiss (1985), do not make any attempt to test for exogeneity. Finally, the vast majority of previous studies use the Choleski decomposition to identify the structural shocks in multivariate systems. In general, while a number of studies exhibit *some* of the desirable features described earlier, none of them meets *all* these requirements. The investigation here aims to avoid the methodological ambiguities found in other studies, in an attempt to provide more reliable evidence on the dynamic interactions between the monetary variables and output.

This dissertation adds methodological, empirical, and theoretical contributions to the literature on monetary and macroeconomics. The investigation is based on the analytical distinctions *outside money vs inside money* and *money vs. monetary policy*, too often neglected in the existing empirical literature The econometric modeling

strategy is properly adapted to the specific purpose of investigating the short run interactions between the key macroeconomic variables. The empirical results of this study include findings that are not reported elsewhere in the literature. These findings shed new light on the complexity of the relationship between the monetary variables and output. A theoretical hypothesis, found to be consistent with the empirical evidence, is formulated here. This hypothesis, new in the literature, suggests that portfolio redistributions among monetary assets might play an important role in explaining the observed patterns of short run monetary and macroeconomic dynamics. Overall, the results of this dissertation provide valuable insights on the nature of the relationships between the monetary and the real sectors of the economy.

REFERENCES

Bernake, B. (1986),'Alternative explanations of money-income correlation', *Carnegie-Rochester Conference Series on Public Policy* 25

Charemza, W.W. and Deadman, D.F. (1997), *New directions in econometric practice*, 2nd ed., Edward Elgar.

Davidson, J , Hendry, D.F., Srba, F., and Yeo, S. (1978), 'Econometric modeling of the aggregate time series relationships between consumers expenditure and income in the United Kingdom', *Economic Journal* 88.

Davis, M. and Tanner, J.E. (1997), 'Money and economic activity revisited', *Journal of International Money and Finance*, vol. 16, No.6.

Eichenbaum, M. (1991), Comments on: 'Interpreting the macroeconomic time series facts: The effects of monetary policy', *European Economic Review* 36.

Enders, W. (1995), *Applied econometric time series*, John Wiley & Sons, Inc.

Engle, R.F. and Granger, C.W.J. (1987),'Cointegration and error correction: representation, estimation, and testing', *Econometrica* 55.

Engle, R.F. and Granger, C.W.J. (1991),'Cointegrated economic time series: an overview with new results', in Engle, R.F. and Granger, C.W.J. (eds.) *Long-Run Economic Relationships*, Oxford University Press.

Engle, R.F , Hendry, D.F., and Richard, J.-F. (1983),'Exogeneity', *Econometrica* 51.

Gurley, J.G. and Shaw, E.S. (1960), *Money in a theory of finance*, Washington: The Brookings Institution.

Harris, R.D. (1995), *Using cointegration analysis in econometric modeling*, Prentice Hall/Harvester Wheatsheaf

Hendry, D.F. (1993), *Econometrics: alchemy or science?*, Oxford UK and Cambridge US, Blackwell

Hendry, D.F. and Mizon, G.E. (1978), 'Serial correlation – a convenient simplification not a nuisance; a comment on a study of the demand for money by the Bank of England', *Economic Journal*, 88.

Hendry, D.F., Pagan, A R. and Sargan, J.D (1984), 'Dynamic specification', in Griliches, Z. and Intriligator, M.D. (eds.), *Handbook of econometrics*, Amsterdam. North-Holland.

Litterman, R. and Weiss, L (1985), 'Money, real interest rates, and output: a reinterpretation of US postwar data', *Econometrica* 53.

Lucas, R.E. (1976), 'Economic policy evaluation: a critique', in Brunner, K. and Meltzer, A.M (eds), *The Phillips Curve and labor markets*, Carnegie-Rochester Conference series in Public Policy, vol.1, North-Holland.

Manchester, J. (1989), 'How money affects real output', *Journal of Money, Credit, and Banking*, Vol.21, No.1 (February)

Sargan, J.D. (1964), 'Wages and prices in the United Kingdom: a study of econometric methodology', in Hart, P.E. and Whittaker, J.K. (eds.), *Econometric analysis for natural planning*, London: Butterworths

Sims, C. (1980b), 'Macroeconomics and Reality', *Econometrica* 48.

Sims, C. (1986), 'Are forecasting models usable for policy analysis?', *Quarterly Review*, Federal Reserve Bank of Minneapolis, Winter.

Strongin, S. (1995), 'The identification of monetary policy disturbances. Explaining the liquidity puzzle', *Journal of Monetary Economics*, 35.

Swanson, N.R. (1998), 'Money and output viewed through a rolling window', *Journal of Monetary Economics,* 41.

Zellner, A (1979), 'Causality and econometrics', in Brunner, K. and Meltzer, A.H. (eds.), *Three Aspects of Policy and Policymaking*, Amsterdam, North-Holland.

PART TWO

OUTSIDE MONEY, INSIDE MONEY, AND OUTPUT

Chapter One

Introduction

The effectiveness of monetary policy for short run output stabilization is a key issue in monetary and macroeconomics. The transmission mechanism linking monetary policy actions to output variations involves two analytical dimensions: monetary policy – output and money – output. Various macroeconomic theories recommend different objectives and approaches to monetary policy-making. However, in most of the existing literature, the similarity between monetary policy actions and changes in money is taken for granted, assuming that the monetary authorities exert high discretion over the money supply. Therefore, the differences between policy prescriptions come mainly from different views about the degree of influence of money on output. If changes in money induce changes in output, and if this influence is stable and predictable, then policies aiming at output stabilization may be recommended. If, on the other hand, changes in money do not affect output, a policy focused solely on price stability would be desirable The purpose here is to investigate the dynamic relationships between monetary variables and output, abstracting from the distinction between monetary policy actions and changes in monetary aggregates. The latter issue will be specifically addressed in Part Three.

The results of this investigation may be brought to bear in resolving theoretical controversies regarding the interactions between money and output. More specifically, the consistency between the competing macroeconomic theories and the empirical evidence for the U.S., over the period 1960 1 –1997:4, will be assessed. An important

analytical tool employed in this investigation is the decomposition of money into outside money and inside money. While properly documented in theoretical studies (such as Gurley and Shaw, 1960, Patinkin, 1965, and a number of Real Business Cycles models), this decomposition is neglected in the vast majority of the empirical literature

Other important features that distinguish this investigation from the common approaches in the existing literature consist in formal exogeneity tests and the use of an error-correction framework to analyze the dynamic relationships betweeen the variables of interest. The error-correction framework is the appropriate analytic tool when variables of interest are cointegrated, which is actually the case with the main macroeconomic variables.

The remainder of Part Two is organized as follows Chapter Two lies the theoretical background of the investigation and reviews previous empirical findings. Chapter Three describes the econometric methodology employed as well as data specifics. Estimation results are presented in Chapter Four. Chapter Five offers an interpretation of the results and Chapter Six summarizes the conclusions.

Chapter Two

Theoretical Issues and Previous Empirical Findings

Most macroeconomists agree that money is partially determined by its interactions with other economic variables. The disagreement starts with the nature and degree of influence of money on output. The main positions on this issue range from a two-way causation between money and output to a complete endogeneity of money.

2.1. The Main Theoretical Positions

Monetarist (both orthodox and New Classical) and, recently, New Keynesian economists argue that the causal connections between money and output run both ways. Therefore changes in money supply can and do affect output, primarily in the short run (The opposing policy conclusions of the two schools will not be discussed here.)

The monetary theories of business cycles offer various explanations for the short run non-neutrality of money. Milton Friedman (1968) points to the misperception of real wage changes and the resulting temporary 'money illusion' that make output and employment deviate from their full-employment levels. In Lucas' (1973, 1981) New Classical models, unanticipated demand shocks have output effects because the economic agents cannot distinguish between general and idiosyncratic price shocks. New Keynesian models focus on price rigidity – and therefore real output adjustments - due to various reasons such as menu costs, imperfect competition, efficiency wages, and staggered price setting.

Real business cycle (RBC) theory focuses on the technology shocks as the single most important factor determining the instability of output and other real economic variables. In RBC view, business cycles actually represent fluctuations in the full-employment level of real income, rather than variations around a "natural" level. In a very classical tradition, money is completely neutral with respect to real economic activity. The monetary authorities can actually control the changes in the quantity of outside (fiat) money; these changes, while having no effect on output, induce proportional changes in prices. The only causal relationship between money and output runs from output to inside money. The model built by Freeman and Huffman (1991)[1] clearly illustrates the RBC view (see also Champ and Freeman, 1994, chapter 8).

It appears that the bone of contention between the monetary and RBC theories lies in the capacity of policy-induced changes in the money stock to effect changes in real income. As shown next, the theoretical debate is fueled by contrasting empirical findings.

2.2. Empirical Evidence

The causal connection running from money to income was largely documented by a series of studies authored by monetarists: Friedman (1964), Friedman and Schwartz (1963, 1982), and Cagan (1993) Recent studies by the New-Keynesians

[1] Freeman and Huffman (1991) built a general equilibrium model consistent with three empirical observations First, innovations in the money supply are positively correlated with and precede innovations in output Second, innovations in the money stock represent innovations in inside, not outside, money Third, when interest rates are included in vector autoregressions, their innovations, rather than the money stock innovations, explain and precede output fluctuations The study concludes that fluctuations in inside money are endogenously determined and that changes in outside money are not related to (and therefore do not cause) changes in output.

Romer and Romer (1989, 1990) continue the works of Friedman and Schwartz. Their findings confirm that money does affect output.

The empirical content of these studies was either directly criticized (for instance, in Hoover and Perez, 1994) or indirectly challenged by a series of works using newer econometric techniques, such as vector autoregressions (VARs). Christopher Sims pioneered studies based on time-series methodology. Employing Granger-causality tests, Sims (1972) concluded that, in postwar US data, causality appeared to run unidirectional from money to income. Subsequently, however, Sims (1980) found that money is no longer Granger-causally prior for output when some short-run nominal interest rate is added to a vector autoregression including money, output, and prices. In addition, whereas the nominal interest rate innovations explain a substantial fraction of the variance of output, the explanatory power of monetary innovations is substantially reduced. Sims' findings were confirmed by other studies, such as Litterman and Weiss (1985), Friedman and Kuttner (1993), and Thoma (1994).

Other studies using VAR, however, support the monetary view. Strongin (1995) identifies the exogenous monetary policy shocks with innovations in non-borrowed reserves (NBR) and finds that policy Granger-causes output even with interest rates included in the VAR specification. Davis and Tanner (1997) reexamine the relationships between output, inflation, an interest rate, a private-government interest rate spread, and M2 growth over the sample period 1847-1993. They conclude that M2 growth is the most important variable in explaining real GDP.

Despite their varying conclusions, the influential empirical studies quoted above share a common feature: they regard the monetary aggregate chosen for analysis as a

homogenous variable[2]. The shortcomings of this approach are explained in the next section.

2.3. Inside Money vs. Outside Money

A fruitful line of research in monetary economics was initiated in the early 1960s. A series of studies (Gurley and Shaw, 1960; Tobin and Brainard, 1963; Patinkin, 1965) addressed the distinction between inside and outside money. Gurley and Shaw argued that the classical assumption of neutrality failed to recognize that the components of money stock are heterogeneous. Outside money is created by the central bank and can be identified as the monetary base[3]. Inside money is bank-created money, via the fractional reserve banking system. Outside money is a net asset, whereas inside money is both an asset and a liability for the private sector. This asymmetry is the source of real effects of changes in the money stock. For instance, an increase in outside money indeed raises the price level, but this is not the end of the story. At higher prices, real inside money balances are lower and some asset market is not in equilibrium, which triggers changes in equilibrium interest rates and consequently real output adjustments. Patinkin, on the other hand, suggests that neutrality might still hold, since inside and outside money are structurally linked under a fractional reserve system, and changes in the quantity of outside money induce proportional changes in the quantity of inside money.

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[2] Strongin (1995) is an exception, but not in the sense that is under focus here He employs proxies for policy variables that are different from monetary aggregates, but he does not distinguish between inside and outside money (see below)

[3] Monetary base (or "base money", or 'high powered money") is the sum of currency in circulation and "bank reserves", i e the commercial banks' balances with the central bank

Many theoretical models acknowledge today the distinction between the two components of monetary aggregates. Freeman and Huffman (1991) warn against the misleading conclusions that may be generated by the aggregation of inside and outside money. Inside money represents deposits at banks, used to make loans to agents who create capital. Therefore, inside money can be seen as intermediated capital. The authors argue that " inside money differ from outside money in its link to output because of the fundamental difference between intermediated capital and unbacked, intrinsically useless pieces of paper issued by the government"[4].

Oddly enough, very few empirical studies assessing the relationship between money and output *explicitly* allow for the important distinction outside-inside money. The common practice is to focus on some monetary aggregate, while the inferences about the effects of the two components are made *implicitly*, by comparing the results obtained using the monetary base (the measure for outside money), with the results obtained using broader monetary aggregates.

Noticeable exceptions are the studies of Manchester (1989) and Cagan (1993). Manchester includes in a VAR analysis both the monetary base and the money multiplier, the latter standing as a measure of inside money. The author finds that both components explain output, the explanatory power of the money multiplier being substantially higher than that of outside money. Cagan employs the same decomposition

[4] It is worth mentioning that Freeman and Huffman (1991) model base money as currency only When bank reserves are included in outside money, it is questionable if base money can be any longer considered as representing "useless pieces of paper" The magnitude and the fluctuations of bank reserves may influence the amount of loans made to the private sector, and therefore inside money This aspect opens the theoretical possibility for a connection between outside and inside money This qualification, however, does not diminish the importance of the distinction between outside and inside money

of money in a single regression framework, finding that both monetary variables have almost equal explanatory power for output

The present study will maintain the clear distinction between outside money and inside money (measured by the money multiplier) to examine the interactions between these variables and their effects on output. This study extends the period of analysis. More important, this investigation adds significant methodological improvements over Manchester (1989) and Cagan (1993). Integrated in a general-to-specific modeling approach, the improvements include use of cointegration analysis, use of a vector error-correction model (VECM) rather than a standard VAR (or single regression) and formal testing for exogeneity. These features are discussed in the next chapter.

Chapter Three

Econometric Methodology and Data

A distinguishing feature of this study is the econometric modeling strategy employed to investigate the interactions between the monetary variables and output. The assessment of the main tenets of the competing business cycle theories requires focus on short run rather than long run dynamics. Therefore, an important goal of the methodology adopted here is to identify and isolate the short run relationships between the key variables. A presentation of the main components of the modeling strategy, as well as of the advantages of this approach over the alternative methodologies, was offered in Section 1.2 of Part One. This section starts with a presentation of the particular steps of econometric modeling. The section will end with a discussion of the data.

The analysis starts from the data generating process (DGP) formulated as the unrestricted VAR model.

$$y_t = A_1 y_{t-1} + \ldots + A_k y_{t-k} + u_t \tag{3.1}$$

where y_t is a vector of 5 variables (including output, outside money, the money multiplier, the interest rate, and the price level), A_i is a (5x5) matrix of parameters, and u_t is the vector of error terms.

Further modeling of the DGP can follow three approaches. A first approach would be to maintain the standard VAR form of equation (3.1). A second approach is to

estimate a VAR in first differences of the level variables Differencing the time series is necessary if the variables of interest are non-stationary (or integrated of order 1) in levels. These two approaches are the most commonly used in the existing literature. A third approach, used in this study, is to model the DGP in a *vector error-correction form* (VECM). This method was recently developed in connection with the literature on cointegration (see, for instance, Engle and Granger, 1987 and 1991, Hamilton, 1994, Enders, 1995). See Section 1.2. in Part One for a discussion of the advantages of VECMs over standard VARs.

The VAR in equation (3.1) can be reparameterized in a VECM form as:

$$\Delta y_t = \Gamma_1 \Delta y_{t-1} + \ldots + \Gamma_{k-1} \Delta y_{t-k+1} + \Pi y_{t-k} + u_t \qquad (3.2)$$

where $\Gamma_i = -(I - A_1 - \ldots - A_i)$, $(i = 1, \ldots, k-1)$, $\Pi = -(I - A_1 - \ldots - A_k)$, and **I** is an identity matrix of order n (in this case $n = 5$).The term Πy_{t-k} expresses the long run relationships between the variables in y_t, whereas the rest of the model, i.e. the differenced variables, represents the short run component[1].

On the VECM form, cointegration analysis is performed, which includes: testing for cointegration rank; selecting the deterministic components (i.e. constants and/or trends that enter the short run and/or the long run components of the model); testing restrictions on the long run parameters of the Π matrix; testing for weak exogeneity. These steps are performed using Johansen's (1988) methodology (JM). Based on

[1] A VAR in first differences would omit the term Πy_{t-k}, thus "throwing away" relevant information Only when Πy_{t-k} is a null matrix (implying no cointegration) a first differences VAR becomes a correct specification

maximum likelihood estimation, JM decomposes the (n x n) matrix Π in equation (3.2) in two (n x r) matrices α and β, such that $\Pi = \alpha\beta'$[2]

The columns of β represent the cointegrating vectors, i.e. the long run relationships. Matrix α includes the parameters that measure the speed of adjustment of the key variables following a deviation of the system from the long run equilibrium. The JM allows testing restrictions on both β and α. Since the main purpose of this study is to investigate the short run relationships between monetary and real variables, specific economic hypotheses on the long run parameters will not be tested. Restrictions on β will still be tested, but with the limited purpose of properly identifying the parameters of Π (see next chapter for further details) As shown below, tests of restrictions on α are important for assessments regarding the weakly exogenous or otherwise status of the variables of interest. Weak exogeneity is important since the DGP can be estimated conditional on the weakly exogenous variables. Furthermore, it provides information regarding some contemporaneous relationships between variables. This information can be later used to model the structural (Sims-Bernake) decomposition employed in innovation accounting. Weak exogeneity is also a necessary condition for strong exogenity (allowing forecasting of endogenous variables conditional on weakly exogenous variables) and superexogenity (related to the invariance of the parameters of interest in the equations of endogenous variables)

In JM, testing for cointegration is done simultaneously with testing for the existence of deterministic regressors in the model. Testing for weak exogeneity through

[2] The rank of Π, the number of cointegrating vectors, and the number of columns of α and β, all equal r

JM amounts to a test of the significance of the parameters of matrix α. If all α_{ij} in row i of matrix α are statistically zero, then equation i contains no information about the long-run relationship. Thus the dependent variable in that equation is weakly exogenous for the system. The model can be safely conditioned on the weakly exogenous variables. The conditional and marginal models[3] are given by the equations (3.3) and, respectively, (3.4)

$$\Delta y^*_t = \Gamma_0 \Delta z_t + \Gamma^y{}_1 y_{t-1} + \ldots + \Gamma^y{}_{k-1} \Delta y_{t-k+1} + \alpha\beta' y_{t-k} + u_{yt} \qquad (3.3)$$

$$\Delta z_t = \Gamma^x{}_1 y_{t-1} + \ldots + \Gamma^x{}_{k-1} \Delta y_{t-k+1} + u_{xt} \qquad (3.4)$$

where z_t is the vector of w weakly exogenous variables and y^*_t contains the endogenous variables, i.e. the elements of the original y_t that are not weakly exogenous (and thus are not elements of z_t). Γ_0 is of dimensions [(n-w)x w], $\Gamma^y{}_i$s are [(n-w) x (n-w)], and $\Gamma^x{}_i$s are (w x w). $\beta' y_{t-k}$ is called 'the error-correction term(s)'(ECT)[4].

Granger-causality tests are widely used in empirical studies. Many authors draw causal inferences from Granger-causality tests. However, as Cooley and LeRoy (1985) pointed out, Granger-causality tests are neither necessary nor sufficient for a genuine causal interpretation of the conditional correlations between economic variables. Therefore, it is correct to refer to Granger-causality as 'temporal-causality' (Masih and Masih, 1995) or, more accurate, as 'predictability'. As such, Granger-causality is still a

[3] The conditional model includes the equations of the endogenous variables, whereas the marginal model includes the equations of the weakly exogenous variables

[4] ECTs estimated at this stage are saved and then carried over as exogenous components in the short run equations of the seemingly unrelated regressions (SUR) system underlying the innovation accounting

useful concept, since predictability among economic variables is necessary for conditional forecasting[5]. Moreover, variables that Granger-cause other variables can be regarded as leading indicators for the latter, fact that provides useful information for policy makers.

Toda and Phillips (1993) show that Wald test statistics for non-causality in the context of unrestricted VARs have, in general, nonstandard limit distributions in which nuisance parameters are present. They recommend using a VECM framework for Granger-causality tests, as in Mosconi and Giannini (1992). This suggestion is adopted here.

Superexogeneity tests are performed here using the methodology developed by Engle and Hendry (1993). The basic idea is that the parameters of an endogenous variable (say output) might not be invariant to changes in the mean and variance of a weakly exogenous variable (say money). If this is the case, then the weakly exogenous variable is not superexogenous. In this Part, under the provisional assumption that base money may be seen as a suitable policy variable[6], the test of superexogeneity of base money with respect to the parameters of output equation will be performed.

To assess superexogeneity, the significance of the first two moments of the conditioning variable is tested in the following equation of the conditional variable:

$$y_t = x_t\beta_0 + z_t'\gamma + (\delta_0 - \beta_0)\,\bar{\eta}_t + \delta_1(\sigma^{xx}_t\,\bar{\eta}_t) + \beta_1\,\bar{x}^2_t + \beta_2\sigma^{xx}_t + \beta_3(\bar{x}_t\sigma^{xx}_t) + \varepsilon_t \quad (3.5)$$

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[5] As mentioned before, a variable that is weakly exogenous and is not Granger-caused by an endogenous variable is strongly exogenous for the endogenous variable in question The latter can be efficiently forecasted conditional on the former

where $\overline{\eta}_t$, $\sigma^{xx}{}_t$, and $\overline{x}_t$ are residuals, conditional variance, and respectively fitted values from the marginal equation. The vector z_t includes other regressors.

Testing for superexogeneity amounts to test the hypothesis $\beta_1 = \beta_2 = \beta_3 = 0$. In addition, a test of H_0: $(\delta_0 - \beta_0) = 0$ assesses weak exogeneity; H_0: $\delta_1 = 0$ is a test for the constancy of the parameters of interest, β_0[7].

The analysis will be finalized by innovation accounting (impulse response functions – IRFs, and forecast error variance decomposition - FEVD), based on a structural VAR approach, as in Sims (1986) and Bernake (1986). An IRF is a graphical representation that helps visualize the behavior of a variable over time, following a one-time shock (innovation) to any of the variables of interest. The FEVD measures the proportion of the variation in a variable that is explained by its own innovations as well as by the innovations in the other variables. The IRFs are important because they reveal the sign of the relationships between variables, and provide information about the persistency of the effects of various shocks. The FEVD helps assessing the quantitative and economic significance of these effects

The multivariate analysis is based on US quarterly data over the period 1960.1-1997.4. The model includes the following five variables: (i) Real GDP, as a measure of output. (ii) The corresponding GDP deflator, as a measure of the price level[8]. The M2 aggregate is the broad monetary aggregate to be decomposed into the outside and inside money components. (iii) Outside money is measured by the monetary base adjusted for

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[6] This assumption will be questioned in Part Three, which addresses the issue of the connection between monetary policy and output together with the issue of the appropriate policy measure

[7] For the derivation of equation (3 5) and a detailed discussion of the test, see Engle and Hendry (1993)

[8] For reasons explained in the next chapter, the price level will be replaced by the inflation rate

reserve requirement changes, i.e 'St. Louis monetary base'[9]. (iv) The money multiplier, calculated as the ratio of the M2 aggregate to St. Louis monetary base, captures inside money movements. More is said about this below. (v) The spread between the 3-month Treasury bill rate and the 'own return of money', i e. the weighted average of the rates received on assets included in M2. As such, the spread will measure the real interest rate as the opportunity cost of holding money[10]. All variables except the interest rate are in logs and seasonally adjusted. Data were obtained from FRED, the database of the Federal Reserve Bank of St. Louis.

There are two alternatives for measuring the behavior of inside money. The first alternative is to use the value of inside money as M2 minus the monetary base. The second alternative is to use the money multiplier calculated as the ratio of M2 to the monetary base. A number of reasons favor the choice of the money multiplier. First, most theoretical models are based on the base-multiplier approach This choice also allows the results of this study to be compared to those of Manchester (1989), and Cagan (1993). Further, the chosen decomposition allows expressing the log of money as the sum of logs of the monetary base and the money multiplier, a relationship that is not valid when the absolute value of inside money is used. This feature will allow a comparison of Granger-causality results for money (M2) with those for its components, within the same framework (see Chapter Four). Finally, the use of the money multiplier

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[9] The unadjusted (Board of Governors') monetary base incorporates the effects of only two of the Fed's actions that change the money stock open market operations and the discount window loans to member banks The third major action, changes in reserve requirements, is not reflected in the unadjusted base St Louis monetary base eliminates this shortcoming See Burger (1979) for a discussion and a description of the adjustment methodology

[10] This is a *real* interest rate measure since the same expected inflation is included in both terms of the spread (cf 'Fischer effect')

is able to reveal a pattern of connections between movements in monetary variables and output that may be clouded by the use of the alternative specification. Details will be given in Chapter Five[11]. The next chapter presents the sequence of results

[11] Notice that it is possible that money multiplier and the absolute value of inside money move in opposite directions This is clear from the relationship $M_I = BM\ (MM-1)$, where M_I is inside money, BM is the monetary base, and MM is the money multiplier It is worth mentioning that the fact that the money multiplier and inside money are not perfectly equivalent is ignored in most studies based on the base-multiplier approach.

Chapter Four

Estimation and Results

The investigation of short run relationships among key macroeconomic variables requires a proper sequence of modeling procedures. The dynamics of output, outside money, the money multiplier, the interest rate, and the inflation rate are analyzed here in a vector error correction model. In the general model, the long run and short run relationships are identified and separated. Innovation accounting based on the short run dynamics will provide answers to the main questions of the inquiry.

An important preliminary step of the analysis requires the assessment of the order of integration of the variables of interest. The validity of the subsequent cointegration analysis depends on the assumption that the variables analyzed are I(0) or I(1), i.e. they do not contain more than one unit root. To find out if there are I(2) variables in our set, the Augmented Dickey-Fuller unit root tests (Dickey and Fuller, 1981), for both levels and first differences of variables were run. Summarized below are the conclusions, based on the 5 percent significance level:

Variable	Level	First difference	Second difference
Real GDP	Non-stationary	Stationary	-
GDP deflator	Non-stationary	Non-stationary	Stationary
Interest rate	Stationary	-	-
Base money	Non-stationary	Stationary	-
Money multiplier	Non-stationary	Stationary	-

These results indicate that real GDP, base money and the money multiplier are I(1), interest rate is I(0), and price level is I(2) Therefore, the analysis will be continued with inflation replacing the price level, to yield an I(1) variable.

To select the optimal lag length for our model, five-variable VARs with 12, 8, and 4 lags were estimated. Likelihood ratio tests for reduced lag structure from 12 to 8 lags gives a p-value of 0.0005, strongly rejecting the reduction. For 12 to 4 lags, the p-value is 0.0637. Both Akaike and Schwartz/Bayes information criteria select the 4 lag model However, the residual diagnostics indicate that, for the 4 lag model, the hypotheses of normality and no serial correlation are rejected at 5 percent for most individual series as well as for the multivariate tests. Since most subsequent tests are dependent on white noise errors in the maintained (unrestricted) hypothesis, the appropriate choice is the 12 lag model[1].

In order to perform the cointegration analysis, the VAR with 12 lags is reparameterized as in equation (3.2) and the resulting unrestricted VECM is estimated. Cointegration analysis is performed using Johansen's (1988) methodology.

Following the procedure described in Johansen (1992), a joint test for cointegration rank and deterministic components is performed. The test is based on the λ_{trace} statistic[2] and selects one of the alternative patterns for deterministic components.

[1] As shown by Cheung and Lai (1993), Monte Carlo evidence suggests that tests for cointegration rank are relatively robust to over-parameterization, whereas too short lag length severely distorts the size of the tests

[2] The statistic is calculated as

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \bar{\lambda}_i)$$

where $\bar{\lambda}_i$s are the estimated values of the characteristic roots (eigenvalues) obtained from the estimated Π matrix λ_{trace} tests the null hypothesis that the number of cointegrating vectors is less than or equal to r

Three alternatives were examined here. The first model includes only an intercept in the long run relationships (βs), assuming no linear trends in level variables The second model allows for a linear trend in (some of the) level variables and therefore includes a constant (drift) in the short run part of the model[3]. The third model includes both a trend in cointegration vectors and a drift.

At the 5 percent and 10 percent significance levels, the results of the test indicate that a model with one cointegrating vector and a constant in the short run model properly describes the data generating process (DGP)[4]. Thus, $r = 1$ represent the first restriction imposed on the model of equation (3.2), where a vector of constants is added.

Testing restrictions on β (the matrix of long run parameters) is necessary in order to identify the parameters of matrix Π and to estimate the whole system of equations. Johansen and Juselius (1992, 1994) developed a framework for testing homogeneity and zero restrictions on the cointegration vectors. In general, unrestricted estimation of Π does not result in uniquely identified parameters of α and β[5]. The rank condition for identification is discussed in Johansen (1992). A simple rule for exact identification is to set on each β vector a number of restrictions $k = r - 1$. If $k > r - 1$, overidentifying restrictions can be tested. (All tests for restrictions on α and β are

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against a general alternative The test is performed using the rank procedure in CATS See Johasnen (1992) and Hansen and Juselius (1995) for a detailed description of the test procedure.

[3] It is assumed that the intercept in the cointegrating vectors is cancelled by the intercept in the short run model, leaving only an overall intercept in the short run model See Enders (1995, pp 387-389) for details

[4] The calculated λ_{trace} statistic is 40 439, whereas critical values are 47 208 (5 percent) and 43 844 (10 percent) Critical values are given in Hansen and Juselius (1995)

[5] For any ω non-singular matrix of dimensions (r x r), $\alpha\beta' = \alpha\omega^{-1}\omega\beta' = \alpha^*\beta^{*\prime}$ It follows that $\Pi = \alpha\beta' = \alpha^*\beta^{*\prime}$, meaning that the parameters of α and β are not identified

likelihood ratio tests.) In the particular case of r =1, α and β are exactly identified (up to a scalar)

For each variable in the model, the hypothesis of exclusion from the long run relationship was tested For output, inflation, the interest rate, and the monetary base, the hypothesis is strongly rejected, with a p-value of 0.00 in all cases. For the money multiplier, results indicate that this variable does not belong in the cointegrating vector (the p-value is 0.67). This can be taken to mean that the other variables do not react in the long run to changes in money multiplier.

Next, weak exogeneity tests are performed by imposing zero restrictions on the parameters of the vector α. Restrictions on α are tested jointly with the accepted restriction on β. The following results were obtained:

Variables tested for weak exogeneity	P-values of likelihood ratio tests
Real GDP	0.03
Interest rate	0.81
Base money	0.67
Real GDP *and* interest rate *and* base money	0.09
Interest rate *and* base money	0.67

There is strong evidence that both interest rates and outside money are weakly exogenous. In contrast, the evidence for exogeneity of output is weak and suggests the rejection of this hypothesis (later tests will confirm this decision, as shown shortly). At this point, another check of residuals of the final restricted model showed that the model satisfies the required white noise criterion[6].

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[6] All multivariate and univariate tests for autocorrelation, normality, and heteroskedasticity fail to reject the null hypothesis at all conventional significance levels Results of the tests are available upon request

The first implication of finding outside money and the interest rate weakly exogenous is the possibility to estimate the endogenous variables conditional on these two variables. The conditional and marginal equations can be now estimated by OLS in the form given by equations (3.3) and (3.4), reproduced here:

$$\Delta y^*_t = \Gamma_0 \Delta z_t + \Gamma^y{}_1 y_{t-1} + \ldots + \Gamma^y{}_{k-1} \Delta y_{t-k+1} + \alpha(\beta' y_{t-k}) + u_{yt} \quad (4\ 1)$$

$$\Delta z_t = \Gamma^x{}_1 y_{t-1} + \ldots + \Gamma^x{}_{k-1} \Delta y_{t-k+1} + u_{xt} \quad (4.2)$$

The term $(\beta' y_{t-k})$ in (4.1) is now included as a deterministic regressor (called ECT -error correction term), as estimated in the long run (cointegration) analysis. Initial variables are now replaced by their first differences. The vector Δy^*_t of endogenous variables includes first differences of real GDP, inflation, and the money multiplier. The vector Δz_t of weakly exogenous variables includes the first differences of the interest rate and the monetary base (outside money) Based on this model, short run analysis and further testing can be performed.

To smooth the exposition, hereafter the variables of interest will be referred to as real GDP (output), base money, the money multiplier, inflation, and the interest rate. However, the reader should keep in mind that *for the rest of the short run analysis, the variables are specified as log differences or growth rates.*

Predictability among key variables is assessed by Granger-causality tests. Following the suggestions of Mosconi and Giannini (1992) and Toda and Phillips (1993), Granger causality tests were run in the VECM framework of equations (4.1) and

(4.2) as follows: (1) t-tests on the coefficients α_i of ECT - for long-run Granger-causality; (2) Wald/F-tests on the coefficients of Γ^x_i and Γ^y_i - for short-run Granger-causality; (3) Wald tests for the joint significance of α_I and Γ^y_i – the complete Granger-causality.

The following results were obtained:

Equation	F-tests on the lags of					t-test
	Real GDP	Inflation Rate	Money Multiplier	Interest Rate	Base Money	ECT
Real GDP	**0.023**	0.057	**0.022**	**0.001**	**0.011**	**0.034**
Inflation	0.446	0.282	0.058	**0.007**	0.065	**0.001**
Money mult.	**0.044**	**0.014**	**0.000**	**0.000**	0.125	**0.006**
Interest Rate	**0.006**	0.352	0.233	**0.000**	0.133	-
Base Money	0.099	0.253	0.278	**0.014**	**0.004**	-

Note: Figures are p-values; bold values are significant at 5 percent. The null hypothesis is that the column variables do not Granger-cause the row variables.

Notice that the last column confirms the earlier findings that output, inflation, and money multiplier are not exogenous. In terms of Granger-causality, each of these variables is predicted in the long run by all the others except the money multiplier, which is not included in ECT

Short run Granger-causality results reveal some interesting findings. Contrary to most results obtained in the literature using standard VARs for Granger-causality tests, both the money multiplier and outside money predict output. Further, being weakly exogenous and not Granger-caused by output, outside money is strongly exogenous for the output equation. This implies it is possible to forecast output conditional on base money Real interest rate is the only variable that Granger-causes all the others. However, interest rate is not strongly exogenous for output, since output predicts the

interest rate The money multiplier is Granger-caused by all variables except outside money In fact, the two components of money do not predict each other.

Finally, the complete Granger-causality test, (item 3 above) was performed for the equation of output. The following results were obtained

Null hypothesis		P-values
Base money does not Granger-cause output		0.016
Interest rate does not Granger-cause output		0.000
Base money and the money multiplier do not Granger-cause		
output:	- without ECT	0.042
	- with ECT	0.054

The results confirm that output is Granger-caused by outside money and the interest rate. Results regarding money (both components) are ambiguous. Notice here that the specification used for inside money, i.e. as the money multiplier, allows testing Granger-causality on money (M2), as a test on the sum of logs of the two components When both outside and the money multiplier are tested together, the p-values are very close to the critical values at 5 percent significance and would be both rejected at 4 percent or less. This shows why treating money as a homogenous variable can obscure relevant relationships between each of the two components and other key variables.

The model can be more efficiently estimated in a more parsimonious form. Based on F-tests, those lagged variables that *jointly* do not Granger-cause the dependent variable were dropped from each equation The model after reduction is the following:

$$DY = k_1 + w_{11}\,DR + w_{12}\,DBM + a_1(L)DY + a_2(L)D2P +$$

$$a_3(L)DR + a_4(L)DBM + a_5(L)DMM + \alpha_1\,ECT + u_1 \qquad (4.3)$$

$$D2P = k_2 + w_{21}\, DR + w_{22}\, DBM + b_1(L)D2P + b_2(L)DR +$$
$$+ b_3(L)DBM + b_4(L)DMM + \alpha_2\, ECT + u_2 \quad (4.4)$$
$$DMM = k_3 + w_{31}\, DR + w_{32}\, DBM + c_1(L)DY + c_2(L)D2P +$$
$$+ c_3(L)DR + c_4(L)DMM + \alpha_3\, ECT + u_3 \quad (4.5)$$
$$DR = k_4 + d_1(L)DY + d_2(L)DR + u_4 \quad (4.6)$$
$$DBM = k_5 + e_1(L)DR + e_2(L)DBM + u_5 \quad (4.7)$$

where DY, D2P, DMM, DR, and DBM , respectively, are the first differences of real GDP, inflation, the money multiplier, the interest rate, and the base money, and the terms in (L) are lag polynomials. Time subscripts are omitted.

As mentioned earlier, a provisional assumption adopted here, in line with most of the existing literature, is that base money may be considered a policy variable[7]. In this hypothetical case, it is interesting to test for superexogeneity of base money with respect to the parameters of output equation. Superexogeneity would imply that changes in base money do not change the behavioral parameters of the output equation. If base money is a discretionary variable and if, at the same time, it is superexogenous for output, it follows that base money is also an effective policy instrument. As explained in the previous chapter, the test for superexogeneity is performed in the general framework of equation (3.5). Specifically, the significance of the first two moments of the process generating base money (equation 4.7) is tested in the equation of real GDP.

[7] See Chapter Five for arguments that make this assumption highly questionable These arguments are further documented in Part Three

Preliminary tests for the stability of coefficients of equations (4.3) and (4.7) are necessary. Assessing the results of CUSUM and CUSUM of squares tests (as in Brown et al., 1975), based on recursive residuals, it appears that both conditional and marginal process exhibit satisfactory stability over the estimation period.

Since the residuals of the marginal process are not heteroskedastic[8], the squared residuals can be used as a proxy of the conditional variance (Charemza and Deadman, 1987, p. 240). The following equation is estimated:

$$\begin{aligned} DY = k_1 + w_{11}\, DR + w_{12}\, DBM + a_1(L)DY + a_2(L)D2P + \\ + a_3(L)DR + a_4(L)DBM + a_5(L)DMM + \alpha_1\, ECT + \\ + m\, RES3 + p_1 FITSQ + p_2 RESQ + p_3 FITRESQ + v \end{aligned} \qquad (4.8)$$

where the last four regressors are constructed variables obtained from the base money equation, v is the error term, and the time subscripts are omitted. RES3 is a proxy for (conditional variance x residuals), FITSQ is the squared fitted value of DBM, RESQ is the proxy of conditional variance, and FITRESQ = (fitted values x RESQ).

The following results were obtained:

Null hypothesis	P-value
Base money superexogenous ($p_1 = p_2 = p_3 = 0$)	0.783
Constancy of coefficient w_{12} ($m = 0$)	0.427

Based on these results, we conclude that outside money is superexogenous for the parameter of interest w_{12} and this parameter is constant to variations in the mean and

variance of base money At this point it appears that there is a stable structural relationship between outside money and output. The policy implications of this finding will be discussed in Chapter Five.

The model given by equations (4.3) – (4.7) is next estimated as seemingly unrelated regressions (SUR). SUR improves the efficiency as compared to OLS estimation when the residuals are correlated across equations. The variance-covariance matrix of the estimated system is then used to generate impulse response functions (IRFs) and forecast error variance decompositions (FVEDs). The IRFs indicate the behavior of variables of interest over time, following one-time own shocks or shocks to other variables. The FEVDs measure the proportions of the variance in a variable that are explained by its own innovations and by innovations in the other variables.

Equations (4.3)-(4.7) represent the reduced form of a "near-VAR" (Enders, 1995), obtained from the VECM representation. The error-terms u_t are linear combinations of the structural innovations, i.e the error terms of the underlying structural model. To recover the structural innovations, either a Choleski decomposition or a Sims-Bernake decomposition can be used. For reasons explained in Section 1.2 of Part One, in this study the structural innovations are modeled as suggested by Sims (1986) and Bernake(1986). (See also Enders, 1995, pp. 320-331, for a clear exposition of this method) The relationship between the structural and reduced-form innovations is given by the equation (1.4), reproduced here as (4 9)·

$$u_t = \Lambda^{-1} v_t \tag{4.9}$$

[8] The residuals from equation (4 7) are tested against heteroskedasticity White's (1980) test is applied,

where u_t is the (5x1) vector of reduced-form innovations in equations (4 3)-(4.7), v_t is the (5x1) vector of the structural innovations, and Λ is a (5x5) matrix of the contemporaneous relationships between the variables of interest. Whereas the reduced-form innovations are correlated across equations, it is assumed that the structural innovations are uncorrelated (orthogonal).

Based on common theoretical insights as well as the results of weak exogeneity testing and SUR estimation, the contemporaneous (in our case, within the quarter) relationships are modeled as follows:

$$u_{1t} = v_{1t} + \lambda_{14}v_{4t} + \lambda_{15}v_{5t} \qquad (4.10)$$

$$u_{2t} = v_{2t} \qquad (4.11)$$

$$u_{3t} = \lambda_{31}v_{1t} + v_{3t} + \lambda_{34}v_{4t} + \lambda_{35}v_{5t} \qquad (4.12)$$

$$u_{4t} = v_{4t} + \lambda_{45}v_{5t} \qquad (4.13)$$

$$u_{5t} = \lambda_{52}v_{2t} + \lambda_{53}v_{3t} + v_{5t} \qquad (4\ 14)$$

where λ_{ij} is the row i, column j element of Λ.

Equation (4.10) means that, within a quarter, innovations in output are affected by innovations the interest rate and the monetary base[9]. Equation (4.11) shows that innovations in inflation are not contemporaneously related with any other structural

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and the null of homoskedasticity is accepted at all conventional levels (p-value = 0 314)

[9] It was found that these variables are weakly exogenous for the parameters of the output equation, and the coefficients w_{11} and w_{12} in equation (4 3) were found to be statistically significant, with p-values of 0 000 and respectively 0 001

innovation[10] Innovations in the money multiplier (equation 4.12) are related to those in weakly exogenous variables[11] In addition, it is assumed that the money multiplier is contemporaneously affected by innovations in output Equation (4.13) allows interest rate innovations to be correlated with innovations in base money. Finally, equation (4.14) assumes a reaction function of the Fed, where the monetary base is adjusted in response to innovations in inflation and the money multiplier.

As pointed out by Sims (1980b), any a priori structure imposed on a simultaneous equations system is debatable and may involve "incredible restrictions". Therefore, it is worth emphasizing that the number of a priori considerations in modeling the matrix Λ (equations 4.10-4.14 above) is held as small as possible. Most of the above contemporaneous relationships are modeled based on previous results regarding weak exogenity and SUR estimation results (see footnotes 9-11). The remaining assumptions (i.e. the relationships money multiplier-output, interest rate-base money, and the reaction function of the central bank) are largely uncontroversial. Moreover, as shown shortly, the above structure is subjected to empirical testing and proves to be supported by the sample data. Testing of the restrictions is made possible by the fact that the number of restrictions included in equations (4.10)-(4.14) overidentifies the system.

As modeled above, the matrix Λ includes 12 zero restrictions on λ_{ij}s. Since only n(n-1)/2 restrictions are necessary for just identification of the structural model, there

[10] Although the interest rate and base money are exogenous for the inflation equation, the coefficients w_{21} and w_{22} in equation (4 4) are not statistically significant at 5 percent (p-values 0 414 and respectively 0 066)
[11] The p-values for w_{31} and w_{32} in equation (4 5) are 0 004 and, repectively, 0 000

are two overidentifying restrictions. The likelihood ratio test for the overidentifying restrictions gives a p-value of 0.381. The restrictions are therefore accepted at all conventional significance levels, showing that the model of equations (4.10)-(4 14) is supported by data[12]

The complete results of the variance decomposition based on the structural model are presented in Tables 2.1-2.5. The impulse response functions relevant for the analysis here are those generated by innovations in outside money (Figure 2.1), the money multiplier (Figure 2.2), and output (Figure 2.3).

Focusing on the relationships between outside money, the money multiplier, and output, the findings can be summarized as follows. At 4 and 8-quarter horizons, outside money innovations explain more than one third of output prediction error. Interest rate innovations are less important than outside money innovation for output variance, while still explaining a significant proportion (16 percent at 4-quarter and 22 percent at 8-quarter). The earlier findings regarding the exogeneity of outside money and the interest rate are confirmed here. The variation of these variables is due to own innovations in a proportion that does not fall below 80 percent at any horizon.

The above results indicate that base money and the interest rate are the main explanatory variables for short run output fluctuations. The substantial explanatory power of base money seems to favor the monetary theories of business cycles, contradicting the RBC view that outside money cannot explain output variations.

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[12] Other patterns of restrictions on Λ matrix were tested, but rejected at conventional significance levels The only alternative accepted, with a p-value of 0 42, involved a single difference as compared to the chosen pattern, setting $\lambda_{45} = 0$ Since some monetary theories assume a contemporaneous inverse relationship between interest rate and base money, it is preferable to allow for this feature in the model However, the results of innovation accounting with $\lambda_{45} = 0$ are almost identical with those reported

Table 2.1 Part Two - FEVD for DY

FH	DY	D2P	DMM	DR	DBM
1	79 84	0 00	0 03	12 66	7 47
2	75 99	0 05	2 16	13 85	7 96
3	58 97	0 83	1 58	16 41	22 21
4	45 48	2 49	1 84	15 93	34 27
5	38 97	2 93	3 47	14 97	39 65
6	37 51	2 69	4 26	17.58	37 96
7	35 96	2 71	5 10	19 08	37 15
8	33 76	2 51	7 37	21 97	34 39

Table 2 2 Part Two - FEVD for D2P

FH	DY	D2P	DMM	DR	DBM
1	0 00	96 32	0 01	0 55	3 13
2	0 10	91 58	1 22	2 47	4 62
3	0 38	88 12	1 16	2.16	8 18
4	0 54	85 80	1 14	2 30	10 22
5	0 96	82 66	3 19	2 16	11 03
6	0 94	77 30	4 66	4 97	12 13
7	1 15	74 60	6 02	5 53	12 70
8	1 62	72 95	6 44	6 13	12 86

Table 2 3 Part Two - FEVD for DMM

FH	DY	D2P	DMM	DR	DBM
1	2 26	0 00	50 84	3 31	43 59
2	2 83	4 27	31 55	18 15	43 20
3	2 99	3 41	26 29	19 77	47 55
4	4 63	2 82	21 09	21 33	50 14
5	4 62	2 77	19 21	22 06	51.33
6	4 34	2 71	18 49	23.10	51 36
7	3 99	2 55	16 81	27 78	48 87
8	3 90	2 33	15 35	31 09	47 32

Table 2 4 Part Two - FEVD for DR

FH	DY	D2P	DMM	DR	DBM
1	0 00	0 00	0 00	99 37	0 63
2	1 51	0 00	0 00	97 88	0 61
3	3 15	0.00	0 06	95 61	1 18
4	3.20	0 01	0 09	95 32	1 38
5	3.19	0 17	0 16	93 95	2 53
6	3 25	0.17	0 35	92 33	3 89
7	3.37	0 30	0 42	92 04	3 87
8	3 27	0 33	0 45	92 25	3 71

Table 2 5 Part Two - FEVD for DBM

FH	DY	D2P	DMM	DR	DBM
1	0 02	0 00	0 35	0 00	99 63
2	0 01	0 00	0 33	6.66	92 99
3	0 13	0.00	0 31	12 18	87 38
4	0 50	0 00	0 32	11 69	87 49
5	0 54	0 00	0 33	14.02	85 11
6	0 58	0 02	0 33	15 75	83 34
7	0 76	0 02	0 33	16 33	82 55
8	0 77	0 02	0 32	17 56	81 33

Note.

Y = output, R = the interest rate, 2P = inflation rate, MM = the money multiplier, BM = base money. D denotes first differences and FH = forecast horizon.

Each row shows, for the forecast horizon indicated in the first column, the proportion of the variance in the variable at the top of the table explained by the innovations in column variables. The row numbers sum up to 100 (save for rounding errors).

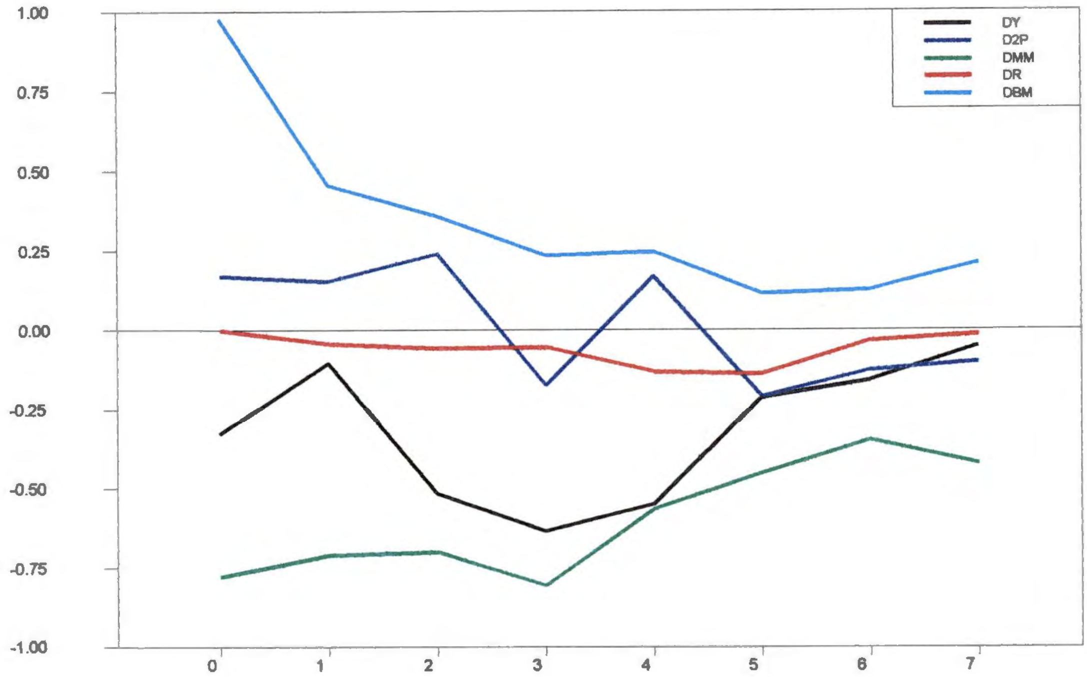

Figure 2.1: Part Two – Responses to a One Standard Deviation Shock to Base Money Changes

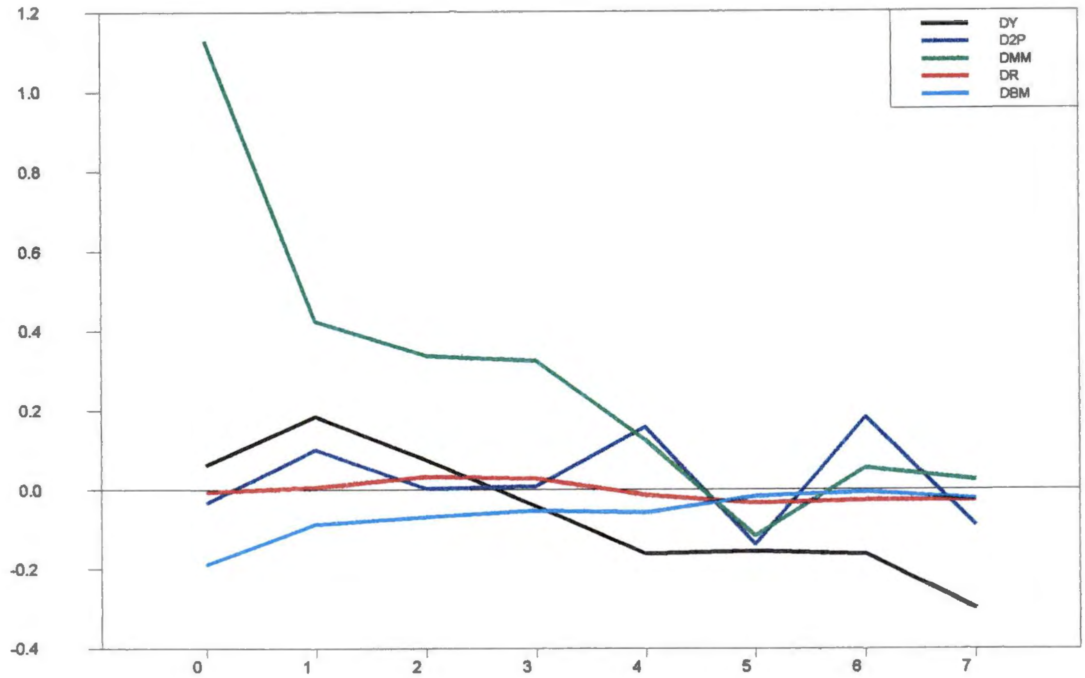

Figure 2.2: Part Two – Responses to a One Standard Deviation Shock to Money Multiplier Changes

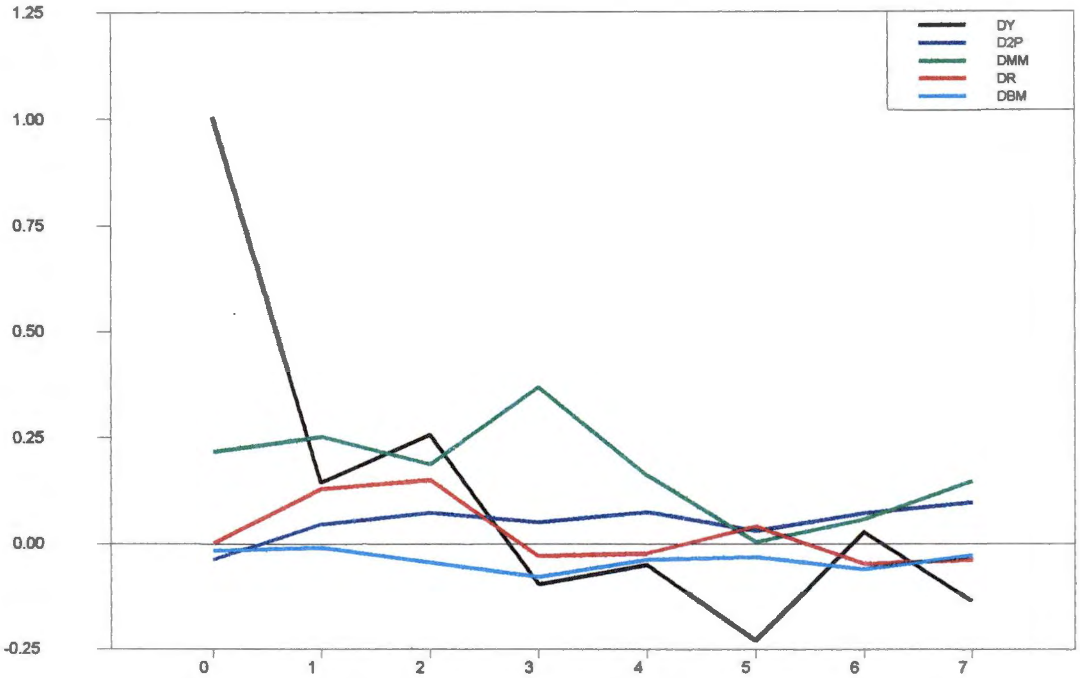

Figure 2.3: Part Two – Responses to a One Standard Deviation Shock to Output Changes

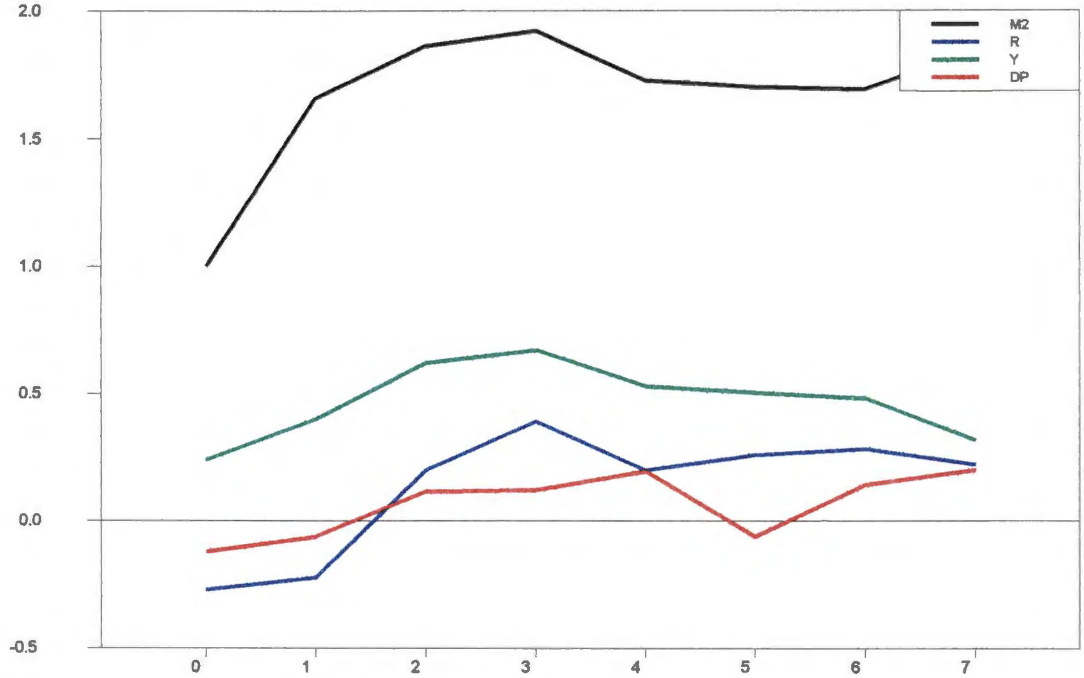

Figure 2.4: Part Two – Responses to a One Standard Deviation Shock to Money (M2), Model (a)

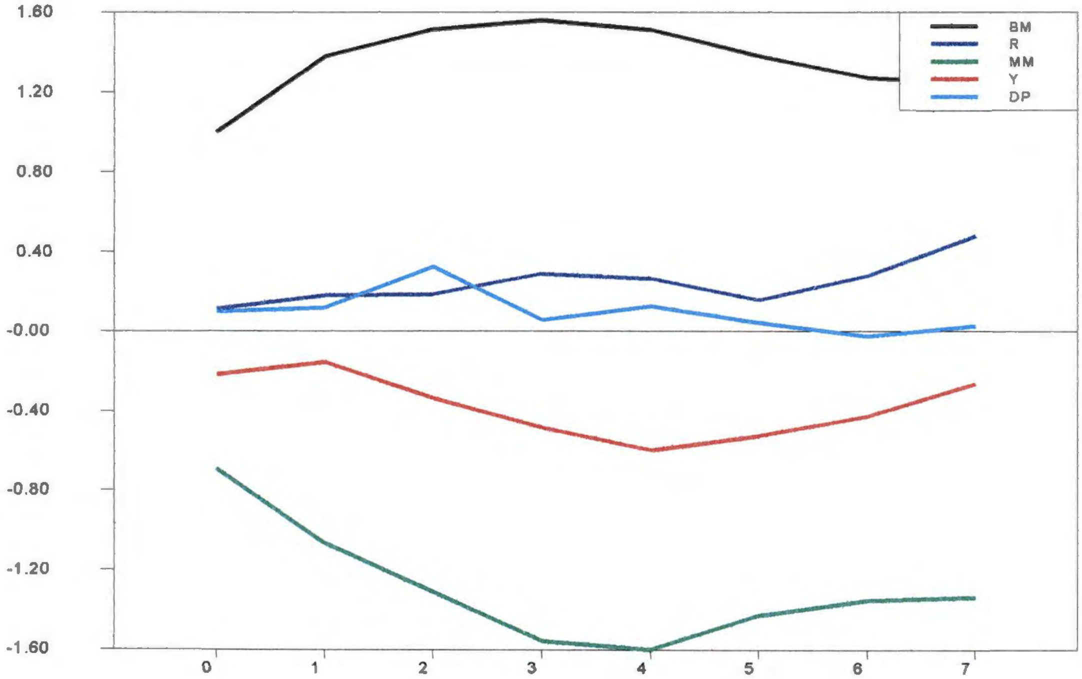

Figure 2.5: Part Two – Responses to a One Standard Deviation Shock to Base Money, Model (b)

However, conclusions regarding the nature of these relationships cannot be reached based on FEVD alone, which does not provide any information about the sign of the relationships between variables. This type of information is provided by IRFs, which will be presented shortly

Results further indicate that money multiplier innovations explain only a relatively small percentage of output variation, up to 7.4 percent at 8-quarter horizon. This finding may appear surprising in light of most theoretical considerations that assume a close connection between output (Y) and the money multiplier (MM). However, it is very likely that the *observed* direct relationship between these variables is subject to considerable noise. FEVD results show that the money multiplier is the variable whose variation is the least explained by its own variations, suggesting that MM is the "most endogenous" variable. In addition, the money multiplier may be affected by portfolio redistributions (among M2 assets) that are the result of changes in private sector's preferences, i.e. deep behavioral parameters of the economy[13].

Another noticeable result of the variance decomposition is the substantial proportion of the variation in the money multiplier (40-50 percent at all horizons) that is explained by base money innovations. This is a surprising result, in light of both monetary and RBC theories. While acknowledging the importance of the distinction between outside and inside money, both theories deny significant inter-connections between these monetary variables. Information about the nature of this relationship is further provided by the IRFs.

[13] Part Four will provide empirical evidence supporting this argument

The IRFs of interest here are those generated by innovations in base money (Figure 2.1), the money multiplier (Figure 2.2), and output (Figure 2.3). The impulse response functions show that a one-standard-deviation innovation in outside money is followed by a response *of opposite sign* in output, whereas an innovation in the money multiplier is followed by a response *of the same sign* in output. Innovations in outside money are also followed by negative responses in the money multiplier and interest rates and by positive responses in inflation. Output innovations induce negative responses in outside money and positive responses in all other variables.

An interesting and revealing exercise is to compare the results obtained using the methodology adopted in this study with the results that can be obtained using the standard procedures most frequently employed in the existing literature. Based on the same data as above, two other models were estimated: (a) a 4-variable VAR in levels, including money measured as (the log of) the aggregate M2, output, the interest rate, and the inflation rate, and (b) a 5-variable VAR including the levels (rather than first differences) of the same variables as in the main analysis

Models (a) and (b) are standard VARs, whereas our model (let's call it 'model c') is a VECM. Compared to standard VARs, one important advantage of the VECM is the possibility of distinguishing between short run and long run dynamic interactions among variables. Also notice that model (a) regards money as a homogenous aggregate, whereas models (b) and (c) employ the theoretical distinction between outside money and inside money (the money multiplier). To illustrate the comparison between the results obtained with models (a), (b), and (c), the assessment will focus on the impulse response functions (IRFs) describing the path of variables of interest following a one-

standard-deviation change in money (M2) for model (a) (see Figure 2.4), and in base money for model (b) (see Figure 2.5). These are to be compared to Figure 2.1, the corresponding IRFs for the model (c) developed here. Please note that, in Figures 2.1, 2 4, and 2.5, the IRFs for the same variable may appear in different colors

The IRFs for models (a) and (b) were obtained through a Choleski decomposition, rather than a structural one as in model (c). One reason for this choice is that most existing studies use the Choleski decomposition. A second reason is that the structure imposed on model (c) (equations 4.10-4.14) cannot be imposed on model (a), which has fewer variables. However, the orderings imposed on models (a) and (b) are broadly consistent with our earlier findings for model (c), namely that the base money and the interest rate are weakly exogenous for output equation. These orderings were chosen in order to provide a reasonable (though inevitably limited) degree of comparability between models. Specifically, the orderings are: (a) M2 $\rightarrow$ R $\rightarrow$Y $\rightarrow$ dP; (b) BM $\rightarrow$R $\rightarrow$MM $\rightarrow$Y $\rightarrow$dP.

Figure 2.4 shows that, if money is treated as a whole (model a), a positive relationship between money and output obtains. However, in Figure 2.5 (for model b), which accounts for the distinction between outside money and the money multiplier, the relationship between changes in base money and changes in output is clearly negative. This finding confirms the result obtained in model (c) (see Figure 2 1) It is also found that base money and the money multiplier move in opposite directions, again confirming the results of model (c)

Comparing the results of model (a) with those of models (b) and (c) shows clearly that treating money as a homogenous variable obscures relevant aspects of the

dynamic relationships between the monetary variables and output. Models like (a), commonly employed in the existing literature, may conclude that expansionary monetary policy increase base money, and therefore money supply (M2) and, further, output. However, models like (b) and (c), that duly account for the distinction between outside and inside money, show the fragility of such inferences Most theories associate monetary policy measures with changes in base money rather than the money multiplier. Therefore, the conclusion that expansionary monetary policy increases output cannot be warranted by models such as (a), that ignore the decomposition of money.

It is also worth pointing out that the negative relationship between changes in outside money, on one hand, and output and the money multiplier, on the other hand, is robust across models (b) and (c) As mentioned above, the ordering used for innovation accounting of model (b) was chosen in such a way to be *broadly consistent* with the structure imposed on model (c). However, these structures are definitely *not identical*: whereas model (a) implies strictly ordered causal relationships[14], model (b) allows for mutual contemporaneous causality. This shows that the negative relationship reported in this study is not model-specific.

The results obtained here by decomposing money into outside money and the money multiplier, within a VECM framework, differ in several respects from the results reported by earlier studies that ignore this decomposition and use standard VAR procedures. In contrast to Sims (1980), Litterman and Weiss (1985), and Friedman and

[14] In the sense that the first variable causes all the others, the second variable causes all variables except the first, and so on

Kuttner (1993), results here find that money, mainly through its outside component, explains a substantial proportion of the variance in output. The explanatory power of outside money exceeds that of the interest rate at close horizons. An important result of this study reveals that *outside money and the money multiplier move in opposite directions in the short run* This finding explains why studies that ignore the decomposition fail to assess properly the relevance of co-movements in monetary variables and output. The next chapter summarizes findings and offers a theoretical interpretation of the results.

Chapter Five

Interpretation and Policy Implications

The foregoing analysis investigated both the long run and short run relationships between output, outside money, the money multiplier, the real interest rate, and inflation. The analysis revealed that a long run relationship exists between output, outside money, the interest rate, and inflation. The money multiplier is not included in the cointegrating relationship. It was also found that outside money and the interest rate are weakly exogenous for the parameters of output, inflation, and money multiplier equations. Together, these results suggest that the money multiplier adjusts to deviations from the long run equilibrium induced by changes in other variables, whereas the other variables do not respond in the long run to changes in the money multiplier. The findings also imply that output, inflation, and money multiplier equations can be estimated conditional on given values of outside money and interest rate, without loss of efficiency.

The short run analysis started with Granger-causality tests. Earlier studies conducted in a standard VAR framework (Sims, 1980; Litterman and Weiss, 1985) found that money does not Granger-cause output when model specification includes an interest rate. In this study, Granger-causality is tested in an appropriate VECM framework, where distinction is made between outside and inside money. Results indicate that both outside money and the money multiplier Granger-cause output. However, as regards Granger-causality of money (M2) on output, the results are

ambiguous, showing the shortcoming of treating money as a homogenous aggregate. Results further show that output does Granger-cause the money multiplier, but not outside money.

Being both weakly exogenous and not Granger-caused by output, outside money is strongly exogenous with respect to the parameters of output equation. This means that short run forecasts of output can be made conditional on forecasts of the monetary base. Changes in monetary base can therefore be regarded as a useful leading indicator for policy makers.

It was further found that outside money is superexogenous with respect to output equation. A question naturally arises in light of the discussion in Chapter Three. Since monetary base Granger-causes output and, in addition, is superexogenous, can it be used as a valid policy instrument for *causing* output adjustment? An affirmative answer is not warranted. This would be the case if superexogeneity can be positively identified as equivalent to structural causality. Engle et al.(1983) suggest that superexogeneity 'seems to satisfy the requirement for causality', if one accepts Zellner's (1979) definition of causality as 'predictability according to a law'. Confirmations of this view or alternative suggestions regarding empirical tests for structural causality, however, can hardly be found in recent literature. Moreover, a valid policy instrument needs to be highly discretionary. It is doubtful that this is the case with monetary base, since it is known that (i) public's demand for currency is fully accommodated by the central bank, and (ii) changes in bank reserves might by due to Fed's accommodation of innovations in the demand for reserves rather than policy-induced supply innovations (Strongin, 1995). Given these arguments, the finding that outside money is superexogenous for the

output equation can only be interpreted as evidence of a stable structural relationship between the monetary base and output. Strong conclusions about the direction or even the existence of *direct* genuine causality between the two variables are not warranted, even if they may appear widely in the literature.

Variance decomposition results show substantial explanatory power of outside money innovations for output forecast errors. Contrary to Manchester's (1989) findings, the explanatory power of outside money exceeds significantly that of the money multiplier and, at close horizons, that of the interest rate[1].

The impulse response functions revealed findings that are not hitherto documented in the existing literature, namely the short run *negative* relationships between (i) outside money and output, and (ii) outside money and the money multiplier These patterns contradict the theories that assume that monetary variables and output move invariably in the same direction over the business cycles Results here show that, in the short run, the pattern of interactions between outside money, inside money, and output is more complex than commonly acknowledged.

The results of innovation accounting are important not only for the direct conclusions presented above. They also explain why investigations that treat money as a homogenous variable (for instance Sims, 1980; Friedman and Kuttner,1993) are unable to assess properly the interactions between the monetary variables and output. This conclusion is clearly illustrated by comparing the main results obtained in this study with the results obtainable using a standard VAR procedure where aggregate rather than

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[1] However, the investigation in Part Four, where the model accounts for the effects of portfolio redistributions for monetary dynamics, this result no longer obtains Under the new model specification,

decomposed money is employed. The comparative analysis in Chapter Four showed that the results obtained employing the latter approach (common in most of the existing literature) are likely to support the conclusion that policy induced changes in money supply determine changes of the same sign in output. However, the analysis proved that the evidence based on the same data set no longer warrants this conclusion when the model accounts for the distinction between outside an inside money.

The short run negative relationship between base money, on one hand, and output and the money multiplier, on the other hand, requires a theoretical interpretation. One possible explanation can be given in a RBC framework. The co-movements of output and the money multiplier are perfectly consistent with the RBC view (see, for instance, Freeman and Huffman, 1991). The fact that outside money and output move in opposite directions can be explained simply by arguing that over the period of analysis the Fed followed in general a countercyclical monetary policy[2]. If the policy is ineffective but is followed with regularity, the reported pattern obtains. The fact that base money predicts (Granger-causes) output can be explained by arguing that the Fed anticipates the output movements and the policy actions are pre-emptive. However, the

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the explanatory power of outside money for output is substantially reduced, not exceeding five percent at any horizon within two years

[2] It is extremely difficult to assess empirically the stance of monetary policy This will require the availability of a proxy for policy actions capable of capturing the intentional actions of the policy-makers In addition, it would be necessary to assume that the actual intentions are readily translated into appropriate actions, and also that the policy instruments used are highly discretionary An illustration of the ambiguities involved in assessing the stance of monetary policy is provided by the attempt of Romer and Romer (1989) to identify voluntary policy innovations with specific decisions taken by the Federal Open Market Committee (FOMC). This approach was criticized on the account that it focuses on what the Fed says, not on what the Fed actually does (Hoover and Perez, 1994) Another relevant episode is that of 1979-1982 Many economists characterize this period as "the monetarist experiment" However, many monetarists (Friedman included) denied repeatedly that Fed's policy was truly monetarist at the time. An investigation of the effects of monetary policy by employing a measure of voluntary policy actions that is more discretionary than base money is performed in Part Three of this study

above explanation assumes that base money is a discretionary policy variable. Part Three of this study will challenge this assumption

Next, an alternative scenario is suggested, aimed at explaining the connections between short run changes in output, outside money, and the money multiplier. The interpretation is consistent with all the empirical findings in this Part. Naturally, there may be other plausible explanations for the patterns found here. This scenario is offered as one possible process[3].

Two arguments underlie the proposed scenario. First, to explain the positive relationship between output (Y) and the interest rate (R), it is assumed that economic agents sensing opportunities for increased output and profits increase their demand for credit. The increase in the demand for loanable funds will induce an increase in the interest rate. Alternatively, a higher interest rate may signal, as in RBC models, a positive technological shock Note that this argument is consistent with both monetary and RBC theories. If expectations are rational, then actual output (Y) can be used as a proxy for expected output (Y^e). Therefore, the IRF of R generated by a positive innovation in real GDP should indicate an initial positive response of R, as the results here show (Figure 2.3).

The second argument of the proposed scenario aims to explain the negative short run relationship found between outside money, on one hand, and output and the money multiplier, on the other hand. The idea is that the observed pattern obtains if it happens that output fluctuations are regularly accompanied by asset portfolio redistributions

[3] Further empirical evidence consistent with this scenario is offered in Part Four

within M2 aggregate, as follows: when output increases (decreases) private agents increase (decrease) the share of their holdings of non-M1 (or quasi-money) assets and, correspondingly, decrease (increase) the share of their holdings of M1 assets. The mechanism is explained next.

A simple model will help the exposition:

$$M = C + D + Q \quad (5.1)$$

$$BM = C + R_D + R_Q + E \quad (5.2)$$

$$MM = (k + q + 1) / (k + r_D + r_Q q + e)^4 \quad (5.3)$$

$$M = BM\ MM \quad (5.4)$$

$$M_I = M - BM = BM\ (MM - 1) \quad (5.5)$$

where M = monetary aggregate M2, BM = monetary base, MM = the money multiplier, M_I = inside money, C = currency in circulation, D = transaction deposits in M1, Q = quasi-money (i.e. non-M1 components of M2), R_D = required reserves on transaction deposits, R_Q = required reserves for Q assets, E = excess reserves, k = C/D, $r_D = R_D/D$, $r_Q = R_Q/Q$, q = Q/D, e = E/D.

While more analytic models of the money multiplier than equation (5.3) can be used, this form serves well its limited purpose here. The same model is used by Manchester (1989). The RBC model of Freeman and Huffman (1991) employs a base-

[4] The analytic expression for multiplier is derived as follows

$$BM = (C/D + R_D/D + R_Q/D + E/D)\ D = (k + r_D + r_Q q + e)\ D$$
$$M = (C/D + D/D + Q/D)\ D = (k + 1 + q)\ D$$
$$MM = M / BM = (k + q + 1) / (k + r_D + r_Q q + e)$$

multiplier model focused on M1 rather than M2, which explains why their study overlooks the mechanism discussed here.

In terms of the above model, the proposed argument can be reformulated as follows: the observed pattern of relationships between outside money, inside money, and output obtains if the ratio q is pro-cyclical. The key premise of the argument consists in a known fact, namely that $r_D > r_Q$. Historically, the required reserve ratio on checkable (transactions) deposits was always higher than the required reserve ratio on Q (quasi-money) balances, at least over the sample period of this study. Currently, according to Fed's 'Regulation D', r_Q equals zero.

Now, assuming that a portfolio redistribution occurs exclusively among D assets and Q assets[5], an increase in q (which, as noted, occurs pro-cyclically) implies a decrease in D and an increase in Q by the same amount. However, since the reserve requirements on Q are smaller than the reserve requirements on D, the corresponding decrease in R_D is larger than the increase in R_Q. If the demand for credit of the private sector does not increase, then excess reserves E would increase with the difference $R_D - R_Q$, and total reserves would be unchanged. However, the very first event in our scenario, i.e the perceived opportunity for higher output, implies a higher demand for credit. Having now higher excess reserves, commercial banks may accommodate this demand by increasing lending (and reducing E to the previous level or even lower). It is worth emphasizing that commercial banks have strong incentives to extend credit when holding excess liquidity. Idle resources are costly, since commercial banks' balances

[5] This assumption, made to simplify the exposition of the main argument, will be relaxed in Part Four, where the hypothesis formulated here is presented in more detail and empirically tested

with the central bank do not earn interest. While banks are reluctant to extend credit (and may indeed reduce lending) when the economy is slow, due to the risk of accumulating bad loans, in an expanding economy banks rapidly transform any excess liquidity in loan assets. Under such circumstances, the money multiplier will increase following a decrease in the total reserves and therefore in base money[6].

The above argument will be further elaborated in Part Four of this study, where the hypothesis formulated here is subjected to direct empirical testing The assumption that portfolio redistributions imply equal changes in D and Q will be relaxed. A formal analysis will show that the relationships observed here between outside money, output, and the money multiplier are consistent with more general patterns of portfolio redistributions.

At this point it is interesting to notice that, under the proposed scenario, a policy action would not be connected with output changes in the absence of private sector's actions. A policy-induced increase in total reserves will be merely reflected in higher excess reserves. It is only when credit supply meets the increased credit demand (determined by perceived profit opportunities), that changes in outside money and the money multiplier will be connected with changes in output. In such cases, the growth rates of output and base money move in opposite directions, while the growth rates of the money multiplier and output move in the same direction The relationship between output and base money, however, is negative only in the short run. In the long run,

[6] Here, it is assumed that no change in currency in circulation (C) occurs However, under the circumstances, it is conceivable that C may also decrease, since it is likely that the same type of incentives that trigger substitution of Q for D would also work towards diminishing currency holdings Thus, Q assets may be substituted for both C and D If this happens, the effects on base money and the money multiplier would be augmented

monetary base follows the raise in output, due to output-induced increases in the demand for currency and transaction deposits (and therefore in required reserves).

Given the scenario described above, two questions naturally arise. First, is it likely that the q ratio is indeed pro-cyclical? Second, if this is actually the case, then what factors can explain this pattern?

The first question is an empirical one. Both the pattern found here for the relationships between output, outside money and the money multiplier and the proposed explanation of this pattern are new in the literature Therefore, a new empirical investigation is needed to document the existence or otherwise of the assumed behavior of the key variables. Some corroborating evidence will be provided in Part Three, by the finding that total reserves are negatively related to output. A direct investigation of the relationships between the q ratio and output, outside money, and the money multiplier is undertaken in Part Four of this study. Evidence will be provided that sample data are consistent with the scenario proposed here. In Part Four, some possible answers to the second question will also be explored. The proposed explanations will show that the negative relationships between outside money, on one hand, and output and the money multiplier, on the other hand, can be generated by factors such as real demand and supply shocks, or by adjustments in the behavior of the private sector (households, firms, and commercial banks).

What are the causal implications of the empirical findings at this stage of our investigation? In general, causal interpretation of empirical results is ambiguous. The dynamic relationships between macroeconomic variables imply continuous and quasi-simultaneous movements of these variables. It is practically impossible to detect

empirically a strict sequencing of economic events assigning the initial causal impulse to a certain variable. Any such attempt can be in principle challenged as a "post hoc ergo prompter hoc" fallacy. IRFs are a most useful tool for revealing the dynamic behavior of some variable following the innovation in other variables, but they do not provide information about genuine causal orderings In this context, strong conclusions about the direction of (structural) causality can only be relative. However, it is possible, based on corroborating evidence from exogeneity tests, variance decomposition, and IRFs, *to assess the consistency or otherwise between an assumed causal ordering and data.* This is the approach adopted in this study for the interpretation of the empirical findings.

Before presenting the conclusions of this Part regarding the assessment of causality between money and output, two additional aspects need to be addressed. First, it happens that causality conclusions depend on each researcher's interpretation of the concept of causality. This is so because the existing literature on genuine causal connections in economics is extremely scarce and hardly offers reliable assessment criteria. Therefore, ambiguities cannot be avoided. To illustrate, one can argue that output or expectations about output cause changes in outside money and the money multiplier. On the other hand, if the central bank and the banking system do not accommodate the movements in the demand for credit, the financing of the new projects may be hindered unless deflation occurs. From this standpoint, one can argue that changes in monetary variables cause (i.e. make possible or sustain) changes in output. Without a rigorous and widely accepted definition of causality, both positions may be held.

A second observation brings us closer to the conclusions of this essay. Assessing the causality between money and output, it is important to notice that there is no logical necessity requiring that causality runs in one direction or the other, or both ways. Logically, it is perfectly possible that direct causal connections between money and output do not exist. Changes in both money and output can be independently caused by third factors. The following analysis suggests that the evidence provided here seems to favor this conclusion.

The FEVD finding that base money innovations have relatively high explanatory power for output fluctuations, together with the result of the superexogeneity test, seem to be consistent with a causal connection running from base money to output. However, the IRF results indicate that the relationship between base money and output is negative. A mechanical interpretation of these findings in terms of causality would suggest that accelerations of base money growth cause slower output growth. Clearly, it is difficult to find theoretical arguments in defense of this conclusion. An alternative, more plausible interpretation of the empirical findings is therefore needed. The hypothesis formulated earlier suggests that the observed co-movements of outside money and output may not be the result of direct causal interactions between these variables. These co-movements might rather be the common effects of factors that cause both portfolio redistributions among monetary assets and output fluctuations. The investigation in Part Four will further examine the interactions between money and output, by properly taking into account the implications of portfolio redistributions. The results will show that, while the negative relationship between outside money and output is robust across model specifications, the explanatory power of outside money for output drops

substantially when the ratio of quasi-money to transactions deposits is explicitly included in the model As the overall results of the entire investigation will show, the evidence consistent with direct causal connections between money and output is very weak.

As will be argued in detail in Part Three, changes in base money do not capture accurately the intentional actions of the policy makers. While certainly affected by policy actions, base money fluctuations are also caused by factors beyond the control of monetary authorities Therefore, the findings in this Part cannot generate complete conclusions on policy issues. However, the earlier interpretation of the results suggests that it is unlikely that policy-induced increases in monetary base will be followed by output increases, if not met by a higher credit demand from the private sector. Such actions will be followed by mere increases in the excess reserves of the banking system. When excess liquidity in the banking system lasts long enough, the incentives of banks to lend and of the private sector to borrow may increase even in the absence of actual conditions for higher output. Under such circumstances, inflationary pressures are likely to mount up. This possibility suggests that the policy actions of the central bank should be consistent with real economy's potential. An effective "cooperation" between the monetary policy actions and the real economy require price or inflation stability. Were this condition not met, the credit demand signals from the private sector to the policy maker would be confusing. The signal may be interpreted either as increased output potential, case that requires an accommodating policy, or as adjustments to inflation, in which case a contractionary policy might be appropriate. Under such conditions, it is obvious that the policy signal sent back to the private sector would itself be ambiguous.

The findings in Part Two and their interpretation suggest the directions of further investigation of the relationships between monetary and real variables. It was argued earlier that base money might not be the appropriate measure of voluntary policy actions. Part Three will investigate the connections between output and a policy variable that is more discretionary than monetary base, namely the proportion of borrowed reserves in total reserves of the banking system. The interpretation of the evidence provided here includes the assumption that the fluctuations in the ratio of quasi-money to transactions deposits play an important role in shaping the observed pattern of the short-run relationships between output, outside money, and inside money. Empirical testing of this assumption will be undertaken in Part Four.

Chapter Six

Conclusions

Part Two investigates the interactions between the monetary variables and output, in a framework based on the explicit distinction between the outside and the inside components of money This theoretically acknowledged decomposition is widely neglected in the existing empirical literature. Compared to the few studies that do employ this decomposition (for instance, Manchester, 1989 and Cagan, 1993), this paper improves the econometric modeling procedures. Specifically, a vector error correction model is used instead of a VAR in first differences or a single-equation framework, exogeneity is tested rather than assumed, and the innovation accounting results are based on a structural VAR/VECM approach rather than a Choleski decomposition.

The dynamic relationships between output, inflation, the real interest rate, outside money, and the money multiplier were investigated over the period 1960.1 – 1997.4, by means of cointegration analysis, Granger-causality tests, and innovation accounting.

The long run and short run relationships between the key variables are identified and separated by means of cointegration analysis. It is found that the long run equilibrium relationship between the variables of interest does not include the money multiplier. This implies that the other variables do not react *in the long run* to changes in the money multiplier

Exogeneity analysis indicate that outside money and the interest rate are weakly exogenous, whereas output, inflation, and the money multiplier are endogenous variables Found to be strongly exogenous for output, base money might be a useful leading indicator of business cycles. In addition, outside money is superexogenous for the output equation. This result implies that monetary policy actions that affect base money may interact to a certain extent with changes in output.

Further results indicate that both outside money and the money multiplier Granger-cause output, whereas results regarding aggregate money (M2) are ambiguous. This finding emphasizes the importance of the distinction between outside and inside money for macroeconomic research.

As opposed to earlier findings based on standard VARs, evidence from VECM shows that outside money innovations explain a substantial proportion of the variance of output, exceeding the explanatory power of the money multiplier and, at close horizons, that of the interest rate. It will be shown in Part Four how this particular result is altered in a model that includes the ratio of quasi-money to transactions deposits as a relevant variable

In the short run, innovations in outside money are related to innovations of opposite sign in output and the money multiplier. This result has never been reported in the previous literature. The implications of this finding represent the most important positive result of Part Two. They show that *empirical studies that ignore the decomposition of money into outside money and inside money cannot warrant valid conclusions about the effectiveness of monetary policy.* Since monetary policy is primarily associated with changes in outside money rather than the money multiplier,

and these components behave differently in relation to output, the behavior of aggregate money cannot have an independent relationship with output.

An interpretation of the reported relationship between outside money, the money multiplier, and output was offered. The main idea of the interpretation is that the observed pattern obtains if the ratio of quasi-money to transactions deposits, reflecting portfolio redistributions among monetary assets, is pro-cyclical.

Subject to the caveats imposed by the conceptual ambiguities that persist in the literature on general and economic causality, the evidence here seems to favor the conclusion that changes in money and output are independently caused by third factors. Under alternative interpretations, however, a case can be made for reciprocal causality.

The conclusions based on the findings of Part Two are provisional in the context of the whole study. Parts Three and Four will further investigate the interactions between the monetary and the real sector of the economy. Part Three will switch the focus from the relationship "money – output" to the relationship "monetary policy – output" Part Four will reexamine the interactions between money and output by taking into account the influence of portfolio redistributions on monetary dynamics. The final conclusions of the study will be based on the combined evidence from all stages of investigation

REFERENCES

Bernake, B. (1986),'Alternative explanations of money-income correlation', *Carnegie-Rochester Conference Series on Public Policy* 25.

Brown, R.L., Durbin, J., and Evans, J.M. (1975),'Techniques for Testing the Constancy of Regression Relationships Over Time', *Journal of the Royal Statistical Society*, Series B, 37.

Burger, A.E (1979),'Alternative measures of the monetary base', *Review* 61(June), Federal Reserve Bank of St.Louis

Cagan, P. (1993), 'Does endogeneity of money disprove monetary effects on economic activity?', *Journal of Macroeconomics*, Summer, vol 15, No.3.

Champ, B. and Freeman, S. (1994), *Modeling monetary economies*, John Wiley & Sons, Inc.

Charemza, W.W and Deadman, D.F. (1997), *New directions in econometric practice*, 2nd ed., Edward Elgar.

Cheung, Y.W., and Lai, K.S.(1993),'Finite-sample sizes of Johansen's likelihood ratio tests for cointegration', *Oxford Bulletin of Economics and Statistics* 55.

Cooley, T.F., and LeRoy, S.F. (1985), 'Atheoretical macroeconomics', *Journal of Monetary Economics* 16

Davis, M. and Tanner, J.E. (1997), 'Money and economic activity revisited', *Journal of International Money and Finance*, vol. 16, No.6.

Dickey, D. and Fuller, W.A. (1981), 'Likelihood ratio statistics for autoregressive time series with a unit root, *Econometrica* 49.

Enders, W. (1995), *Applied econometric time series*, John Wiley & Sons, Inc.

Engle, R.F. and Granger, C.W.J. (1987),'Cointegration and error correction: representation, estimation, and testing', *Econometrica* 55

Engle, R.F. and Granger, C.W.J. (1991),'Cointegrated economic time series: an overview with new results', in Engle, R.F. and Granger, C.W.J. (eds.) *Long-Run Economic Relationships*, Oxford University Press.

Engle, R.F. and Hendry, D.F. (1993),'Testing superexogeneity and invariance in regression models', *Journal of Econometrics* 56.

Engle, R.F., Hendry, D F., and Richard, J.-F. (1983),'Exogeneity', *Econometrica* 51.

Freeman S. and Huffman, W (1991), 'Inside money, output, and causality', *International Economic Review*, vol 32, No.3.

Friedman, B.M., and Kuttner, K.N. (1993), another look at the evidence on money-output causality', *Journal of Econometrics*, May-June.

Friedman, M. (1968),'The role of monetary policy', *American Economic Review* 58

Friedman, M. (1964), 'The monetary studies of the National Bureau', *NBER Annual Report*', No.44.

Friedman, M. and Schwartz, A.J. (1963), *A monetary history of the United States, 1867-1960*, Princeton: Princeton University Press.

Friedman, M. and Schwartz, A.J. (1982), *Monetary trends in the United States and the United Kingdom: Their relation to income, prices, and interest rates*, Chicago: Chicago University Press.

Gurley, J.G. and Shaw, E.S. (1960), *Money in a theory of finance*, Washington: The Brookings Institution.

Hamilton, J.D. (1994), *Time Series Analysis*, Princeton University Press, Princeton.

Hansen, H., and Juselius, K. (1995), *Manual to Cointegration Analysis of Time Series CATS in RATS*, Institute of Economics, University of Copenhagen

Harris, R.D. (1995), *Using cointegration analysis in econometric modeling*, Prentice Hall/Harvester Wheatsheaf.

Hendry, D.F (1993), *Econometrics: alchemy or science?*, Oxford UK and Cambridge US, Blackwell.

Hoover, K.D. and Perez, S.J. (1994), '*Post hoc ergo prompter hoc* once more: An evaluation of 'Does monetary policy matter?' in the spirit of James Tobin', *Journal of Monetary Economics* 34.

Johansen, S. (1988),'Statistical analysis of cointegration vectors', *Journal of Economic Dynamics and Control*, 12.

Johansen, S. (1992),'Identifying restrictions of linear equations', Institute of Mathematical Statistics, University of Copenhagen.

Johansen, S. and Juselius, K (1992),'Testing structural hypotheses in a multivariate cointegration analysis of the PPP and the UIP for UK', *Journal of Econometrics* 53

Johansen, S and Juselius, K (1994),'Identification of the long-run and the short-run structure: an application to the ISLM model', *Journal of Econometrics* 63.

Litterman, R. and Weiss, L (1985), 'Money, real interest rates, and output: a reinterpretation of US postwar data', *Econometrica* 53.

Lucas, R.E. (1973),'Some international evidence on output-inflation tradeoffs', *American Economic Review* 63.

Lucas, R E.(1981), *Studies in Business Cycle Theory*, Cambridge, Mass.: MIT Press.

Manchester, J. (1989), 'How money affects real output', *Journal of Money, Credit, and Banking*, Vol.21, No.1 (February).

Masih, A.M.M. and Masih, R. (1995), 'Temporal causality and the dynamic interactions among macroeconomic variables within a multivariate cointegrated system: evidence from Singapore and Korea', *Weltwirtschaftliches Archiv*, 131(2).

Mosconi, R and Giannini, C (1992), 'Non-causality in cointegrated systems: Representation, estimation, and testing', *Oxford Bulletin of Economics and Statistics* 54,3

Patinkin, D. (1965), *Money, interest, and prices: an integration of monetary and value theory*, 2nd ed., New York: Harper and Row.

Romer, C.D. and Romer, D.H. (1989), 'Does monetary policy matter? A new test in the spirit of Friedman and Schwartz', *NBER Macroeconomics Annual.*

Romer, C.D. and Romer, D.H. (1990),' New evidence on the monetary transmission mechanism', *Brookings Papers on Economic Activity*, No.1.

Sims, C. (1972), 'Money, income, and causality', *American Economic Review* 62 (September).

Sims, C. (1980),'Comparison of interwar and postwar cycles. Monetarism reconsidered', *American Economic Review* 70 (May).

Sims, C. (1980b), 'Macroeconomics and Reality', *Econometrica* 48.

Sims, C. (1986), 'Are forecasting models usable for policy analysis?', *Quarterly Review*, Federal Reserve Bank of Minneapolis, Winter.

Strongin, S. (1995), 'The identification of monetary policy disturbances. Explaining the liquidity puzzle', *Journal of Monetary Economics*, 35.

Swanson, N.R. (1998), 'Money and output viewed through a rolling window', *Journal of Monetary Economics,* 41.

Thoma, M.A. (1994), 'Subsample instability and asymmetries in money-income causality', *Journal of Econometrics*, 64.

Toda, H.Y. and Phillips, P C B. (1993),' Vector autoregressions and causality', *Econometrica*, Vol.1, No 6.

Tobin, J and Brainard, W.C. (1963), 'Financial intermediaries and the effectiveness of monetary controls', *American Economic Review,* 53, No.2.

Zellner, A. (1979), 'Causality and econometrics', in Brunner, K. and Meltzer, A.H (eds.), *Three Aspects of Policy and Policymaking*, Amsterdam, North-Holland.

PART THREE

MONETARY POLICY AND OUTPUT

Chapter One

Introduction

Is monetary policy able to stabilize short run output fluctuations? This is the critical question that connects the monetary theory with the practical problems of policy-making. For a long time, economists used to seek the answer by assessing the neutrality or otherwise of money with respect to output variations. The idea underlying this approach was that changes in money supply reflect primarily exogenous monetary policy actions. More recently, however, a number of theoretical and empirical studies (for instance, Meulendyke, 1989, and Strongin, 1995) challenged this idea, arguing that the stock of money is to a considerable extent determined by factors beyond the control of the monetary authorities. Therefore, the effectiveness of monetary policy and the non-neutrality of money should be seen as distinct issues. If factors other than policy actions determine changes in the money supply, then the policy effects on output ought to be assessed independently of the relationship between money and output.

Moreover, for monetary policy to be effective for output stabilization, its non-neutrality is just a *necessary*, but *not sufficient*, condition. To be useful, monetary policy actions need to produce predictable effects. As Milton Friedman forcefully pointed out, policy actions may be able to affect output (non-neutrality), but, if the effects are not predictable, the desired policy results cannot be reliably achieved.

Even after the distinction *money - output* versus *monetary policy – output* relationships is acknowledged, the question still remains how to identify properly monetary policy actions. In this study, the investigation of the effectiveness of monetary

policy identifies policy actions as the proportion of non-borrowed reserves in total reserves of the banking system (NBRX), as proposed by Strongin (1995).

Four main questions are addressed in this study. First, the exogenity of the proposed policy measure is tested. Exogeneity of the policy variable with respect to the target variable (output) implies that policy actions can be undertaken independently of the changes in the target. Exogeneity is therefore a prerequisite for policy effectiveness.

Next, the effectiveness of policy actions is questioned. An effective monetary policy instrument should meet three conditions. First, the variable in question should be to a large extent under the control of the monetary authorities. Second, it has to be superexogenous for the target variable, in the sense that changes in (the mean and variance of) the instrument should not change the parameters of the equation for the target variable[1]. In other words, the policy action should not alter the behavior of the economic agents (see Lucas, 1976). Third, changes in the policy variable should Granger-cause (i.e. predict) changes in the target[2]. As Ericsson et al. (1998) argue, "without Granger causality from instruments to targets, policy is unlikely to be effective," since the achievement of the desired effects require predictability. Following Meulendyke (1989) and Strongin (1995), it is argued in this study that the first condition, namely controllability, is fulfilled by the policy measure adopted here, NBRX. The fulfillment of the remaining conditions is subjected to empirical testing Specifically, the project will analyze the extent to which policy actions alter the pattern

[1] Superexogeneity implies weak exogeneity

[2] The reader should bear in mind that, in spite of its name, a Granger-causality test *does not* test for genuine causality A variable X Granger-cause a variable Y when, in a regression of Y on other variables, the inclusion of X among the regressors improves the predictability of Y

of economy's responses to changes in monetary variables, as well as the predictability of impacts from the policy instrument to the target.

A third objective of the investigation is to evaluate the sign of the short run relationship between policy actions and output changes. This result is relevant in assessing the adequacy of the common belief that expansionary policy actions may induce output increases.

Finally, the magnitude of the actual policy effects on output will be evaluated. In general, empirical investigations cannot settle controversies regarding the direction of genuine causal relationships. However, to assess the desirability of policy actions, it is important to evaluate the economic significance of policy impacts on output, in case a genuine causal relationship, running from policy to output, exists. In other words, while we cannot be sure that policy genuinely causes output, it is still useful to know how significant the policy impacts might be, in case the assumed causal relationship exists. The relevance of the potential effects of policy on output, contingent on the existence of the causal connection, is evaluated here by means of forecast error variance decomposition (FEVD). If the empirical evidence from FEVD is not inconsistent with substantial impacts of policy on output, then a case for stabilization policy can still be made, hoping that the theoretical assumption that policy causes output is correct. On the other hand, if the potential policy effects are negligible, then a policy-induced stabilization may not be worth pursuing.

The investigation is carried out in a vector error-correction framework. Unlike standard VAR models, a vector error-correction model (VECM) distinguishes between the short run dynamics and the long run relationships between the variables of interest.

This feature is particularly desirable when assessing the competing business cycle theories, which are focused on the short run interactions between the key macroeconomic variables.

The results will show that the policy variable identified here, namely the proportion of non-borrowed reserves in the total reserves of the banking system (NBRX), is unlikely to be effective for output stabilization. While NBRX is exogenous with respect to the target variable, policy actions do not induce predictable effects on output. Policy ineffectiveness is further documented by the finding that innovations in the policy variable explain a very small proportion of output variations. Moreover, the short run relationship between NBRX and output appears to be negative. This pattern is consistent with a countercyclical and ineffective policy, rather than with an effective policy.

The remainder of Part Three is organized as follows. Chapter Two presents the problems raised by the identification of monetary policy actions and offers theoretical justification for the policy measure adopted. It is argued that NBRX fulfills the first condition required by an effective policy instrument. The empirical investigation that follows aims at testing for the fulfillment of the remaining conditions. Chapter Three outlines the specific questions of the empirical investigation, together with the methodology used to answer these questions, and presents data specifics The estimation steps and the results are presented and interpreted in Chapter Four. Chapter Five compares results across Parts Two and Three. Implications of these results are extracted Chapter Six concludes.

Chapter Two

Identification of Monetary Policy Actions

2.1. The Traditional Approach

Most theoretical and empirical studies identify monetary policy actions with changes in some monetary aggregate, such as base money, M1, M2, and so on. This approach originates in a simple model of the money market, where the money supply function is depicted as a vertical curve in the money stock – interest rate space. This representation implies that money supply is an exogenous variable under the complete control of monetary authorities. Therefore, changes in the equilibrium value of the money stock coincide with monetary policy actions. For empirical studies investigating the effects of monetary policy on output, this approach suggests a straightforward measure of policy shocks, namely the innovations (i.e. error terms) in the stochastic money supply equation. Following this tradition, even empirical studies testing the implications of more sophisticated theoretical models continue to identify policy actions as changes in the monetary aggregates.

However, the traditional approach is questionable since money supply, upon closer inspection, appears to be largely endogenously determined. Decomposing the money supply into outside money (monetary base) and inside money (or the money multiplier) helps clarify the issues. Theoretical models in the RBC tradition point to the endogeneity of inside money, whose changes are driven by real shocks (for instance, Plosser, 1989, and Freeman and Huffman, 1991). The money multiplier endogeneity was also documented by empirical studies such as Gauger and Black (1991) and Gauger

(1998). Moreover, the process generating outside money is itself subject to non-discretionary (i.e. non-policy) influence. Base money is the sum of currency in circulation and total reserves of the banking system It is known that the central bank fully accommodates public's demand for currency. Further, as Meulendyke (1989) and Strongin (1995) argue (see next section), changes in the supply of total reserves are to a large extent responses to demand fluctuations.

Under the circumstances, with multiple influences on inside and outside money, changes in monetary aggregates do not serve as accurate measures of monetary policy actions. The above arguments do not imply that policy is completely passive or accommodative. What they suggest is that, in order to identify voluntary policy actions, a different proxy than changes in monetary aggregates should be employed.

Aware of the problems raised by the monetary aggregates, some researchers chose to measure monetary policy shocks by changes in interest rates (for instance, Sims, 1992, and Bernake and Blinder, 1992). Under certain assumptions about the central bank's behavior, namely interest rate targeting rather than monetary aggregate targeting, this solution seems appropriate. However, interest rate measures of monetary policy actions pose the same type of endogeneity problems as monetary aggregates do. Changes in interest rates are certainly caused by other factors besides policy innovations, such as fluctuations of the demand for loanable funds, expectations, balance of payments flows, portfolio adjustments etc. In empirical work, controlling for the influence of all these factors (some of which are unobservable or hardly quantifiable) is an extremely difficult task

Facing these problems, some researchers abandoned the traditional approach, looking for more direct measures of intentional policy actions. Romer and Romer (1989) identified exogenous monetary policy innovations with significant decisions taken by the Federal Open Market Committee (FOMC). They read the Records of Policy Actions and the minutes of the FOMC, in order to identify those decisions by Fed officials to fight recessions and inflation. However, this solution was criticized, among others, by Hoover and Perez (1994), who argue that "a world in which the Fed only announces intentions to act cannot be distinguished from one in which it in fact acts."

Some recent work singles out the idea that an appropriate measure of policy innovations should focus on non-borrowed reserves of the banking system. Distinguishing the Fed's control over the non-borrowed reserves from bank borrowing at the discount window, this approach better captures Fed intentions on monetary policy. The particular solution proposed by Strongin (1995), to identify policy actions, is adopted in this paper. Arguments pointing to the endogeneity of total reserves, as well as the specifics of Strongin's solution are presented in the next section.

2.2. The Mix of Reserves as a Policy Measure

As indicated, the problems raised by identifying monetary policy actions with either monetary aggregates or interest rate innovations strongly suggest the need for alternative solutions.

The elements of outside money[1] are an obvious starting point Since the stock of currency in circulation is clearly endogenous, closer attention was paid to the total reserves of the banking system. A possible decomposition of total reserves (TR) is into borrowed reserves (BR) and non-borrowed reserves (NBR)[2]. BR represents that part of TR that commercial banks are borrowing from the central bank at the 'discount window' NBR is that part of reserves that is created by the central bank through open-market operations. Eichenbaum (1991) and Christiano and Eichenbaum (1992) suggest that innovations in the level of non-borrowed reserves are the appropriate policy measure, since Fed can control the NBR better than any other monetary aggregate.

Strongin (1995), shows that this argument is not sufficient; after all, the same argument was offered for base money itself. More important, the level of non-borrowed reserves is partially determined by Fed's accommodative actions meeting the changes in banks' demand for reserves. The same endogeneity problem encountered in the case of broader monetary aggregates arises when policy actions are measured by the *levels* of reserves. However, Strongin argues that *the mix BR – NBR*, i.e. their shares in total reserves, can properly identify intentional policy actions.

Two key propositions underlie Strongin's (1995) suggested identification of monetary policy actions:

(1) Innovations in the level of total reserves represent, to a large extent, the Fed's accommodation to innovations in the demand for total reserves.

[1] Outside money = Base money = C + TR, where C = currency in circulation, and TR = total reserves held by commercial banks with the central bank Base money is also known as 'high-powered money'
[2] The alternative decomposition, employed in the first essay of this paper, is the following

$TR = R_D + R_Q + E$, where R_D = required reserves on checkable deposits, R_Q = required reserves on non-M1 elements of M2, and E = excess reserves

(2) Intentional (i.e. non-accommodative) policy actions are carried out through changes in the mix of borrowed – non-borrowed reserves supplied by the Fed. The FOMC's policy directive labels this type of action as 'the degree of pressure on reserve positions'.

Proposition (1) is based on the fact that bank reserves are supplied by the Fed through both open-market operations and the discount window, as well as on institutional rigidities of the Federal funds market. As shown by Meulendyke (1989) in her coverage of monetary policy implementation, commercial banks have severely limited short run control over the level of deposits. Therefore, their demand for required reserves is highly inelastic in the short run. Meulendyke argues that:

> … [The] banks adjustment options to a reserve excess or shortage are in actuality quite limited. Banks confronting a shortage would have several possible options, but most of the options would be impractical to carry out in such a short time period. …When non-borrowed reserves within a reserve maintenance period are insufficient to meet the demand, the banking system as a whole has no practical alternative to borrowing more reserves at the discount window.[3]

The implication of this rigidity is that the existence of the discount window provides automatic accommodation of banks' demand for reserves. How is then proposition (2) justified if banks are ultimately provided with the needed reserves? The answer is that a genuine supply shock affects deposit creation via an interest rate effect. Banks are generally reluctant to borrow from the discount window, since this "involves exercising a nontransferable option to borrow again in the near future" (Strongin, 1995).

[3] Meulendyke (1989), quoted in Strongin (1995)

When the Fed reduces the supply of reserves through open-market operations (a contractionary policy shock), banks first attempt to meet their demand for reserves on the Federal funds market. Nevertheless, for the banking system as a whole, the supply of reserves falls short of the demand, bidding up the Federal funds rate. When the interest rate is high enough, the banks overcome their reluctance to borrow at the discount window, and the demand for reserves is thus accommodated. However, the increase in the interest rate will subsequently reduce lending and deposit creation (and therefore the money multiplier). Notice that the contractionary effect of the policy action is not immediate (due to the accommodation of current demand for reserves through the discount window); rather it occurs with a lag, after the interest rate effect is altering next period's demand for required reserves. In other words, the supply shortage of reserves is induced with a lag.

Strongin formalizes the argument as follows.

$$u_{NBR} = v_s + \phi\, v_d \qquad (2.1)$$

$$u_{BR} = - v_s + (1 - \phi)\, v_d \qquad (2.2)$$

$$u_{TR} = u_{NBR} + u_{BR} = v_d \qquad (2.3)$$

where u_{NBR} = the innovation in NBR, u_{BR} = the innovation in BR, u_{TR} = the innovation in TR, ϕ = the proportion of the demand for bank reserves that Fed is accommodating through open-market operations, v_s = the supply of reserves shock (i.e, the actual voluntary policy action), v_d = the demand for reserves shock, and time subscripts are omitted.

Equations (2.1) and (2.2) show that the central bank accommodates the demand for reserves through open-market operations and the discount window in proportions ϕ

and, respectively, $(1 - \phi)$ A voluntary policy action does not affect the level of TR contemporaneously, since the actual demand for reserves is accommodated through the discount window. Notice that the supply shock, v_s, has opposite signs in these equations. As shown below, this assumption can be relaxed without affecting the main conclusions Equation (2.3) shows that policy innovations are cancelled out in total reserves innovation such that the shocks to total reserves reflect pure demand shocks

Since only u's, but not v's, can be directly observed, policy shocks can be empirically identified by the changes in the relative shares of NBR and, respectively, BR in TR. From equations (2.1) and (2.2) it follows that an expansionary policy (i.e. a positive v_s) increases the ratio NBR/ TR and reduces the ratio BR/TR[4].

The above argument is based on the extreme assumption that the demand for reserves is completely accommodated through the discount window. Therefore, the policy shocks do not have any contemporaneous effect on total reserves (since v_s has opposite signs in u_{NBR} and u_{BR}). This assumption can be relaxed (as Strongin, 1995, shows in the appendix of his study), allowing for some incomplete accommodation. In this context, the equations (2 1) – (2.3) become:

$$u_{NBR} = v_s + \phi\, v_d \qquad (2.1')$$

$$u_{BR} = -(1-\gamma)\, v_s + (1-\phi)\, v_d \qquad (2.2')$$

$$u_{TR} = u_{NBR} + u_{BR} = v_d + \gamma\, v_s \qquad (2.3')$$

where $0 < \gamma < 1$.

[4] Notice that a change in ϕ will also change the ratio NBR/TR Although in the model of equations (2 1) – (2 3) ϕ represents just a proportion in which demand is accommodated through NBR versus BR, its change would alter the 'degree of pressure on reserves' and would induce the same type of interest rate

This more general specification does not change in any way the identification of policy actions as innovations in the share of NBR in TR. However, it may be more realistic in the context of quarterly data (as employed in this study, whereas Strongin's study uses monthly data). The empirical investigation in this paper will therefore be consistent with the framework of equations (2 1')-(2.3')[5].

This study will adopt the identification of monetary policy actions as changes in the proportion of non-borrowed reserves in total bank reserves (NBRX), in order to investigate the effects of monetary policy on economic activity. In this context, a policy stimulus is identified as a positive innovation in NBRX, i.e. a decrease in the degree of pressure on reserves. More specifically, the central bank increases the proportion of bank reserves provided through open-market operations, thus reducing the excess demand on the Federal funds market and banks' recourse to the discount window. The resulting decrease in the interest rate induces the intended expansionary effect on credit. The solution adopted here circumvents to a large extent the endogeneity problems created by the use of alternative policy measures. The next chapter presents the main questions asked in this study, reformulated in terms of the adopted policy measure, the procedures used to answer these questions, and data specifics.

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effects as a non-zero v_s Therefore, changes in ϕ also qualify as policy actions It is important to notice that the specification of policy suggested in the text accounts for both types of policy actions

[5] More important, as shown in Chapter Four, results indicate a statistically significant contemporaneous effect of the policy variable on TR Therefore, the subsequent identification of structural disturbances in the VECM will be consistent with equations (2 1')-(2 3') rather than (2 1)-(2 3).

Chapter Three

Objectives, Procedures, and Data

Part Two investigated the relationship between money and output, based on the decomposition of the total money stock into outside money and inside money (captured by the money multiplier). Here, the main goal of the investigation is to assess the effects of monetary policy on output. As argued earlier, the questions asked in Parts Two and Three are different, since changes in money do not always represent intentional monetary policy actions. Following the solution proposed by Strongin (1995), the latter are identified by the innovations in the mix of non-borrowed – borrowed reserves provided by the Fed to commercial banks, more specifically the innovations in the share of non-borrowed reserves (NBR) in total reserves (TR).

Four main questions will be addressed in this investigation. First, formal tests for weak exogeneity are employed to assess if the policy measure proposed (NBRX) is indeed exogenous for output. The weak exogeneity of the policy variable, implying that the direct feedback of output to NBRX is negligible, is a prerequisite for policy effectiveness. It also means that the output equation can be estimated conditional on given values of NBRX, a feature that improves the stochastic properties of the empirical model (Harris, 1995).

The second important question asked is: Does NBRX meet the conditions for an *effective* policy variable aimed at short-run output stabilization? An effective monetary policy instrument should meet three conditions. First, the variable in question should be to a large extent under the control of the monetary authorities Second, it has to be

superexogenous for the target variable, in the sense that changes in (the mean and variance of) the instrument should not change the parameters of the equation for the target variable[1]. In other words, the policy action should not alter the behavior of the economic agents (see Lucas, 1976). Third, changes in the policy variable should Granger-cause (i.e predict) changes in the target. As Ericsson et al. (1998) argue, 'without Granger causality from instruments to targets, policy is unlikely to be effective', since the achievement of the desired effects require predictability. It was argued in Chapter Two that, unlike alternative policy measures used in the literature (such as various monetary aggregates or the interest rate), NBRX meets the condition of being tightly controlled by the central bank The fulfillment of this condition cannot be tested empirically. The arguments presented earlier are based on careful analyses of the Fed's procedures and of the workings of the banking system, such as those provided by Meulendyke (1989) and Strongin (1995). The empirical investigation here is aimed at testing the fulfillment of the superexogeneity and predictability conditions, required by the effectiveness of NBRX as a policy instrument.

The third main objective of the investigation is to assess the sign of the short run relationship between policy actions and changes in output. A positive sign of this relationship would suggest the possibility that expansionary policy may induce output increases. A negative sign would be consistent with a countercyclical but ineffective policy

The final important question asked in this essay is: How significant are policy actions for output variations? Contingent on the other findings of this essay, the answer

[1] Superexogeneity implies weak exogeneity

to this question may suggest a desirable conduct for monetary policy. To illustrate, if NBRX is found to be an effective policy instrument and the policy impacts on output are substantial, then active stabilization policies are recommendable. Alternatively, if the policy impacts are substantial but not predictable, then stabilization policies involve the risk of adverse effects on the economy. Finally, if the policy effects are of a negligible magnitude (whether they are predictable or not), then stabilization policies may not be worth pursuing.

The investigation is carried out in a vector error-correction framework (VECM). Compared to a standard VAR approach, a VECM allows the separation of the short run and long run relationships between the variables of interest. This feature is important for focusing the analysis on the short run interactions between the variables of interest, as required by the assessment of business cycle theories.

The first stage of the investigation, cointegration analysis, will identify the long run relationships between the variables of interest, in order to isolate them from short run dynamics. At this stage, weak exogeneity tests will answer the first question, showing if NBRX is weakly exogenous and if output can be estimated conditional on NBRX. Weak exogeneity is also a necessary condition for superexogeneity. The remaining analysis will focus on the short run relationships.

It was argued in the previous section that NBRX fulfills the condition of being under the direct control of the monetary authorities (unlike the monetary base). The second main question in Part Three regards the fulfillment of the superexogeneity and predictability conditions. This second question is answered by means of superexogeneity and Granger-causality tests.

Innovation accounting based on a structural decomposition of VECM innovations will provide answers to the remaining questions of the analysis. Impulse response functions from the VECM will show the path of output changes following an innovation in the policy variable, revealing the sign of the relationship between NBRX and real GDP. Forecast error variance decomposition will measure the significance of policy shocks in explaining output fluctuations.

The investigation is based on quarterly data for the U.S. over the period 1960.1 – 1997.4. The VECM includes the following variables. (i) Real GDP (in logs), as a measure of output. (ii) The spread between the 3-month Treasury bill rate and the 'own return of money', i.e. the weighted average of the rates received on assets included in M2. (iii) The (log of the) money multiplier, calculated as the ratio of M2 aggregate to St. Louis monetary base; (iv) Total reserves of the banking system, specified as TR_t/TR_{t-1}, where TR represents total reserves adjusted for changes in reserve requirements (v) The policy measure, labeled NBRX and specified as NBR_t/TR_{t-1}, where NBR represents non-borrowed reserves as reported by the Board of Governors[2].

The specification of the last two variables assures the comparability of the results here with those obtained by Strongin (1995). The normalization of both TR and NBR by the lag of TR achieves simultaneously the objectives of providing an index for TR and a measure of policy innovations as the proportion of NBR in TR.

The reader is reminded that Part Two focused on the relationship between *money and output*, whereas Part Three investigates the interactions between *monetary*

[2] Data are obtained from FRED, the database of the Federal Reserve Bank of St Louis

policy and output. Since the results of Parts Two and Three should be combined to understand the complex dynamic relationships between the monetary and the real sector of the economy, it is worth comparing the variables employed in both investigations. As compared to Part Two, here the total reserves and the policy measure NBRX are included as relevant variables, whereas base money and the inflation rate are excluded from the model. The results in Part Two indicate that inflation rate has very low explanatory power for the variations in other variables Substituting the mix of reserves for base money reflects the change in focus from money to monetary policy. Since total reserves represent an important component of base money, the inclusion of the former in the analysis here provides a bridge between the results of Parts Two and Three and, more important (as explained later) allows corroboration of some key findings in Part Two. Finally, including the money multiplier in both analyses reflects the importance attached in this study to the analytical decomposition of money into outside and inside money.

The results in Parts Two and Three will be compared for consistency. A joint interpretation of these results will provide some useful insights on the dynamic relationships between the monetary and the real sector of the economy. The results of the analysis are presented in the next chapter.

Chapter Four

Estimation and Results

The main goal of this investigation is to assess the nature and strength of monetary policy impacts on output, based on U.S. economy data over the period 1960.1-1997 4. The monetary policy measure employed here is the proportion of non-borrowed reserves in the total reserves of the banking system (NBRX). As compared to the alternative policy measures employed in the existing literature, NBRX better captures the intentional actions of policy makers Therefore, NBRX fulfills one of the conditions required by an effective policy instrument. The fulfillment of the other two conditions, namely superexogeneity and predictability from instrument to the target (output), is subjected to empirical testing here. Two specific questions are addressed to this purpose. First, the weak exogeneity of NBRX with respect to output is tested. Weak exogeneity is a prerequisite for NBRX superexogeneity Weak exogeneity also allows conditional estimation of the endogenous variables, a feature that improves the stochastic properties of the empirical model. Contingent on the results of the weak exogeneity test, direct tests for superexogenity and predictability (i.e. Granger-causality) will be performed in the second stage. The third specific question addressed is the sign of the short run relationship between policy actions and output changes. This question is answered by the analysis of impulse response functions (IRFs). Finally, the magnitude of policy impacts on output is assessed by means of forecast error variance decompositon (FEVDs)

The sequence of results aimed at answering these questions is presented below together with the econometric procedures employed. Since the same procedures are used in Part Two, they will be discusses in less detail in this section, for a more detailed description, the reader is referred to Section 1 2 in Part One and Chapters Two and Three of Part Two.

The multivariate analysis includes five variables: real GDP (Y), the interest rate spread measuring the opportunity cost of holding M2 balances (R), the money multiplier (MM), the index of total reserves (TOTR) measured as TR_t/TR_{t-1}, and the policy variable (NBRX), measured as NBR_t/TR_{t-1}. Y and MM are expressed in logs The interactions between NBRX and Y are of primary interest here. Theoretical considerations that predict strong interactions between NBRX and Y, on one hand, and TOTR, R, and MM, on the other hand, motivate the inclusion of the latter as relevant variables. While innovations in NBRX represent policy shocks, TOTR innovations capture primarily shocks to the demand of bank reserves, as argued in Chapter Two. In addition, the sign of the relationship between TOTR and Y will provide an indirect test of the sign of the relationship between base money and output found in Part Two, since TOTR represents an important component of base money. Various theories also predict short run interactions between policy actions and the interest rate (R), as well as between Y and R. In addition, previous empirical studies (for instance, Sims, 1986, and Litterman and Weiss, 1985) documented the importance of interest rate innovations in explaining output variation. Many theories also assume a close relationship between inside money, captured here by the money multiplier, and output. However, the vast majority of previous empirical studies neglected the decomposition of the total money

stock into outside money and inside money. Therefore, the assumption of strong interaction between MM and Y received little empirical confirmation. The analysis here, as well as that in Parts Two and Four, aims to assess the strength of this interaction.

The investigation is carried out in a VECM framework, which allows the analysis of short run dynamics in isolation from the long run relationships between the variables of interest. In contrast, a standard VAR analysis does not allow such a distinction. Therefore the conclusions regarding the short run dynamics, relevant for the assessment of business cycle theories, may be obscured by the interference with the long run relationships, as reflected in the co-movements of the variables measured in levels. The VECM, while taking due account for the long run (cointegrating) relationships for model estimation, represents the short run dynamics in the form of relationships between first differences. The coefficients of innovation accounting (IRFs and FEVDs), used to assess the pattern of short run dynamics, are appropriately derived from the short run part of the model, estimated conditional on the long run relationships (and the weakly exogenous variables). Shortly, more specific details will further clarify this methodology.

Some preliminary analysis is necessary to assess the order of integration of the variables of interest. Augmented Dickey-Fuller unit root tests (Dickey and Fuller, 1981) for both levels and first differences revealed that R, TOTR, and NBRX are I(0) whereas

Y and MM are I(1)[1]. Since there are no I(2) variables, the conditions for the validity of the subsequent cointegration analysis are met.

The investigation starts with the most general data generating process (DGP), namely a standard (unrestricted) VAR. In the spirit of the general-to-specific modeling, a series of restrictions are tested and imposed on the initial model.

The first step involves the choice of the lag length for the VECM. VARs with 12, 8, and 4 lags were estimated. Likelihood ratio tests for reduced lags structure from 12 to 8 and from 12 to 4 lags were performed. The p-values obtained were, respectively, 0.008 and 0.18, leaving a choice between 12 and 4 lags. Since the 12 lag model performs significantly better in terms of residual analysis (normality, no serial correlation, and no heteroskedasticity), it is the final choice. The decision is justified by the fact that the validity of most subsequent tests requires white noise errors in the maintained hypothesis. It is worth noticing that a 12 lag model preserves the same lag structure as the model of Part Two.

To perform cointegration analysis, the standard VAR is reparameterized as a vector error-correction model (VECM):

$$\Delta y_t = \Gamma_1 \Delta y_{t-1} + \ldots + \Gamma_{k-1} \Delta y_{t-k+1} + \Pi y_{t-k} + u_t \qquad (4.1)$$

where Δy_t is the vector including DNBR, DTOTR, DR, DY, and DMM, i.e. the first differences of the variables of interest, $\Gamma_i = -(I - A_1 - \ldots - A_i)$, $(i = 1, \ldots, k-1)$, $\Pi = -(I - A_1 - \ldots - A_k)$, and **I** is an identity matrix of order n (in this case n = 5)

[1] ADF tests were run with the URADF procedure in RATS, that chooses the optimal lag length for the ADF regression using the BIC model selection criterion

As argued earlier, the advantage of a VECM over a standard VAR is that the VECM isolates the long run and the short run dynamics The term Πy_{t-k} expresses the long run relationships between variables in y_t,. The rest of the model, i.e. the differenced variables, represents the short run component. Cointegration analysis will identify the long run relationships and will provide the framework for tests of weak exogeneity, answering the first question of our investigation Specifically, if the policy variable (NBRX) is found to be weakly exogenous, subsequent testing for superexogenity is warranted. The analysis of short run dynamics will provide answers to the remaining questions.

Cointegration analysis is performed using Johansen's (1988) methodology. The (n x n) matrix Π in equation (4.1) is decomposed into two (n x r) matrices α and β, such that $\Pi = \alpha\beta'$. The columns of β (β_i's, i = 1, ..., r) represent the cointegrating vectors (long-run relationships). α represents a matrix of parameters that may be interpreted as the speed of short-run adjustments to deviations from the long-run equilibrium[2].

The cointegration rank (r) and the deterministic components of the model are determined through the test procedures described in Johansen and Juselius (1992) and Johansen (1992). The results of the tests suggest a model with three cointegrating vectors (β_i's) and a constant in the short-run model[3]. Therefore, r = 3 becomes the first

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[2] The rank of Π, the number of cointegrating vectors, and the number of columns of α and β, all equal *r*

[3] Both λ_{trace} and λ_{max} statistics (Johansen and Juselius, 1990) select r = 3 The joint test for r and detreministic components (Johansesn, 1992) selects a model with a constant and r =2 at 5 percent and 10 percent significance level, whereas r = 3 is accepted at 10, 5, and 1 percent significance The combined evidence of the tests suggest the choice r =3

restriction imposed on equation (4.1) model, where a vector of constant is added[4] On this model restrictions on β and α can be tested.

Restrictions on β are necessary for a unique identification of the parameters of β and α[5]. Using the procedures developed by Johansen and Juselius (1992,1994), various possible restrictions on β_i's were tested The following cointegration vectors were selected by the likelihood ratio tests, with a p-value of 0.56: β_1 includes Y, TOTR, and NBRX, β_2 includes Y and R, and β_3 includes NBRX, R, and MM[6].

Further tests were run to find out if any of the variables of interest is excluded from the long run relationships. The null hypothesis of long run exclusion was rejected for each variable The implication of this finding is that all five variables are important for inducing short run deviations from the long run equilibrium.

Having identified the parameters of the cointegrating vectors, tests of weak exogeneity can be performed by imposing restrictions on the rows of matrix α. A variable is weakly exogenous for the parameters of the equation of another variable if the process generating the first variable can be estimated without knowledge of these parameters Identifying the weakly exogenous variables is useful for two reasons. First, conditioning the system on the weakly exogenous variables improves the stochastic

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[4] The vector of constants allows for a linear trend in (some of the) level variables

[5] For any ω non-singular matrix of dimensions (r x r), $\alpha\beta' = \alpha\omega^{-1}\omega\beta' = \alpha^*\beta^{*\prime}$ It follows that $\Pi = \alpha\beta' = \alpha^*\beta^{*\prime}$, meaning that the parameters of α and β are not identified.

[6] The cointegrating vectors represent long-run equilibrium relationships between variables However, these relationships do not have an explicit causal interpretation (Rao, 1994) More specifically, since β_i's are obtained from reduced forms, they cannot be interpreted as structural equations (Dickey et al , 1994) By imposing restrictions on β, theoretical hypotheses about long-run relationships may nevertheless be tested However, this is not the goal of this study, where the cointegrating relationships are estimated with the limited purpose of isolating them from the short-run relationships to be estimated Therefore, the parameters of β_i's are not presented and discussed in the text They are available upon request

properties of the model (Harris, 1995) Second, weak exogeneity is a necessary condition for superexogenity The significance of superexogeneity will be discussed shortly.

The testing framework is given by equation (4.1), where the matrix Π is written as $(\alpha\beta')$·

$$\Delta y_t = \Gamma_1 \Delta y_{t-1} + \ldots + \Gamma_{k-1} \Delta y_{t-k+1} + \alpha\beta' y_{t-k} + u_t \qquad (4.1')$$

If the row i of matrix α is a zero vector, then the variable i does not adjust endogenously in response to the deviations from the long-run equilibrium induced by the other variables, i.e. the variable i is weakly exogenous. Therefore, testing weak exogeneity amounts to testing zero restrictions on α The null hypothesis of weak exogeneity was rejected for Y, TOTR, and MM (in each case with a p-value of 0.00), and accepted for NBRX (p-value = 0.25) and R (p-value = 0.36)[7].

The question of whether the measure of policy action adopted in this study indeed represents an exogenous variable is answered affirmatively. The weak exogeneity of NBRX shows that the mix of reserves does not respond endogenously to changes in other variables. While this interpretation does not exclude the existence of a reaction function of the monetary authorities, it suggests that the changes in NBRX might be seen as voluntary (i.e. exogenous) policy actions[8].

The interest rate spread (R), measuring the opportunity cost of holding M2

[7] The joint test of weak exogeneity of NBRX and R gives a p-value of 0 19

[8] In some studies, a reaction function is seen as an endogenous response of policy to changes in target variables The rigorous definitions of exogenity/endogeneity employed in this study avoid the conceptual ambiguities

balances, is also weakly exogenous. This finding is consistent with the view that, in the long run, interest rates are determined by fundamental factors such as technology and time-preference.

The tests for weak exogeneity conclude the cointegration analysis. It was found that NBRX and R are weakly exogenous, whereas Y, TOTR, and MM are endogenous under the model specification. In the analytical framework elaborated by Engle et al.(1983), adopted for exogeneity analysis in this study, the concept of weak exogeneity is not interpreted in terms of genuine causality; it rather describes a statistical property that allows conditional estimation This approach is different from the traditional approach to econometric modeling, where a concept closely related to, but not identical with, weak exogeneity is that of pre-determinedness Pre-determined variables are a priori assumed to cause the endogenous variables. In Engle et al. (1983), the a priori assumptions play little role. More structural content than weak exogeneity is assigned, in this approach, to the concept of superexogeneity, to be addressed shortly. Weak exogeneity, however, is important since it represents a necessary condition for superexogeneity.

Here, it is worth emphasizing an important point for the correct interpretation of the next results, based on short run dynamics. To smooth the exposition, hereafter the variables of interest will be referred to as real GDP (output), the policy variable, the money multiplier, the total reserves, and the interest rate. However, the reader should keep in mind that *for the rest of the short-run analysis, the variables are specified as first differences, reflecting relative changes or growth rates.*

To answer the remaining questions of this essay, the VECM is estimated conditional on the weakly exogenous variables, as follows:

$$\Delta y^*_t = \Gamma_0 \Delta z_t + \Gamma^y{}_1 y_{t-1} + \ldots + \Gamma^y{}_{k-1} \Delta y_{t-k+1} + \alpha(\beta' y_{t-k}) + u_{yt} \quad (4.2)$$

$$\Delta z_t = \Gamma^x{}_1 y_{t-1} + \ldots + \Gamma^x{}_{k-1} \Delta y_{t-k+1} + u_{xt} \quad (4.3)$$

where the vector Δy^*_t includes the endogenous variables Y, TOTR, and MM (in first differences), Δz_t is the vector of weakly exogenous variables including the first differences of NBRX and R, and $(\beta' y_{t-k})$ represents the error-correction terms as estimated in the cointegration analysis. Autocorrelation, normality, and heteroskedasticity tests on the residuals of the above model show satisfactory results as regards the fulfillment of the white noise criterion[9]. In the framework of equations (4.2) and (4.3), the investigation will focus primarily on the short dynamics to address the issues of superexogeneity, Granger-causality, the sign of the short-run relationships and the strength of interactions between the variables of interest.

The model in general form is captured by equations (4.2) and (4.3) In terms of specific variables here, the specification of the model is given by:

$$DY = k_1 + w_{11}\,DNBRX + w_{12}\,DR + a_1(L)DY + a_2(L)DTOTR + a_3(L)DMM + a_4(L)DNBRX + a_5(L)DR + \alpha_{11}\,ECT_1 + \alpha_{12}\,ECT_2 + \alpha_{13}\,ECT_3 + u_1 \quad (4.4)$$

[9] Tests results are available upon request

$$DTOTR = k_2 + w_{21}\ DNBRX + w_{22}\ DR + b_1(L)DY + b_2(L)DTOTR + \ + b_3(L)DMM +$$

$$b_4(L)DNBRX + b_5(L)DR + \alpha_{21}\ ECT_1 + \ \alpha_{22}\ ECT_2 + \alpha_{23}\ ECT_3 + u_2 \qquad (4.5)$$

$$DMM = k_3 + w_{31}\ DNBRX + w_{32}\ DR + c_1(L)DY + c_2(L)DTOTR + \ c_3(L)DMM +$$

$$c_4(L)DNBRX + c5(L)DR + \alpha_{31}\ ECT_1 + \ \alpha_{32}\ ECT_2 + \alpha_{33}\ ECT_3 + u_3 \qquad (4.6)$$

$$DNBRX = k_4 + d_1(L)DY + d_2(L)DTOTR + d_3(L)DMM + d_4(L)DNBRX +$$

$$+ d_5(L)DR + u4 \qquad (4.7)$$

$$DR = k_5 + e_1(L)DY + e_2(L)DTOTR + e_3(L)DMM + e_4(L)DNBRX +$$

$$+ e_5(L)DR + u5 \qquad (4.8)$$

where k's are constants, D denotes first differences, (L) denotes lag polynomials, and ECT's capture the long-run relationships ($\beta' y_{t-k}$). The time subscripts are omitted.

Does our policy variable qualify as an effective policy instrument for output stabilization? To answer this question, superexogenity and Granger-causality tests are employed. Superexogeneity of NBRX with respect to output implies that changes in the first two moments of the stochastic process generating NBRX (equation 4.7) do not change the parameters of the output equation (4 4). The interpretation of this condition is that policy actions do not alter the behavior of economic agents.

The superexogeneity test is performed following the methodology developed by Engle and Hendry (1993). The basic idea of the test is to assess the significance of the first two moments of the conditioning variable (here, NBRX) in the equation of the conditional variable (output). To this purpose, equation (4.4) is augmented with regressors that measure the mean and variance of the policy variable. These variables

are obtained from equation (4.7)[10] It is also possible to test for the constancy of NBRX coefficient in the output equation This test provides useful information about the stability of the short run relationship between NBRX and Y over the sample period. The test equation is the following[11]:

$$DY = k_1 + w_{11}\,DNBRX + w_{12}\,DR + a_1(L)DY + a_2(L)DTOTR +$$
$$a_3(L)DMM + a_4(L)DNBRX + a_5(L)DR + ECT_1 + ECT_2 + ECT_3$$
$$+ m\,RES3 + p_1FITSQ + p_2RESQ + p_3FITRESQ + u_1 \qquad (4.9)$$

where RES3 is a proxy for (conditional variance x residuals), FITSQ is the squared fitted value of DNBRX, RESQ is the proxy of conditional variance, and FITRESQ = (fitted values x RESQ).

The test results are as follows:

Null hypothesis	P-value
NBRX superexogenous ($p_1 = p_2 = p_3 = 0$)	0.263
Constancy of coefficient w_{12} ($m = 0$)	0.107

Based on the conventional significance levels, the results show that the policy variable is superexogenous for the parameter of interest, w_{11}, in the output equation. This parameter is constant, over the sample period, to variations in the mean and variance of NBRX Thus, the policy variable meets the second condition of an effective policy instrument (besides controllability). Moreover, the short run relationship between NBRX and Y appears to be relatively stable over the period under investigation. This

[10] White's (1980) heteroskedasticity test on the residuals of equation (4 7) fails to reject the null hypothesis (p-value = 0 13). This results allows the conditional variance of NBRX to be approximated by the squared residuals of NBRX equation (Charemza and Deadman, 1987, p 240)

[11] CUSUM and CUSUM of squares tests (Brown et al, 1975) show that both equations (4 4) and (4 7) exhibit satisfactory parameter stability over the sample period Therefore, hypothesis testing in equation (4 9) is valid

result is important since it suggests that the policy regime changes that may have occurred over the sample period did not fundamentally alter the relationship between policy actions and output This finding lends more reliability to the final conclusions regarding the short run interactions.

The third condition for policy effectiveness, namely predictability from the instrument to the target, is verified through Granger-causality tests. The test of Granger-causality from the policy variable (NBRX) to the target (Y) is performed on equation (4.4). As shown by Mosconi and Giannini (1992) and Toda and Phillips (1993), in a VECM framework the appropriate Granger-causality test requires the assessment of the joint significance of the lagged terms (of NBRX in our case) and the ECTs[12]. The p-value obtained from the Wald test is 0.104, failing to reject, at all conventional significance levels, the null hypothesis that NBRX *does not* Granger-cause Y. In addition, the Granger-causality test was also performed for the lagged NBRX only (i.e., neglecting the ECTs). This can be interpreted as a short run Granger causality test. The null hypothesis that NBRX does not Granger-cause Y cannot be rejected (p-value = 0.216).

Based on the above results, the answer to the second important question of this study is negative. NBRX does not fulfill all the conditions required for an effective policy instrument. The policy variable is highly discretionary, as argued in Section 2.2. The superexogeneity test confirms that changes in NBRX do not alter the parameters of interest in the output equation. However, the policy variable fails to meet the third

[12] The reader is reminded that ECTs capture the long-run relationships between the variables of interest, as estimated by means of cointegration analysis

necessary condition. Since the NBRX does not accurately predict the target variable, it is unlikely that policy actions will bring about the desired results. This result questions the desirability of stabilization policies If the results of policy actions are not predictable, then active policy may potentially augment economic instability.

Even if adjustments of the policy variable cannot produce predictable effects on output, the question still remains what is the sign of the actual relationship between NBRX and Y, and what is the magnitude of the policy effects, if any, on output. These questions will be answered through innovation accounting (IRFs and FEVDs) performed in the framework of equations (4.4)-(4.8)

To this purpose, the system of equations is estimated as seemingly unrelated regressions (SUR). As compared to OLS, SUR improves the efficiency of estimation when the regressors are not the same in all equations[13] and the residuals are correlated across equations. Based on the estimated variance-covariance matrix, the impulse response functions (IRSs) and the forecast error variance decompositions (FEVDs) are generated. The impulse response functions provide information regarding the signs of the relationships of interest. Forecast error-variance decompositions provide a quantitative measure of the interactions between variables.

In the reduced form of equations (4 4)-(4.8), the error terms u's are linear combinations of the underlying structural model. The procedure suggested by Sims (1986) and Bernake (1986) is used to recover the structural innovations. As compared to the most commonly used Choleski decomposition, the Sims-Bernake procedure has the

[13] Notice that equations (4 4)-(4 8) of endogenous variables include the contemporaneous values of the weakly exogenous variables NBRX and R, as well as the ECTs These regressors are not included in equations (4 7)-(4 8)

advantage of allowing a more acceptable economic interpretation of the structural innovations. While the former implies the extreme assumption of a strictly recursive causal ordering of the variables, the latter allows for mutual contemporaneous causality.

The relationship between the reduced-form and the structural innovations is given by:

$$u_t = \Lambda^{-1} v_t \qquad (4.10)$$

where u_t is the (5x1) vector of reduced-form innovations in equations (4.4)-(4.8), v_t is the (5x1) vector of the structural innovations, and Λ is a (5x5) matrix of the contemporaneous relationships between the variables of interest. Unlike u's, the v's are assumed to be uncorrelated (orthogonal) across equations, representing genuine structural shocks.

As pointed out by Sims (1980b), any a priori structure imposed on a simultaneous equations system is debatable and may involve "incredible restrictions". Therefore, it is worth emphasizing that in modeling the matrix Λ (equations 4.11-4.15 below) the *a priori* considerations were employed mainly to select candidate structures, whereas the final choice is based on testing restrictions. Some restrictions imposed on matrix Λ are consistent with previous results from weak exogeneity tests and SUR estimation. Specifically, the innovations in NBRX and R are allowed to be correlated with innovations in endogenous variables if the estimated coefficients w_{ij} in equations (4.4)-(4.8) are statistically different from zero Alternative assumptions for additional restrictions were made, based on common theoretical insights regarding possible patterns of the contemporaneous correlations among structural innovations. These possible patterns were subjected to tests of overidentifying restrictions. This modeling

strategy, made possible by the Sims-Bernake procedure, is not available when using the Choleski decomposition, the latter imposing a priori a rigid structure where the system is strictly identified. The structure of matrix Λ presented below is chosen based on the results of these tests. The alternative patterns were rejected at all conventional significance levels[14].

$$u_{1t} = v_{1t} + \lambda_{15} v_{5t} \qquad (4\ 11)$$

$$u_{2t} = v_{2t} + \lambda_{24} v_{4t} + \lambda_{25} v_{5t} \qquad (4.12)$$

$$u_{3t} = \lambda_{31} v_{1t} + \lambda_{32} v_{2t} + v_{3t} \qquad (4.13)$$

$$u_{4t} = \lambda_{42} v_{2t} + v_{4t} \qquad (4.14)$$

$$u_{5t} = \lambda_{54} v_{4t} + v_{5t} \qquad (4.15)$$

where λ_{ij} is the row *i*, column *j* element of Λ.

Equation (4.11) shows that innovations in output are correlated within the quarter with interest rate innovations[15], a pattern accepted by most macroeconomic theories. Equation (4.12) implies that policy shocks and interest rate innovations affect the innovations in total reserves[16]. This pattern is consistent with the close relationship between NBRX and TOTR, analyzed in Chapter Two It is also a priori expected that the innovations in the interest rate and total reserves interact via the Federal funds market. Further, innovations in the money multiplier (equation 4.13) are

[14] If tests results showed that more than one structure is supported by data, then the selection of the final model would still require a priori judgement This is not the case here, since tests results rejected the alternative structures

[15] Although the policy variable is exogenous for the output equation, the coefficient w_{11} in equation (4 4) is not statistically significant at 5 percent (p-value 0 812)

[16] Both coefficients w_{21} and w_{22} in equation (4 5) are statistically significant at 5 percent, with p-values of 0 00 and respectively 0 022

contemporaneously correlated with output and total reserves innovations[17]. The connection between MM and TOTR is consistent with the transmission mechanism of policy actions described in Chapter Two. The policy shocks (equation 4.14) are correlated with innovations in total reserves, again reflecting the assumed interactions between NBRX and TOTR. Finally, equation (4.15) indicates that policy shocks affect contemporaneously interest rate innovations, as commonly assumed by theoretical models.

It is important to observe that the specification of NBRX and TOTR innovations is consistent with equations (2.1') and (2.3')[18]. (In addition, equation 4.12 includes the finding that total reserves are affected by the interest rate).

Matrix Λ includes 13 restrictions and therefore three overidentifying restrictions[19]. A likelihood ratio test of the null hypothesis that the overidentifying restrictions are valid was performed. The p-value obtained is 0.99, showing that the structure imposed on the model is strongly supported by the data over the sample period.

The results of innovation accounting, based on the above identification of the structural innovations, are presented next. The IRFs relevant for the investigation here are those generated by innovations in NBRX (Figure 3 1) and Y (Figure 3.2) Forecast

[17] The coefficients of the weakly exogenous variables in equation (4 6), w_{31} and w_{32}, are not statistically significant (p-values are 0 479 and respectively 0 108)

[18] The specifications of these equations are consistent, but not identical, since the innovations of equations (2 1')-(2 3') are changes in the *levels* of reserves, whereas the innovations of equations (4 12) and (4 14) are changes in *relative measures* See the discussion in Chapter Two

[19] For exact identification, only n(n-1)/2 restrictions are necessary, i e 10 restrictions in our model

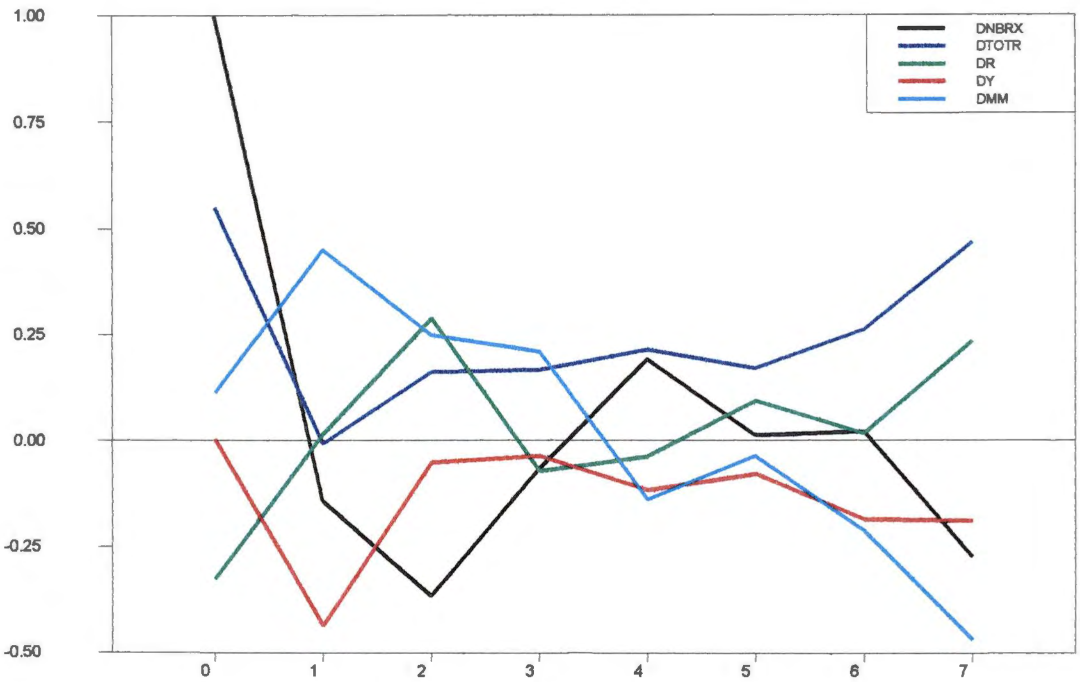

Figure 3.1: Part Three – Responses to a One Standard Deviation Shock to Changes in the Policy Variable (NBRX)

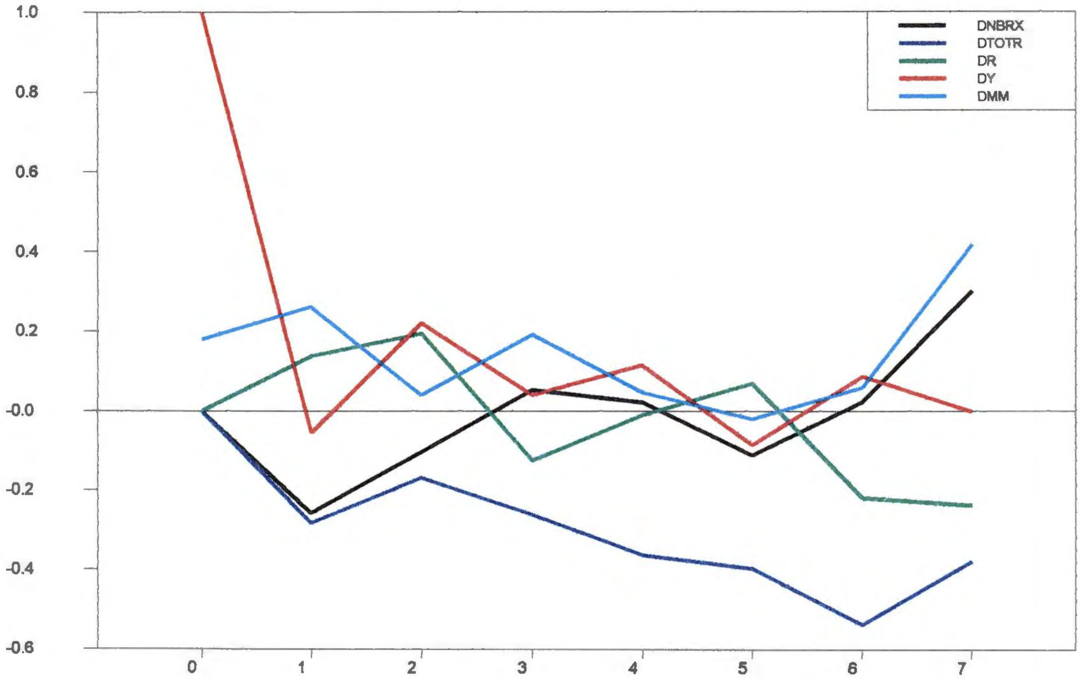

Figure 3.2: Part Three – Responses to a One Standard Deviation Shock to Output Changes

error variance decompositions are presented in Tables 3.1-3.5

To facilitate a correct interpretation of the next results, the reader is reminded that *the variables are specified as first differences*. To smooth the exposition, the variables of interest will continue to be referred to as Y, NBRX, TOTR, R, and MM, avoiding frequent repetitions of references to growth rates. Changes in NBRX and R have a straightforward interpretation. However, in case of Y, TOTR, and MM, a negative relationship between two variables, for instance, should be interpreted as indicating that while the growth of one variable accelerates, the growth of the other variable slows down. This pattern is perfectly consistent with both *level* variables moving in the same direction overtime (reflecting a long run relationship). This point is important since the signs of some relationships may unduly appear counterintuitive, if the distinction between levels and first differences is neglected.

The IRFs describe the behavior over time of a variable, following a one-time, one-standard-deviation innovation in another variable. The shocks to all variables, other than the one generating the IRF, are assumed to be zero. Figure 3.1, for instance, depicts the responses of the changes in NBRX, TOTR, R, Y, and MM, following a policy shock (i.e. a one-standard-innovation in NBRX). The IRFs do not warrant causal interpretations. The fact that a shock to only one variable is generating responses in the other variables does not necessarily imply that the variable shocked causes the others[20]. A less restrictive and perhaps more correct interpretation of the IRFs is that they describe the effects of the interactions between variables *in the presence* of a shock to a

[20] After all, if we interpret IRFs as causal, then the only general causal pattern valid would be one where everything causes everything else, since IRFs can be generated for all variables in the system

Table 3 1 Part Three - FEVD for DNBRX

FH	DNBRX	DTOTR	DR	DY	DMM
1	2 04	97 90	0 06	0 00	0 00
2	2.74	79 66	11 93	5 33	0 34
3	2 74	79 89	10 59	5 49	1 29
4	2 69	78 30	11 68	5 56	1 77
5	3 45	76 38	12 82	5 32	2 04
6	3 42	75 18	12.81	6 05	2 55
7	3 79	73 41	13 50	5 93	3 38
8	5 93	67 53	12 62	10 27	3 65

Table 3 2 Part Three - FEVD for DY

FH	DNBRX	DTOTR	DR	DY	DMM
1	0 00	0 00	0 24	99 75	0 00
2	0 01	15 90	0 23	81 78	2.07
3	0 02	15 09	0 44	80 28	4 18
4	0 19	14 57	2 09	76 80	6 36
5	0 45	14 00	8 95	70 13	6 47
6	0 61	13 23	14 78	64 90	6 48
7	0 77	14 43	16 42	61.96	6.42
8	1 57	15 54	16 44	59 63	6.82

Table 3 3· Part Three - FEVD for DR

FH	DNBRX	DTOTR	DR	DY	DMM
1	0.19	9 03	90 78	0 00	0 00
2	2.86	8 12	87 27	1 72	0 04
3	5.53	11.58	78 48	4 27	0 15
4	6 05	11 64	75 74	5 23	1 34
5	7 38	11 66	74 28	5 14	1 53
6	9 98	11 29	72 05	5.20	1 48
7	17 64	10 00	63 21	7 35	1 81
8	23.16	9.18	53 71	8 44	5 51

Table 3 4 Part Three - FEVD for DMM

FH	DNBRX	DTOTR	DR	DY	DMM
1	5 54	2 06	1 95	3 14	87 31
2	3 53	13 54	13 34	6.12	63 46
3	7.54	15.13	16 87	5 05	55 40
4	13 04	14.35	23 68	5 31	43 62
5	23 41	11.98	23 99	4 47	36 16
6	37 14	9 53	20.12	3 49	29 72
7	52 21	6 90	16.58	2 58	21 73
8	64 95	5 29	11.30	3 80	14 66

Table 3 5 Part Three - FEVD for DTOTR

FH	DNBRX	DTOTR	DR	DY	DMM
1	85 48	11 86	2 65	0 00	0 00
2	74 66	9 94	8 48	4 94	1 98
3	72 95	8 95	9 65	5 71	2 74
4	74 12	7 65	7 97	7 63	2 63
5	69 84	5 85	10 65	9 65	4 01
6	70 32	4 15	8 79	10 31	6 43
7	72 15	2 99	7 73	11 69	5 44
8	76 65	2 38	7 04	9 10	4 84

Note:
NBRX = the policy variable, TOTR = total reserves, Y = output, R = the interest rate, MM = the money multiplier. D denotes first differences and FH = forecast horizon Each row shows, for the forecast horizon indicated in the first column, the proportion of the variance in the variable at the top of the table explained by the innovations in column variables. The row numbers sum up to 100 (save for rounding errors).

single variable. This is nevertheless very useful since the *observed* movements of the variables reflect the combined results of innovations in *all* variables. One variable can be positively associated with innovations in some variables and negatively associated with innovations in other variables. IRFs disentangle these combined effects and help assessing the signs of particular relationships.

Both Figures 3.1 and 3.2 show that the short run dynamic relationship between the policy variable (NBRX) and output is negative. A positive standard deviation innovation in one variable is followed by a negative response in the other. The interpretation of this finding should take into account the caveat that IRFs do not carry any information about genuine causal relationships. Therefore, the negative relationship between the policy measure and output cannot be taken to mean that expansionary monetary policy causes decreases in output. A plausible explanation of this finding is that over the sample period the Fed pursued in general a countercyclical monetary policy.

However, the validity of the above explanation requires not only a countercyclical behavior of the Fed. For the negative relationship to obtain, it is also necessary that the policy actions are not effective in inducing the desired output adjustments. To illustrate, assume that Fed decides to fight a recession. If the policy is expansionary, but its impacts on output are negligible, output will continue to decrease. Then the inverse relationship between NBRX and Y obtains. The results reflected in the forecast error-variance decomposition of output support this scenario. Table 3.2 shows that NBRX variations explain less than one percent of output variations at all horizons except 8-quarter. The reader should notice that the FEVD results pointing to the

ineffectiveness of policy actions are consistent with the results of the Granger-causality test, which show that NBRX does not predict output.

At this point, the last two main questions of the investigation are answered. The results from IRFs and FEVDs indicate that the sign of the short run relationship between the changes in the policy variable and output is negative, and that the explanatory power of policy innovations for output is low. Although not the focus of the analysis, the IRFs and FEVDs reveal some other interesting patterns, discussed below.

Figure 3.1 shows that policy innovations are followed by a positive response of the money multiplier. This finding is consistent with the transmission mechanism of policy actions described in Chapter Two. Specifically, an expansionary policy action increases the supply of bank reserves on the Federal funds market, while simultaneously reduces the need for discount window borrowing. The resulting decrease of the Federal funds rate will increase the quantity of reserves demanded and acquired by the banks. Based on higher reserves, and because excess reserves are costly for the banks, the supply of credit may be increased, generating an increase in the money multiplier. The relationship between policy innovations and the money multiplier is further documented by the variance decomposition of the latter. Innovations in NBRX are the most important factor explaining the MM variance after five quarters In the existing literature, the relationship between monetary policy and the money multiplier is either ignored or addressed in a framework where monetary policy is identified with innovations in base money. Using the latter approach, RBC theorists argue that policy actions and the monetary multiplier are independent of one another (see, for instance,

Freeman and Huffman, 1991). The identification of policy actions adopted in this study helps reveal a relationship that was not previously documented.

Another interesting result is the negative short run relationship between TOTR and Y (Figure 3.2). Since total reserves represent an important component of base money, this finding is consistent with the results in Part Two, where a negative short run relationship between base money and output was found. A theoretical hypothesis was formulated in Part Two to explain this pattern. This explanation relates the movements in base money, the money multiplier, and output, to portfolio redistributions among the monetary assets included in the aggregate M2. It is argued that, if the ratio of quasi-money to transactions deposits (QT) is behaving procyclically, total reserves, and therefore base money, on one hand, and output and the money multiplier, on the other hand, move in opposite directions in the short run[21]. The negative relationship between TOTR and Y found here provides supporting evidence for this hypothesis. A direct empirical test of the proposed scenario is undertaken in Part Four, where supporting evidence for the procyclical behavior of QT and the general patterns discussed here is found.

Table 3.2 shows that output variation is primarily explained by its own innovations. Innovations in total reserves and the interest rate explain, each of them, up to 16 percent of output fluctuations, the explanatory power of the interest rate becoming dominant in the second year. The variations in the money multiplier explain up to 6 percent of output variations after 8 quarters, with a share steadily increasing. Overall,

[21] See Part Two for a detailed discussion of this hypothesis, and Part Four where evidence supporting the hypothesis is provided

these findings suggest that output fluctuations may be primarily determined by fundamental factors, such as real shocks, rather than nominal shocks. This interpretation is consistent with the finding that MM and Y have low explanatory power for each other. Similar results were obtained in Part Two. These patterns suggest that the usual assumptions of direct causal relationships between the monetary variables and output may not be warranted. The co-movements of real and nominal variables over the business cycles may represent the common effects of factors such as real demand and supply shocks, or changes in preferences.

Tables 3.1 and 3.5 indicate a strong relationship between NBRX and TOTR, reflected in the substantial mutual explanatory power. This is hardly surprising, since total reserves fluctuations represent the base for policy decisions and are ultimately affected by policy actions, via interest rate fluctuations on the Federal funds market. The interactions between the total reserves and the interest rate are reflected in Table 3.3, which shows that TOTR innovations explain a relatively constant proportion (about 10-11 percent) of interest rate variations. The policy variable explains a share of interest rate fluctuations that increases over time, up to 23 percent at the 8-quarter horizon. This result may reflect the lagged effects of policy actions on the Federal funds rate (as assumed by the transmission mechanism described in Chapter Two) and, further on, on the other interest rates in the economy

Table 3.3 indicates that interest rate fluctuations are primarily explained by own innovations. Notice that it is possible that own innovations in a variable may reflect the effects of factors that are not directly observable and/or quantifiable, and therefore cannot be explicitly captured in the analysis. Here, the identified pattern of interest rate

variance decomposition may reflect the influence of the same type of factors assumed to affect output, namely productivity shocks or changes in the time preference of the private sector. This assumption is consistent with a causal pattern where both the interest rate and output are the common effects of fundamental economic causes.

Finally, it is interesting to examine the possible implications of the results indicating that the policy shocks explain substantial proportions of the fluctuations in the money multiplier, total reserves, and (for the 7 and 8-quarter horizons) the interest rate. The direct effects of NBRX on output were found to be negligible. However, MM, TOTR, and R explain together about 30-40 percent of output variation after one year. Together, these findings suggest it is possible that policy actions affect output indirectly, through MM, TOTR, and R. However, a careful inspection of the IRFs in Figure 3.1 indicate that the sign of the indirect policy impacts on output is uncertain. The positive effect of an expansionary policy shock on the money multiplier lasts only for the first year. The indirect effects through R are even less clear, since the behavior of the interest rate is rather erratic[22]. These patterns suggest that the indirect effects of policy on output cannot be counted on for policy purpose. It is possible that these effects cancel each other to a certain extent and the net impact on output may by highly unpredictable.

[22] It is worth pointing out that the IRFs obtained from VECMs are expected to be more volatile than those derived from VARs in levels Standard VARs do not distinguish between short-run and long-run dynamics In these models, the presence of the long-run relationships, relatively stable as compared to the short-run fluctuations, smoothes out the path of variables IRFs presented here are based only on the short-run coefficients of a VECM, thus properly reflecting the short-run dynamics This very feature explains the relatively erratic behavior of IRFs from a VECM For an illustrative comparison, see Figures 2 1 and 2.5 in Part Two, that depict IRFs obtained from a VECM and, respectively, a VAR in levels, using the same data set

The results of the empirical investigation can be summarized as follows. First, the test of weak exogeneity confirmed that the policy measure, namely the share of non-borrowed reserves in total reserves of the banking system (NBRX), is exogenous for output. Second, the results indicate that NBRX fulfills only two of the three conditions necessary for an effective policy instrument. While NBRX is both a discretionary variable and it is superexogenous for output, Granger-causality tests indicate that policy actions do not predict output variations. Third, the short run relationship between NBRX and output is negative, suggesting a countercyclical behavior of the monetary authorities over the sample period. Finally, the actual effects of policy actions on output (regardless of their predictability) are likely to be very small, as suggested by the output variance decomposition.

As a point of comparison to previous work, the obvious choice is Strongin (1995) whose measure of policy actions was adopted in this study. The choice of the policy measure is augmented in this paper by empirical testing that confirms the exogeneity of NBRX. However, the results of the two studies are different. Strongin found that NBRX does Granger-cause output, that the relationship between policy and output is positive, and that NBRX explains a substantial proportion of output variations. The findings here contrast notably.

It is not entirely surprising that these investigations generated different results. While both studies use the same policy measure, different solutions are adopted regarding the choice and definition of variables of interest as well as the econometric models employed.

While NBRX and TOTR are identically defined in both studies, Strongin's vector of variables (based on monthly data), includes the industrial production, the consumer price index, and the federal funds rate. Here, the monetary multiplier is included, reflecting the importance attached throughout this study to the outside money-inside money decomposition. The price variable is omitted here because its explanatory power for the other relevant variables is very low, as the results in Part Two indicate. Output is represented by real GDP, which is a more comprehensive measure of economic activity than industrial production. The interest rate is measured in real terms and represents the opportunity cost of holding M2 balances, features that are consistent with most theoretical propositions.

In terms of econometric modeling, Strongin's results are based on standard VARs and Choleski decomposition of reduced form innovations. As argued in Section 1.2 of Part One, the methodology employed here, based on cointegration analysis, VECM, and structural decomposition, is preferable for the study of short run dynamics and allows a more meaningful interpretation of the relationships between the structural innovations

The results here are closer to those obtained by Sims (1980) and Litterman and Weiss (1985), in the sense that monetary policy does not Granger-cause output and it explains a very small proportion of output variations. Note that these studies identified monetary policy impulses with innovations in some monetary aggregates and used standard VARs. Based on a VAR including money (M1), industrial production, the interest rate, and a price index, Sims (1980) finds that money innovations explain 4 percent of output variation (at 48-month horizon), over the period 1948-1978 Litterman

and Weiss (1985) find that money explains only 2 7 percent at the 8-quarter horizon and 2 percent at the 16-quarter horizon, over the period 1950.2-1983.2 Their VAR includes industrial production, M1, a measure for expected inflation, and the real interest rate.

The above comparisons show that this study employs a combination of analytic procedures that is not present in previous studies. These procedures include the identification of monetary policy actions as the proportion of non-borrowed reserves in total reserves, testing for the exogeneity of this variable, use of vector error correction models, and innovation accounting based on structural decomposition of innovations. A number of previous studies based on alternative procedures concluded that monetary policy is neutral. The finding here suggest the same conclusion. In addition, the modeling strategy in this study avoids some of the ambiguities implied by the analytical frameworks used in other studies. The next chapter compares the results in Parts Two and Three and proposes a common interpretation

Chapter Five

Comparative Results and Interpretation

This chapter summarizes the main findings in Part Three, examines some points of consistency between Parts Two and Three, and offers a possible interpretation of the results.

Part Three investigates the relationships between the monetary policy and output, using U.S. quarterly data over the period 1960.1-1997.4. Cointegration analysis, in the framework of a vector error-correction model, is employed in order to isolate the long run and the short run relationships between the key variables. Empirical tests are performed to identify the exogenous variables. Predictability among the variables of interest is detected through Granger-causality tests. Innovation accounting based on structural decompositions of the reduced-form innovations reveals the short run dynamic interactions between variables

The main goal of the investigation is to understand the short run interactions between monetary policy and output, in order to assess the desirability of stabilization policies. A central idea of this study is the necessary distinction between changes in the money stock and policy actions. Meulendyke (1989), Eichenbaum (1991), and Strongin (1995) argue that changes in base money or broader monetary aggregates fail to identify properly the intentional policy actions of the Fed. Here, monetary policy actions are identified, following Strongin (1995), as the proportion of non-borrowed reserves in total reserves of the banking system. The estimated VECM includes the policy variable (NBRX), the total reserves, output, the interest rate, and the money multiplier.

The effectiveness of a policy instrument depends on the fulfillment of three conditions: controllability, superexogeneity, and predictability Controllability implies that the intentional actions of the policy-makers represent the single most important factor affecting the policy variable. Superexogeneity of the instrument with respect to the target (here, output) requires that changes in the instrument variable do not alter the parameters of the process generating the target variable. Predictability implies that the changes in instrument Granger-cause changes in the target. Controllability of NBRX is documented here on theoretical grounds, representing in fact the main criterion for the selection of NBRX as the relevant policy variable. A primary goal of the empirical investigation is to test empirically the fulfillment of the second and third conditions.

Preliminary tests find that NBRX is weakly exogenous with respect to output, weak exogeneity representing a prerequisite for superxogenity. The superexogeneity test confirms that the second condition is fulfilled, i e. that changes in the mean and variance of NBRX do not alter the parameters of the output equation. However, NBRX does not Granger-cause output, failing to meet the third necessary condition. Therefore, the overall conclusion regarding the effectiveness of policy variable, identified as the proportion of non-borrowed reserves in the total reserves of the banking system, is negative. If the potential impacts of policy actions on output are not predictable, then fine-tuning of the economy is not possible.

Regardless of the predictability of policy impacts on output, the nature of these impacts warrants assessment. The relevance of policy impacts is assessed by means of forecast error variance decomposition Impulse response functions are used to reveal the sign of the relevant relationships. It was found that the explanatory power of policy

shocks for output variation is negligible for all horizons within two years. The indirect effects of NBRX on output, via TOTR, MM, and R, while possibly stronger than the direct impacts, may act in opposite directions, such that the net effect is difficult to predict. IRF results indicate that the sign of the direct short run relationship between NBRX and output growth is negative. The only plausible explanation of this finding seems to be that, over the period under investigation, the monetary policy pursued by the Fed was in general counter-cyclical. However, for policy purposes, this result has little implication, given the finding that policy actions have irrelevant impacts on output.

Two more results, relevant for this study as a whole, are discussed next. These results connect the findings of Part Three with those of Part Two. While here the analysis is focused on the relationship *monetary policy – output*, Part Two focused on the relationship *money – output*. An important analytical feature of the investigation is the decomposition of the money stock (M2) into outside money and inside money (measured as the money multiplier)

The most interesting finding in Part Two was the negative short run relationship between the growth rates of outside money, on one hand, and output and the money multiplier, on the other hand. Since this result is new in the literature, a theoretical hypothesis, aimed to explain these patterns, was formulated. A relevant variable for this hypothesis is the ratio of quasi-money (i.e. non-M1 components of M2) to transactions deposits in the banking system, denoted as QT. It was argued that the patterns found obtain if the ratio QT behaves procyclically An increase in the QT ratio implies a substitution of quasi-money for M1 assets. Reserve requirements on M1 assets are

higher that those on quasi-money assets. Therefore, the portfolio redistribution involves a decrease in total required reserves, and a corresponding increase in excess reserves. On this basis, the supply of credit may be increased. An expansionary economy (recall the assumption that QT is procyclical), implies a higher credit demand. Consequently, banks are facing high opportunity costs of holding excess reserves. With both supply and demand for credit increasing, banks reduce their excess liquidity by credit expansion. Under such circumstances, the restructuring of the private sector's portfolio induces simultaneously a decrease in total reserves - and therefore in base money –, and an increase in the money multiplier. Notice that these events imply a negative relationship between the growth rates of total reserves and output Figure 3.2 in Part Three, showing that a positive innovation in output growth is followed by a decrease in the rate of growth of total reserves, provides supportive evidence for the proposed scenario. Further evidence consistent with the theoretical hypothesis presented above is provided in Part Four of this study.

In both Part Two and Part Three, it was found that output and the money multiplier do not explain to a large extent each other's variations, the maximum proportion being seven percent for horizons within two years. This might seem surprising since both monetary and RBC theories assume a close relationship between Y and MM. However, these theoretical beliefs received little empirical support This assertion is based on the fact that the vast majority of previous empirical studies investigating the interactions between output and money neglected the decomposition "outside money – inside money". Therefore, direct empirical assessments of the mutual impacts of inside money (or the money multiplier) and output are very scarce in the

literature The only multivariate study that offers some base of comparison with the results here is Manchester (1989). For the period 1954.3-1979.3, Manchester found that the innovations in the money multiplier explain 21 percent of output variation at the 8-quarter horizon This proportion is significantly higher than found here. The results regarding the explanatory power of output for the money multiplier are close to the findings here, about nine percent at 8-quarter horizon. However, the methodology used by Manchester, namely a standard VAR in first differences, has certain limitations. It is well known that first differences VARs imply a misspecification when cointegration relationships between variables of interest are present (Enders, 1995). Manchester does not report any cointegration tests for the variables used, that include output, base money, the money multiplier, the interest rate, and the GDP deflator.

No previous study analyzed the interaction between monetary policy and output using the same analytical framework employed here. This framework includes the identification of intentional monetary policy actions as changes in the proportion of non-borrowed reserves in the total reserves of the banking system, a vector error correction model, and a Sims-Bernake identification of the structural innovations. With little basis for direct comparison, the findings of this essay may be assessed in terms of broad consistency with results elsewhere The main findings here are that both policy and money multiplier impacts on output are weak. These results are broadly consistent with the findings reported by Sims (1980), Litterman and Weiss (1985), Friedman and Kuttner (1993), and Thoma (1994). All these studies report low explanatory power of money (measured as an aggregate) for output

Chapter Six

Conclusions

Part Three examines the short run relationships between monetary policy and output for the US economy, over the period 1960.1-1997.4. The main goal of the investigation is to evaluate the effectiveness of policy actions, in order to assess the desirability of stabilization policies. A clear distinction is made between changes in the money stock and policy actions, based on the idea that changes in base money or broader monetary aggregates fail to identify properly the intentional policy actions of the Fed. Here, monetary policy actions are identified, following Strongin (1995), as the proportion of non-borrowed reserves in total reserves of the banking system (NBRX).

The analytical framework features cointegration analysis, use of an error-correction model (VECM), and identification of the structural innovations of the system using the Sims-Bernake procedure. Unlike the commonly used standard VAR procedures and Choleski decomposition, the methodology here allows a proper identification and analysis of the short run dynamics, based on a testable structure of the contemporaneous correlations between structural innovations. A general-to-specific approach to econometric modeling is adopted. In this context, the analysis starts with an unrestricted dynamic model, on which subsequently restrictions are imposed, based on a series of empirical tests. The estimated VECM includes the policy variable (NBRX), the index of total reserves, output, the interest rate, and the money multiplier.

The effectiveness of a policy instrument depends on the fulfillment of three conditions: controllability, superexogeneity, and predictability. Controllability implies

that the intentional actions of the policy-makers represent the single most important factor affecting the policy variable. Superexogeneity of the instrument with respect to the target (here, output) requires that changes in the instrument variable do not alter the parameters of the process generating the target variable. Predictability implies that the changes in instrument Granger-cause changes in the target. Controllability of NBRX is documented here on theoretical grounds, representing in fact the main criterion for the selection of NBRX as the relevant policy variable. A primary goal of the empirical investigation is to test empirically the fulfillment of the second and third conditions. In addition, the relative magnitude of policy impacts on output is evaluated by means of variance decomposition.

The results of exogeneity tests confirm that the superexogeneity condition required for policy effectiveness is fulfilled by the policy measure adopted. Specifically, it is found that NBRX is weakly exogenous with respect to output, and that changes in the mean and variance of NBRX do not alter the parameters of the output equation However, NBRX does not Granger-cause output, failing to meet the third necessary condition Since the impacts of policy actions on output are not predictable, the desired policy results are unlikely to be achieved. The main policy instrument used by the Fed, namely 'the degree of pressure on the reserves position' (reflected here in changes in the NBRX) seems to be ineffective for output stabilization This conclusion is supported by further results showing that the explanatory power of policy shocks for the fluctuations in the growth rate of output is very low, below 2 percent at any horizon within two years.

The impulse response functions derived from the estimated VECM reveal a negative short run relationship between the growth rates of output and total reserves. This finding is consistent with the results in Part Two, where the growth rate of base money (that includes total reserves) is found to be negatively related with output growth.

Part Three results also confirm Part Two's finding that output and the money multiplier have low mutual explanatory power. These results are broadly consistent with those of other studies that found small impacts of innovations in money (measured as some monetary aggregate) on output.

As a general conclusion of this investigation, the lack of predictability from policy to output and the low explanatory power of policy shocks for output fluctuations argue against both the desirability and possibility of using monetary policy for *output* stabilization purposes. However, these findings do not rule out policy effectiveness and desirability for *price* stabilization.

REFERENCES

Bernake, B. (1986),'Alternative explanations of money-income correlation', *Carnegie-Rochester Conference Series on Public Policy* 25.

Bernake, B. and Blinder, A (1992), 'The federal funds rate and the channels of monetary transmission, *American Economic Review* 82.

Charemza, W.W. and Deadman, D.F. (1997), *New directions in econometric practice*, 2nd ed., Edward Elgar.

Christiano, L. and Eichenbaum, M. (1992), 'Identification and the liquidity effect of a monetary shock', in Cuckierman, A., Hercowitz, L.Z., and Liederman, L. (eds.), *Political economy, growth, and business cycles*, MIT Press, Cambridge, MA

Dickey, D. and Fuller, W.A. (1981), 'Likelihood ratio statistics for autoregressive time series with a unit root, *Econometrica* 49.

Eichenbaum, M. (1991), Comments on: ' Interpreting the macroeconomic time series facts: The effects of monetary policy', *European Economic Review* 36.

Engle, R.F. and Hendry, D.F. (1993),'Testing superexogeneity and invariance in regression models', *Journal of Econometrics* 56.

Engle, R.F., Hendry, D F., and Richard, J.-F. (1983),'Exogeneity', *Econometrica* 51

Ericsson, N.R., Hendry, D.F., and Mizon, G.E. (1998), 'Exogeneity, cointegration, and economic policy analysis', *Journal of Business & Economic Statistics*, Vol.16, No.4.

Freeman S and Huffman, W. (1991), 'Inside money, output, and causality', *International Economic Review*, vol.32, No.3.

Friedman, B.M., and Kuttner, K.N. (1993), another look at the evidence on money-output causality', *Journal of Econometrics*, May-June.

Gauger, J. and Black, H. (1991), 'Asset substitution and monetary volatility', *Journal of Money, Credit, and Banking*, November.

Gauger, J. (1998), 'Economic impacts on the money supply process', *Journal of Macroeconomics*, vol.20, No 3.

Harris, R.D. (1995), *Using cointegration analysis in econometric modeling*, Prentice Hall/Harvester Wheatsheaf.

Hoover, K.D. and Perez, S.J. (1994), '*Post hoc ergo prompter hoc* once more: An evaluation of 'Does monetary policy matter?' in the spirit of James Tobin', *Journal of Monetary Economics* 34.

Johansen, S. (1988),'Statistical analysis of cointegration vectors', *Journal of Economic Dynamcs and Control*, 12.

Johansen, S. (1992),'Identifying restrictions of linear equations', Institute of Mathematical Statistics, University of Copenhagen

Johansen, S. and Juselius, K (1992),'Testing structural hypotheses in a multivariate cointegration analysis of the PPP and the UIP for UK', *Journal of Econometrics* 53.

Johansen, S. and Juselius, K (1994),'Identification of the long-run and the short-run structure: an application to the ISLM model', *Journal of Econometrics* 63.

Litterman, R. and Weiss, L (1985), 'Money, real interest rates, and output: a reinterpretation of US postwar data', *Econometrica* 53.

Lucas, R.E. (1976), 'Economic policy evaluation: a critique', in Brunner, K. and Meltzer, A.M. (eds.), *The Phillips Curve and labor markets*, Carnegie-Rochester Conference series in Public Policy, vol.1, North-Holland.

Manchester, J. (1989), 'How money affects real output', *Journal of Money, Credit, and Banking*, Vol.21, No.1 (February).

Meulendyke, A.-M. (1989), *U.S. monetary policy and financial markets*, Federal Reserve Bank of New York, New York, NY.

Mosconi, R and Giannini, C (1992), 'Non-causality in cointegrated systems: Representation, estimation, and testing', *Oxford Bulletin of Economics and Statistics* 54,3

Plosser, C.I. (1989),'Understanding business cycles', *Journal of Economic Perspectives*, Summer.

Romer, C.D. and Romer, D.H. (1989), 'Does monetary policy matter? A new test in the spirit of Friedman and Schwartz', *NBER Macroeconomics Annual*

Sims, C (1980),'Comparison of interwar and postwar cycles: Monetarism reconsidered', *American Economic Review* 70 (May).

Sims, C. (1980b), 'Macroeconomics and Reality', *Econometrica* 48.

Sims, C. (1986), 'Are forecasting models usable for policy analysis?', *Quarterly Review*, Federal Reserve Bank of Minneapolis, Winter.

Sims, C. (1992), 'Interpreting the macroeconomic time series facts: The effects of monetary policy', *European Economic Review* 36

Strongin, S. (1995), 'The identification of monetary policy disturbances. Explaining the liquidity puzzle', *Journal of Monetary Economics*, 35.

Thoma, M.A. (1994), 'Subsample instability and asymmetries in money-income causality', *Journal of Econometrics*, 64

Toda, H.Y and Phillips, P C.B. (1993),' Vector autoregressions and causality', *Econometrica*, Vol.1, No.6.

PART FOUR

PORTFOLIO REDISTRIBUTIONS, MONEY, AND OUTPUT

Chapter One

Introduction

What is the nature of the short run interactions between money and output? This question lies at the heart of long-lasting debates in monetary and macroeconomics. The answer has crucial implications for the desirable conduct of monetary policy. The effectiveness of policies aimed at smoothing the short run fluctuations in output depends on two conditions. First, a genuine causal relationship running from money to output should exist. Second, it is necessary that policy makers are able to exert effective control over those monetary aggregates that are causally connected with output. If these conditions are not fulfilled, stabilization policies may be ineffective at best. In the most pessimistic scenarios, policy actions may further fuel economic instability.

The main contemporary schools of macroeconomic thought hold contrasting views regarding both conditions required for the effectiveness of stabilization monetary policies. Both the Keynesian and Monetarist schools believe that money supply fluctuations significantly affect output, in the short run. Real Business Cycle (RBC) theorists reject the possibility that money causes output. When it comes to policy issues, the Monetarist position is closer to the RBC recommendations. While Keynesians, believing that the monetary authorities can effectively fine-tune the money supply, advocate stabilization policies, Monetarists and RBC economists argue against the desirability of such policies Monetarists believe that the relationship between money and output lacks regularity, exhibiting long and variable lags. Therefore, planned policy actions are unlikely to yield the desired results. For RBC analysts, the rejection of

stabilization policies comes not only from the denial of causal connections running from fiat money to output. They further argue that the fluctuations in economic activity are the results of private sector's optimizing behavior. Consequently, policy actions aimed to alter the pattern of these fluctuations are not even desirable.

The main purpose of this study is to provide empirical evidence that may be brought to bear in clarifying some aspects of the ongoing debate. Part Two focused on the dynamic relationships between money and output, in an attempt to assess whether the empirical evidence is consistent with a causal relationship existing between these variables. In contrast to most of the existing empirical literature, the analysis was based on the explicit distinction between outside money and inside money (captured by the money multiplier). The investigation in Part Four builds upon patterns revealed in Part Two, and provides resolution to some seemingly anomalous results, as explained shortly. The final goal here is to reassess the nature of the interactions between money and output in an analytical framework consistent with the findings at earlier stages of the investigation.

Theoretical studies such as Gurley and Shaw (1960), King and Plosser (1984), and Freeman and Huffman (1991) argued that money created by the central bank (outside money) and money created by the fractional banking system (inside money) are essentially different in their interactions with output. The results in Part Two confirm this theoretical position. Moreover, the investigation revealed interesting patterns of the dynamics of outside money, the money multiplier, and output. These patterns are not documented in the previous literature. More specifically, it was found that, over the short run, changes in outside money, on one hand, and changes in output and the money

multiplier, on the other hand, have opposite signs This result warrants further investigation, which is undertaken in this essay.

In Part Two, it was argued that the revealed patterns are consistent with a theoretical hypothesis that emphasizes the role played by the portfolio redistributions among monetary assets for monetary dynamics. In addition to more fully exploring the proposed hypothesis and the empirical evidence from Part Two, Part Four presents formal empirical tests of the hypothesis. The existing literature commonly neglects to account for portfolio redistributions when analyzing the short run interactions between monetary variables and output. The findings here will show how different these interactions may appear when portfolio redistributions are duly accounted for. Using a more comprehensive and meaningful framework to analyze the interactions between money and output, this study generates results that add important contributions to the monetary and macroeconomic literature.

Keynesian and Monetarist theories assume a positive (and causal) short run relationships between outside money (or base money) and output, whereas in the RBC models output and outside money move independently. Most theories neglect the interactions between outside money and the money multiplier, or assume them to be economically insignificant The relationship, if any, is assumed to be positive, as in Patinkin (1965), where it is argued that outside and inside money change more or less proportionally, and in the same direction. However, empirical testing of these theoretical assumptions is actually extremely scarce in the literature. The main reason for this gap is that, as already mentioned, most empirical studies investigating the interactions between money and output measure money as a homogenous aggregate

(most frequently M1 or M2), rather than explicitly distinguishing between outside and inside money Exceptions such as Manchester (1989) and Cagan (1993) will be referred later in the text.

In light of the commonly held, albeit untested, beliefs about the short run interactions between output, outside money, and the money multiplier, the results in Part Two may be surprising. However, these empirical results are consistent with the theoretical hypothesis formulated in Chapter Five of Part Two. As mentioned earlier, the proposed interpretation points to the role of portfolio redistributions among the M2 assets (i.e. fluctuations of the ratio of quasi-money to transactions deposits) in explaining the negative short run relationship between changes in outside money and the money multiplier. In addition, it was argued that, if the ratio of quasi-money to transactions deposits fluctuates pro-cyclically, then this produces the negative relationship between outside money and output movements. The main purpose of Part Four is to assess more closely the empirical evidence relative to the proposed explanation. The investigation finds that the evidence is consistent with the theoretical hypothesis.

A second objective of Part Four is to reassess the relationships between monetary variables and output, under a new model specification. In Part Two, the variables under investigation included output, the interest rate, outside money, the money multiplier, and the inflation rate The empirical findings established that the inflation rate does not have significant explanatory power for the other variables Proved to be irrelevant for the specific purpose of this analysis, the inflation rate is no longer included in the model specification. The hypothesis investigated here requires

that a new relevant variable, namely the ratio of quasi-money to transactions deposits (QT), be included in the model. Under this new specification, results reconfirm the negative short run relationship between outside money, on one hand, and inside money and output, on the other hand, found in Part Two. However, the superexogenity of outside money no longer obtains. Under the interpretation proposed by Engle et al (1993), this finding suggests lack of causality from outside money to output. Further results indicate the significant role played by portfolio redistributions in explaining the pattern of the interactions between outside money and the money multiplier. More important, when portfolio redistributions are properly accounted for, the explanatory power of outside money movements for output fluctuations is substantially reduced.

The overall results in Part Four seem to lend little support to the conventional monetary theories of business cycles. While direct empirical testing of genuine causal relationships is problematic[1], the evidence here suggests that the assumption of direct causal connections between money and output may not be warranted. It is possible that the observed co-movements in monetary and real variables represent the simultaneous effects of third factors, such as *real* demand or supply shocks, or changes in private sectors' preferences.

The remainder of Part Four is organized as follows. Chapter Two provides theoretical background and presents the hypothesis under investigation, that is, the proposed explanation for the patterns of monetary and output dynamics. In addition,

[1] The results of the superexogeneity test, reported here, should be regarded as tentative The suggestion of Engle et al (1993), that superexogenity can be interpreted as causality, did not receive broad confirmation in the literature

some corroborating evidence confirming these patterns is offered, using some simple statistical tools as an alternative to the complex procedures employed in the main analysis Chapter Three outlines the main econometric procedures and describes data specifics. Estimation results are presented in Chapter Four. Chapter Five offers a summary and an interpretation of the results. Chapter Six presents conclusions

Chapter Two

Theoretical Background and Preliminary Evidence

2.1. Outside Money and Inside Money

Knowing the true nature of the dynamic interactions between the monetary and the real variables is crucial for the desirable conduct of monetary policy. Stabilization policies, aimed at smoothing the short run fluctuations in output, in order to increase economic stability, can only succeed if changes in the money supply are causally connected with output variations. Another prerequisite for successful stabilization policies is that the monetary authorities exert effective control over some relevant monetary variable. Parts Two and Three of this study aimed at assessing the extent to which the empirical evidence is consistent with the fulfillment of these two conditions. The results in Part Two pointed to a clear extension of the analysis. The interpretation of those results suggested inclusion of the ratio of quasi-money to transactions deposits (QT) as a potentially relevant variable in the estimated model. This allows investigation of the role of portfolio redistributions for monetary dynamics. Here, the proposed explanation and the empirical evidence are placed under closer examination.

A distinctive methodological feature of the analysis throughout this study is the decomposition of money into outside money and inside money (measured as the money multiplier). This important distinction was initially formulated by Gurley and Shaw (1960) They argued that the components of the money stock are heterogeneous. Outside money is created by the central bank and can be identified as the monetary

base[1]. Inside money is bank-created money, via the fractional reserve banking system. Outside money is a net asset, whereas inside money is both an asset and a liability for the private sector. As Gurley and Shaw argue, this asymmetry may be the source of real effects of changes in the money stock. For instance, an increase in outside money raises the price level. At higher prices, real inside money balances are lower and some asset market is not in equilibrium, which triggers changes in equilibrium interest rates and consequently real output adjustments.

Gurley and Shaw point to the distinction between outside and inside money to reject the classical neutrality proposition. More recently, RBC studies (such as King and Plosser, 1984, and Freeman and Huffman, 1991) employ the same distinction for the very opposite purpose. Freeman and Huffman (1991) warn against the misleading conclusions that may be generated by the aggregation of inside and outside money. Inside money represents deposits at banks, used to make loans to agents who create capital. Therefore, inside money can be seen as intermediated capital. The authors argue that " inside money differs from outside money in its link to output because of the fundamental difference between intermediated capital and unbacked, intrinsically useless pieces of paper issued by the government"[2].

Regardless of the conclusions about neutrality, fact is that many theories acknowledge today the heterogeneity of outside and inside money. However, this

[1] Monetary base (or "base money", or 'high powered money") is the sum of currency in circulation and "bank reserves", i e the commercial banks' balances with the central bank

[2] It is worth mentioning that Freeman and Huffman (1991) model base money as currency only When bank reserves are included in outside money, it is questionable if base money can be any longer considered as representing "useless pieces of paper" The magnitude and the fluctuations of bank reserves may influence the amount of loans made to the private sector, and therefore inside money This aspect opens the theoretical possibility for a connection between outside and inside money

important distinction is neglected by the vast majority of empirical studies. The common practice in empirical work is to focus on some monetary aggregate, while the inferences about the effects of the two components are made *implicitly*, by comparing the results obtained using the monetary base (the measure for outside money), with the results obtained using broader monetary aggregates The drawbacks of this approach are twofold. First, the simultaneous interactions between output and the respective components of money cannot be directly assessed. Second, the relationship between outside money and inside money is also overlooked. The approach taken in this study aims to eliminate these gaps. The next subsection presents a brief review of previous studies that adopt the decomposition "outside money – inside money" For the readers' convenience, a summary of the results from Part Two is also presented, as well as a discussion of some methodological improvements in this paper, as compared to the previous studies.

2.2. Empirical Evidence: Previous Results and Some Methodological Problems

Among the very few empirical studies that explicitly distinguish between outside and inside money are Manchester (1989) and Cagan (1993). Manchester includes in a VAR analysis both the monetary base and the money multiplier, the latter standing as a measure of inside money. The author finds that both components explain output, but the explanatory power of the money multiplier is substantially higher than that of outside money Cagan employs the same decomposition of money in a single regression framework, finding that both monetary variables have almost equal explanatory power for output.

The investigation here adds significant methodological improvements over Manchester (1989) and Cagan (1993). Integrated in a general-to-specific modeling approach, these improvements include use of cointegration analysis, use of a vector error-correction model (VECM) rather than a standard VAR (or single regression), and formal testing for exogeneity. A system analysis has the well-documented advantage, over single-equation models, of eliminating the simultaneity bias. Compared to a standard VAR approach, a VECM allows the separation of the short run and long run relationships between the variables of interest. This feature is important for focusing the analysis on the short run interactions between the variables of interest, as required by the assessment of business cycle theories. It is also worth pointing out that Manchester's analysis was based on a VAR in first differences. When cointegration between the variables of interest exists[3], use of a first-differences VAR implies a misspecification, because it ignores the information about the long run relationships (Enders, 1995). A VECM allows the separate analysis of the short run dynamics while at the same time accounting for the long run effects in the estimated model. While first differences VARs are frequently used in the literature, in many applications VECM is the more appropriate method.

Based on the methodological approach described above, the findings in Part Two indicate negative short run relationships between outside money, on one hand, and output and the money multiplier, on the other hand. In view of the common theoretical

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[3] Lack of cointegration implies the absence of long-run relationships between the variables of interest. While this may be true in some cases, assuming no long-run relationships between *any* of the main macroeconomic variables, such as output, money, and the interest rate, would strongly contradict some fundamental propositions of the economic theory

priors regarding these relationships, these results may appear surprising. Monetary theories (Keynesian and Monetarist) assume a positive short run relationship between outside money and output, while RBC theory assumes that these variables move independently of one another. As regards the relationship between outside money and the money multiplier, the interactions between the two components of money are largely ignored in the literature, or simply assumed to be of small magnitude. However, it is important to point out that empirical tests of these theoretical priors are extremely scarce in the literature. The main reason for this gap is that, as mentioned earlier, most empirical studies ignored the decomposition "outside money – inside money". Therefore, the literature does not provide an extensive basis for comparison of results here. Some previous studies, that may offer context for subsets of the key elements assessed here, are reviewed next.

King and Plosser (1984) examine the relationships between outside money and output in the framework of simple regressions. Using U.S. annual data for the period 1953-1978, they found that output is positively correlated with base money, contemporaneously, but negatively correlated with the first and second lags of base money Cagan (1993), also in a single-equation framework, finds positive coefficients for contemporaneous base money and the money multiplier in the output equation. Cagan used quarterly data for 1953.1-1981.2. Looking at the base money-money multiplier contemporaneous cross-correlations, he found a negative correlation between *real* base money and M1 multiplier, and a positive correlation between base money and M2 multiplier, both statistically insignificant.

An interesting element of comparison with our results can be found in Manchester (1989). The first model in the paper is a five-variable VAR for the period 1954.3 -1979.3, including the first differences of output, base money, the money multiplier, the interest rate, and the inflation rate. Presenting the cross-correlations between the unrestricted VAR innovations, the author remarks: "Only the correlation between the growth in the monetary base and the money multiplier is large enough to be worrisome" (p. 23). Indeed, Table 3 in the paper (p.23) shows that the correlation is 0.775. Not mentioned, however, is the fact that the correlation in case is *negative.* A similar negative correlation (-0.799) between the innovations in base money and the money multiplier obtains in Manchester's second model, an eight-variable VAR that includes, in addition to the above variables, the component ratios of the money multiplier (Table 7, p.29). Nowhere in the paper does the author comment upon the sign of this correlation. Moreover, the impulse response functions of the VAR, which could reveal the sign of the dynamic relationship between base money and the money multiplier, are not presented in the text; the interpretation of the results is based solely on variance decomposition. Thus, prior evidence of this negative and potentially important relationship has been buried in the literature. It just never has been previously pursued.

The foregoing review and the preceding discussion suggest that the existing literature provides little base for meaningful comparison with the results obtained in this study. Manchester's study offers a piece of evidence broadly consistent with the results here, although that particular result was not aggressively pursued. As regards the results of King and Plosser (1984) and Cagan (1993), note that the comparability with the

findings of this study is limited, since those analyses were based on the variables measured in levels. There are a number of problems with this approach First, most macroeconomic variables are non-stationary when measured in levels and statistical inference is invalid unless cointegration relationships are properly identified. Second, the relevant contemporary monetary and macroeconomic theories emphasize the importance of dynamic rather than comparative static analysis. For dynamic analysis, and especially for the business cycle theory, the relationships between the changes (or growth rates) in the variables of interest are more relevant than the relationships between levels. The same distinction between changes and levels is significant in distinguishing between short run and long run relationships. It is perfectly possible that two variables are positively related over the long run, while the short run relationship between their growth rates or between the innovations in their growth rates is negative. This happens if both variables include trends or unit roots with drifts of the same sign.

While base money and output are increasing together over time, it was found in this study that their short run relationship is negative. To interpret properly this finding, a correct understanding of the procedure used to obtain this result is necessary. The negative relationships "base money - output" and "base money – money multiplier" are obtained in this study from impulse response functions (IRFs). Given some of the patterns found here, it is useful to recall what IRFs identify Assume a VAR is estimated, including variables A, B, and C The IRF of A in response to B is a graphical description of the behavior over time (at time t, t+1, t+2,...) of A, following a one-time (at time t) positive shock (innovation) to B, and *assuming zero shocks to the other variables of the system*, A and C. It follows that the behavior described by a

particular IRF can never be observed directly, for the simple reason that, in real life, all variables of the system are subjected to shocks, both at time t and thereafter What can be directly observed is the time path of a variable as a common result of *all* past shocks in *all* relevant variables. The IRFs are analytical tools aimed to disentangle these influences, based on the identification of innovations and the history of the system dynamics reflected in the sample data. To illustrate, if the IRF shows that A decreases following a positive shock to B, this does *not* necessarily imply that one will observe, typically, A and B moving in opposite directions. It is possible that the relationship between A and C is positive and quantitatively stronger than the relationship between A and B. Thus, if B and C are also positively related, one may observe that A, B, and C move generally in the same direction. This occurs because the negative effects of B on A are more than offset by the positive effects of C. It is clear that, as the number of interacting variables increases, it becomes increasingly difficult to assess the adequacy of IRFs based on direct observation.

The above considerations suggest that the results obtained here regarding the sign of the relationships between outside money, the money multiplier, and output may in principle be consistent with any directly observed behavior. The next subsection will take the argument further, presenting the proposed theoretical explanation of the patterns revealed by the IRFs obtained in Part Two The theoretical hypothesis is subsequently subjected to formal empirical tests

2.3. The Theoretical Hypothesis

The theoretical hypothesis presented here explains the patterns, found in Part Two, of the short run dynamics of outside money, the money multiplier, and output. Alternative explanations may be proposed. However, the subsequent empirical analysis will establish that the evidence is consistent with the scenario proposed here.

Two arguments underlie the proposed scenario. The first point relates to the portfolio redistributions among monetary assets, which have been increasingly important in recent decades. Specifically, a portfolio redistribution within the monetary aggregate M2 implies a change in the QT ratio, given by the ratio of quasi-money (non-M1 components of M2) to transactions deposits (included in M1). The second argument is based on the assumption that the QT ratio behaves pro-cyclically.

These arguments together imply that output fluctuations are regularly accompanied by asset portfolio redistribution within M2 aggregate. The hypothesized relationship is as follows: when output increases (decreases) private agents increase (decrease) the share of their holdings of non-M1 (or quasi-money) assets and, correspondingly, decrease (increase) the share of their holdings of M1 assets As explained shortly, this hypothesis generates specific predictions about observable relationships between outside money, the money multiplier, and output movements. Specifically, the hypothesis predicts negative short run relationships between outside money and the money multiplier and between outside money and output, as well as a positive relationship between output and the QT ratio. The predicted negative relationships between outside money, on one hand, and output and the money multiplier, on the other hand, are consistent with the empirical evidence in Part Two. In

this part of the dissertation, the complete set of predictions implied by the hypothesis presented in this section is subjected to empirical investigation. The findings reported in Section 2.4. and Chapter Four provide evidence that strongly support these predictions. The negative relationships outside money – output and outside money – money multiplier, as well as the pro-cyclical behavior of the QT ratio are confirmed by evidence obtained from two independent econometric procedures. Together, these results indicate that the proposed hypothesis is consistent with the empirical evidence.

The rest of this section elaborates on the theoretical hypothesis. The analysis starts by showing how portfolio redistributions among the M2 assets can generate opposite movements in base money and the money multiplier. Next, three broader scenarios will be presented, illustrating possible explanations of the pro-cyclical behavior of the QT ratio.

The effects of portfolio redistributions are analyzed in a base – multiplier framework. A simple model will help the exposition:

$$M = C + D + Q \qquad (2.1)$$

$$B = C + R_D + R_Q + E \qquad (2.2)$$

$$MM = (k + q + 1) / (k + r_D + r_Q q + e)^4 \qquad (2\ 3)$$

$$M = B\ MM \qquad (2.4)$$

[4] The analytic expression for multiplier is derived as follows

$$B = (C/D + R_D/D + R_Q/D + E/D)\ D = (k + r_D + r_Q q + e)\ D$$
$$M = (C/D + D/D + Q/D)\ D = (k + 1 + q)\ D$$
$$MM = M / B = (k + q + 1) / (k + r_D + r_Q q + e)$$

$$M_I = M - B = B\,(MM - 1) \qquad (2.5)$$

where M = M2 monetary aggregate , B = monetary base, MM = the money multiplier, M_I = inside money, C = currency in circulation, D = transaction deposits in M1, Q = quasi-money (i.e. non-M1 components of M2), R_D = required reserves on transaction deposits, R_Q = required reserves for Q assets, E = excess reserves, k = C/D, $r_D = R_D/D$, $r_Q = R_Q/Q$, q = Q/D, e = E/D. In the notation of this model, q is the same as QT, the ratio of quasi-money to transactions deposits, which will be used in later empirical modeling and testing.

While more analytic models of the money multiplier than equation (3) can be used, this form serves well the purpose here. The same model is used by Manchester (1989). The RBC model of Freeman and Huffman (1991) employs a base-multiplier model focused on M1, rather than M2, which explains why their study overlooks the key mechanism discussed here.

In terms of the above model, the proposed argument, concisely stated, is: portfolio redistributions within M2 aggregate, reflected in procyclical behavior of the q (QT) ratio, produce the pattern observed between outside money, inside money, and output. The argument utilizes the observed fact that $r_D > r_Q$ Historically, the required reserve ratio on checkable (transactions) deposits was always higher than the required reserve ratio on Q (quasi-money) balances, at least over the sample period of this study[5]. Currently, reserves are required only on M1 deposits; r_Q equals zero.

[5] This difference between the required reserve ratios on transactions and time deposits is a common pattern for the baking systems of most countries

Assume a portfolio redistribution that implies an increase in q (which, as previously noted, occurs pro-cyclically), through a decrease in D and an increase in Q. For simplicity, the effects of the portfolio redistribution are initially analyzed under a ceteris paribus assumption, implying that the redistribution occurs exclusively between transactions deposits and quasi-money. In such a case, D will decrease and Q will increase by the same amount ($\Delta D = - \Delta Q$). In real life, portfolio redistributions are more complex, involving, besides D and Q, currency, monetary assets included in broader monetary aggregates (such as M3 or L), and government bonds. Therefore, the changes in D and Q would not usually be equal in magnitude. Possible cases are examined after the main argument is presented.

Continuing to analyze the case when $\Delta D = - \Delta Q$, notice that the changes in transactions deposits (D) and quasi-money (Q), reflected in an increase in q, induce corresponding changes in the required reserves for D and Q. However, since the reserve requirements on Q are smaller than the reserve requirements on D, the corresponding decrease in R_D is larger than the increase in R_Q Assuming no change in the demand for credit of the private sector, then excess reserves E would increase with the difference ($\Delta R_D - \Delta R_Q$), and total reserves would be unchanged. However, if this portfolio redistribution occurs when the economy is expanding, it will be accompanied by a higher demand for credit. Having now higher excess reserves, commercial banks may accommodate this demand by increasing lending (and reducing E to the previous level or even lower). It is worth emphasizing that commercial banks have strong incentives to extend credit when holding excess liquidity Idle resources are costly, since commercial banks' balances with the central bank do not earn interest. While banks are reluctant to

extend credit (and may indeed reduce lending) when the economy is slow, due to the risk of accumulating bad loans, in an expanding economy banks rapidly transform any excess liquidity in loan assets. Under such circumstances, one will observe an increase in the money multiplier, as well as a decrease in the total reserves and therefore in base money[6].

The above argument can be formally captured as follows. The effect on base money is given by taking the total differential of B:

$$dB = dC + dR_D + dR_Q + dE$$

Setting dC = dE = 0, and knowing that r_D and r_Q are constants[7], we have:

$$dB = d(r_D D) + d(r_Q Q) = r_D (dD) + r_Q (dQ)$$

Because the assumption that dQ = - dD, it follows that:

$$dB = dD (r_D - r_Q) \Rightarrow dB/dD = (r_D - r_Q) > 0,$$

which shows that a decrease in D is followed by a decrease in B.

The effect on the money multiplier is given by differentiating MM with respect to q:

$$\partial MM / \partial q = [k (1 - r_Q) + (r_D - r_Q) + e] / (k + r_D + r_Q q + e)^2 > 0.$$

The positive relationship between q and MM is clearly established. However, the result that dB/dD > 0 was obtained above under the assumption that dQ = - dD,

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[6] Here, it is assumed that no change in currency in circulation (C) occurs However, under the circumstances, it is conceivable that C may also decrease, since it is likely that the same type of incentives that trigger substitution of Q for D would also work towards diminishing currency holdings Thus, Q assets may be substituted for both C and D If this happens, the effects on base money and the money multiplier would be augmented

[7] Setting dE = 0 reflects the above argument that commercial banks do not accumulate excess reserves in an expanding economy The reserve requirements (r_D, r_Q) are infrequently changed, and thus can be treated as constants

implying a redistribution among D and Q assets, ceteris paribus. For the negative relationship between base money and money multiplier to obtain whenever q increases, $dB/dD > 0$ should hold. As argued earlier, in real life, portfolio redistributions occur not only between D and Q, but also between these and other monetary or financial assets. This implies that often $dQ \neq - dD$ Such cases, and their possible implications on the predicted relationships between base money, QT (=q) ratio, and the money multiplier, are analyzed next. As above, these cases are discussed under the assumption that QT increases.

One possibility is that Q and D still move in opposite directions, but dQ and dD are of different magnitudes. Then $dB/dD = r_D + r_Q\ (dQ/dD)$, where $(dQ/dD) < 0$. Two cases are possible. First, assume Q increases faster than D decreases. This would be the case when the private sector substitutes Q assets for transactions deposits *and* other assets. In this case, $(dQ/dD) < -1$, and the condition $(dB/dD) > 0$ obtains if $(r_D/r_Q) > -(dQ/dD)$. The larger the spread between the required reserves on transactions and quasi-money deposits, the likelier the patterns predicted here obtain. Moreover, when r_Q is zero, as is presently the case in the U.S. economy, $dB/dD = r_D$, and the condition is unambiguously fulfilled. A second possibility with $(dQ/dD) < 0$ is that D decreases faster than Q increases. This happens when the private sector substitutes quasi-money assets *and* other assets for transactions deposits. In this case, $-1 < (dQ/dD) < 0$, and the condition $dB/dD > 0$ unambiguously obtains.

Another possibility is an increase in QT due to a decrease in D, with Q unchanged. In this case, the portfolio redistribution implies that other assets than quasi-

money are substituted for transactions deposits Then again the condition $dB/dD > 0$ is unambiguously fulfilled, since $dQ = 0$ and $dB/dD = r_D$

Finally, QT may increase due to an increase in Q, with D unchanged, implying that the private sector substitutes quasi-money for assets other than transactions deposits. Then $dB = r_Q(dQ) > 0$. This is the only case contradicting the patterns predicted by the hypothesis here, since base money would increase together with QT, the money multiplier, and output.

The discussion suggests that the hypothesis proposed here does not require overly restrictive assumptions, being consistent with various patterns of portfolio redistributions. The predicted relationships would very likely obtain in all cases discussed, save for the last one. Note also that, a priori, the last two cases are rather extreme, and therefore less likely to hold in reality. As the subsequent empirical investigation will show, the evidence does not support the patterns implied by the last case, while being consistent with the alternatives.

The foregoing analysis shows how portfolio redistributions can affect monetary dynamics. Redistributions among monetary assets are likely to generate co-movements in the money multiplier and the QT ratio and movements of opposite sign in base money. Taking the argument a step further, if QT is pro-cyclical, then output and outside money fluctuations are negatively associated, as found in Part Two. Clearly, the assumption that QT is pro-cyclical is crucial for our theoretical hypothesis. Is this assumption reasonable? The empirical investigation will provide convincing evidence for an affirmative answer Here, theoretical arguments are offered. Three possible scenarios generating pro-cyclical behavior of QT are suggested next.

The first scenario starts with an increase in potential output. This event may occur due to decisions by households to increase the supply of labor in the process of intertemporal optimization and substitution between work and leisure. Alternatively, the firms may increase investment, either due to a positive productivity shock (as in RBC theory), or driven by a wave of optimism about profit opportunities (the Keynesian "animal spirits"). For further reference, these initial events are described as an increase in Y^e (expected output). Either alternative would imply an increase in the demand for loanable funds, driving up the interest rate. The reason why QT may be pro-cyclical is that the returns (interest rates offered) on quasi-money (Q) assets are more sensitive (adjust faster) than returns on checkable deposits to market interest rate changes. Quasi-money include the following assets: savings accounts (SA), small time deposits (STD), money market mutual funds (MMMF) and money market deposit accounts (MMDA). Moore et al. (1988) found, for the 1980s, that the rates on STDs respond relatively quickly to market rates changes as compared to M1 deposits (D). More important, however, for the sensitivity of Q assets returns to market rates, are the money market accounts (MMMFs and MMDAs). The returns on these assets are *directly* related to market rates, since money market mutual funds invest in short-term money market securities such as Treasury bills, certificates of deposits, and commercial paper. Hetzel and Mehra (1989) and Moore et al. (1988) confirm that the returns on money market accounts adjust relatively promptly to market rates. Since their introduction in 1971, the volume and the share of money market funds in total quasi-money increased steadily. Because the returns on M1 assets (D) and those on Q assets have different sensitivity to market interest rate changes, fluctuations in market rates determine fluctuations in the

relative returns on D and Q. Further, changes in the relative returns induce portfolio adjustments within the M2 aggregate. For instance, when market interest rate increases, the response of Q assets returns will induce substitution of Q assets for D assets. The substitutability among M2 assets was documented by empirical studies. Gauger (1992) found strong substitutability between M1 assets and the money market accounts. Under this scenario, the sequence of macroeconomic events would be:

$$\uparrow Y^e \Rightarrow \uparrow R \Rightarrow \downarrow TR, \downarrow BM, \uparrow MM, \uparrow QT, \uparrow Y^8,$$

where Y^e = expected output, Y = actual output, R = the interest rate, TOTR = total reserves, BM = base money, MM = the money multiplier, and QT = quasi-money to transactions deposits ratio.

A second reason explaining a pro-cyclical behavior of QT may be the willingness of the commercial banks to balance the maturity of their assets and liabilities portfolios over the business cycles. While typically banks borrow short term and lend long term, the prudential rules and regulations of the banking system require a certain level of banks' liquidity ratios. If output expansion requires financing of additional investment in medium and long term projects, banks may offer higher returns on less liquid deposits included in quasi-money (i.e Q=M2 – M1), in order to substitute longer term liabilities (such as savings and term deposits) for short run liabilities (transactions deposits). The relative returns on M1 and non-M1 assets within M2 are thus altered in favor of the latter and consequently QT increases. The sequence of events would then be:

[8] Actual output increases due to the actions of the private sector, financed by the increased bank lending reflected in the increase in MM

$\uparrow Y^e \quad \Rightarrow \uparrow Y, \uparrow R$

$\Rightarrow \uparrow$Returns on Q $\Rightarrow$ $\downarrow$TR, $\downarrow$BM, $\uparrow$MM, $\uparrow$QT

Finally, the observed behavior documented here may be determined by a certain fiscal-monetary policy mix Assume that the sequence of events starts with an expansionary fiscal action. As all macroeconomic theories agree, bond financed deficits put upward pressure on interest rates. If excess government spending does not crowd-out completely private investment, then output increases Further, if the households do not consider the additional bonds held as hundred percent net wealth, they will increase to some extent savings. This is an argument in the spirit of the "Ricardian equivalence"[9] (see Barro, 1974). However, it should be emphasized that it is *not* assumed here that the Ricardian equivalence strictly holds. The argument here only requires that the private sector reduces *to some extent* consumption and, correspondingly, saves more. This assumption is very plausible. In contrast, the assumption that households ignore completely the intertemporal budget constraint of the government and therefore the possibility of future taxes is as extreme as that of a strict Ricardian equivalence. Now, if the private sector saves more and this additional saving is reflected fully in the additional bonds acquired, no effect on QT will follow However, it is unlikely that this would actually be the case, since the observed behavior indicates that economic agents are portfolio diversifying. Because quasi-money assets (that are primarily saving

[9] The Ricardian equivalence theorem states that a bond financed deficit is equivalent with a tax financed deficit The reason is that households are aware of the intertemporal budget constraint of the government and realize that higher deficit today is bound to be ultimately paid by higher taxes in the future They fully discount their future tax liabilities against the additional bonds held The latter are therefore not counted as an increase in net wealth The bond financed budget deficit crowds-out private consumption the same way as a tax financed one would

instruments) are more liquid than government bonds, it is likely that households sell part of the bonds (that financed the deficit) to banks, in exchange for savings and time deposits. Ratio QT and the money multiplier thus increase. However, this chain of events does not explain so far the decrease in base money[10]. This would be explained if the expansionary fiscal policy is accompanied by a restrictive monetary policy, in order to keep inflation in check. In fact, this policy mix appears as very plausible for the US economy, where over the sample period high budget deficits were accompanied by relatively low inflation (with the exception of the 1970s; however, even during this period, the inflation in US was relatively low compared to the inflation rates in the rest of the world). Such a pattern could not be maintained without monetary policy at least partially sterilizing the potentially inflationary effects of expansionary fiscal policy. Under this scenario, the sequence of events would be.

$$\begin{aligned} \uparrow BD \ &\Rightarrow \uparrow Y, \uparrow R \\ &\Rightarrow \downarrow Cs, \uparrow S \Rightarrow \uparrow QT, \uparrow MM \\ &\Rightarrow \downarrow BM^{11}, \end{aligned}$$

where BD = the budget deficit, Cs = consumption, S = savings It is worth pointing out that this explanation, that assigns fiscal shocks an important role in business cycles, is consistent with both the monetary and the RBC theories, especially if the latter accepts a less than extreme case for the Ricardian equivalence.

Regarding these alternative explanations, one may question if the magnitude of the effects suggested here might be significant enough to account for the observed

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[10] Here, QT increases due to an increase in Q (and M2), with M1 constant

[11] BM decreases as a result of anti-inflationary monetary policy

behavior of the variables of interest. Obviously this question can only be properly answered empirically. However, the theoretical possibility that all three mechanisms described might work in practice ought to be considered. In such a case, it seems reasonable to assume that their combined effects may indeed be significant.

The main purpose of these explanations is to illustrate that the patterns, found in this study, of the relationships between outside money, output, and the money multiplier, may be generated by some plausible combinations of common economic events. Such patterns have not been examined in the previous literature. However, results here suggest they warrant further attention. The subsequent empirical investigation provides supporting evidence for the pro-cyclical behavior of the QT ratio. Further research is necessary to assess to what extent the broader scenarios suggested here are consistent with the empirical evidence. While outside the scope of this study, this investigation represents a planned extension of the dissertation.

The main predictions of the theoretical hypothesis formulated in this section are next subjected to empirical testing. Specifically, innovation accounting (impulse response functions and variance decomposition) from a vector error-correction model will be employed to assess the nature of the dynamic relationships between the QT ratio, output, outside money, and the money multiplier. This assessment will also provide a check on the robustness of some of the patterns found in Part Two. The next section provides some preliminary evidence that corroborates the findings in Part Two, and is also consistent with the predictions to be tested here.

2.4. Preliminary Evidence

The findings of Part Two revealed the nature of the dynamic interactions between the monetary variables and output In particular, three important short run relationships warrant further attention: (1) the negative relationships outside money-output; (2) the negative relationship outside money – money multiplier; and (3) the positive relationship money multiplier-output. Three additional hypothetical relationships are under investigation here. (4) QT-output, (5) QT-money multiplier, and (6) QT-outside money, where QT is the ratio of quasi-money to transactions deposits. Evidence that the relationships (4) and (5) are positive, whereas (6) is negative, would be consistent with the pattern of relationships (1)-(3) and would provide support for the theoretical explanation proposed here.

To assess the relationships (1)-(6), the main investigation in this Part uses innovation accounting from a vector error-correction model. Impulse response functions (IRFs) will provide information about the sign of these relationships. Variance decomposition will be employed to assess in relative terms the magnitude of the interactions between the variables of interest. Before proceeding to the main analysis, it is interesting and useful to examine alternative evidence on the relationships (1)-(6), provided by some simple and intuitive statistical procedures.

Table 4.1 provides information regarding the cross-correlations between the first differences of the variables in relationships (1)-(6), at lags, at leads, and

Table 4.1. Cross-Correlations between Changes in Output, Monetary Variables, and QT Ratio (1960 1-1997.4)

Variables[a]	Cross-correlations[b]								
	T-4	T-3	T-2	T-1	T	T+1	T+2	T+3	T+4
(1) ΔY-ΔBM (-)									
1960 1-1997 4	**-0.0898**	**-0.1151**	**-0.1136**	**-0.014**	0 0217	**-0.1172**	**-0.037**	**-0.0863**	**-0.1378**
1960 1-1979 4	**-0.3234**	**-0.1698**	**-0.0868**	0 0129	0 0933	0.0606	0.1316	**-0.0049**	**-0.0231**
1985 1-1997 4	0.0145	**-0.1795**	**-0.2297**	**-0.3193**	**-0.3486**	**-0.2504**	**-0.2228**	**-0.1056**	**-0.1547**
1975 1-1997 4	0 1438	**-0.0244**	**-0.0753**	0 0357	0 0462	**-0.1859**	**-0.1189**	**-0.0468**	**-0.1399**
(2) ΔBM-ΔMM (-)									
1960 1-1997 4	**-0.1134**	**-0.1662**	**-0.2374**	**-0.2607**	**-0.5321**	**-0.4032**	**-0.365**	**-0.3816**	**-0.3271**
1960 1-1979 4	**-0.0268**	**-0.0844**	**-0.1259**	**-0.0981**	**-0.381**	**-0.2348**	**-0.1881**	**-0.2508**	**-0.2433**
1985 1-1997 4	**-0.1908**	**-0.2131**	**-0.3223**	**-0.4489**	**-0.7135**	**-0.604**	**-0.5828**	**-0.4798**	**-0.3841**
1975 1-1997 4	**-0.003**	**-0.0675**	**-0.1589**	**-0.2078**	**-0.5245**	**-0.3892**	**-0.3217**	**-0.3255**	**-0.2462**
(3) ΔMM-ΔY (+)									
1960 1-1997 4	**0.0031**	**0.053**	**0.0115**	**0.08**	**0.121**	**0.2139**	**0.2684**	**0.1851**	**0.129**
1960 1-1979 4	-0 2049	-0 1537	-0 1408	**0.0634**	**0.2494**	**0.3382**	**0.4135**	**0.364**	**0.3356**
1985 1-1997 4	**0.2698**	**0.2562**	**0.2365**	**0.1559**	**0.296**	**0.2261**	**0.2327**	**0.1086**	-0 0701
1975 1-1997 4	**0.0584**	**0.094**	**0.0235**	**0.005**	**0.0169**	**0.1098**	**0.1653**	**0.057**	-0 0467
(4) ΔY-ΔQT (+)									
1960 1-1997 4	**0.1115**	**0.1389**	**0.0778**	**0.0799**	**0.0231**	**0.1189**	**0.1074**	**0.1462**	**0.0879**
1960.1-1979 4	**0.2711**	**0.3014**	**0.2473**	**0.1877**	**0.044**	-0 0199	-0 1069	-0 2069	-0 3737
1985 1-1997 4	**0.0565**	**0.1381**	**0.1409**	**0.2136**	**0.1933**	**0.3044**	**0.3832**	**0.2992**	**0.3874**
1975 1-1997 4	**0.0776**	**0.1201**	**0.0456**	**0.0623**	**0.0033**	**0.1452**	**0.1538**	**0.2112**	**0.1602**
(5) ΔQT-ΔMM (+)									
1960.1-1997 4	**0.2698**	**0.2981**	**0.3577**	**0.3959**	**0.5523**	**0.4903**	**0.5127**	**0.4885**	**0.3805**
1960 1-1979 4	-0 0196	**0.1401**	**0.3949**	**0.5089**	**0.6049**	**0.6377**	**0.525**	**0.4043**	**0.2279**
1985 1-1997 4	**0.4014**	**0.3562**	**0.4384**	**0.4661**	**0.575**	**0.6181**	**0.5963**	**0.5292**	**0.4281**
1975 1-1997 4	**0.3075**	**0.3244**	**0.3707**	**0.4107**	**0.5859**	**0.5072**	**0.536**	**0.5069**	**0.3224**
(6) ΔQT-ΔBM (-)									
1960 1-1997 4	**-0.3051**	**-0.3501**	**-0.4033**	**-0.4177**	**-0.5244**	**-0.3529**	**-0.3583**	**-0.2929**	**-0.1726**
1960 1-1979 4	**-0.0222**	0 036	**-0.0233**	**-0.0455**	**-0.0615**	**-0.011**	0 031	0 1133	0 1759
1985 1-1997.4	**-0.559**	**-0.5566**	**-0.6542**	**-0.6778**	**-0.7223**	**-0.6185**	**-0.5616**	**-0.4906**	**-0.3677**
1975 1-1997 4	**-0.369**	**-0.4324**	**-0.4893**	**-0.5124**	**-0.6491**	**-4303**	**-0.4325**	**-0.35**	**-0.1964**

Notes:

a. Variables: Y = log of real GDP, BM = base money, MM = M2 money multiplier, QT = ratio of quasi-money to transactions deposits. Δ denotes first differences.

b. Bold figures indicate correlations having the predicted sign, which is indicated in parenthesis after each pair of variables

contemporaneously. The information covers the same sample period as the main analysis, namely the period 1960.1- 1997.4

The cross-correlations at leads and lags are particularly relevant for dynamic analysis. Contemporaneous correlations alone are of little relevance for most relationships in the context of quarterly data Very few theorists would argue that the interactions between the macroeconomic variables (and particularly those between monetary and real variables) manifest themselves entirely within the period of a quarter.

The specifics of dynamic analysis also justify the focus on first differences rather than levels. Correlations between levels provide little relevant information, especially when most variables are non-stationary (here, the only exception is the interest rate) and some exhibit positive trend or drift (in this case, base money and output).

The information in Table 4.1 is provided for the whole sample (1960.1-1997.4), as well as for three sub-samples: 1960.1-1979.2, 1985.1-1997.4, and 1975.1-1997.4. The purpose of calculating the cross-correlations over the sub-samples is to assess whether the nature of the relationships between key variables has changed notably over time, for example, due to changes in policy regimes. The first two sub-samples are chosen to exclude the period of the so-called "monetarist experiment" of 1980-1982 (and two more years to account for possible lagged effects of this event) The third sample covers all major critical economic events of the last quarter of the century. Significant changes over time in the nature of the relationships (1)-(6) would be

reflected in systematic changes of the signs of the cross-correlations across data samples

In Table 4.1, the headings in the first column indicate the pairs of variables for which cross-correlations are calculated, listed in the order of relationships (1)-(6). The predicted sign for each relationship is indicated in parenthesis after each pair listed. Bold figures in the table indicate those correlations having the predicted sign. Cross-correlations are calculated for the first differences of the following variables: Y = log of real GDP, BM = log of base money, MM = log of the M2 money multiplier, QT = the ratio of quasi-money to transactions deposits. The latter is calculated as (M2 – M1) / D, where D = total checkable deposits included in M1. Correlations are calculated between the value, at time t, of the first variable listed and the lags (t-1 to t-4), the contemporaneous value (at t), and the leads (t+1 to t+4) of the second variable[12]. If the order of the variables is reversed, the interpretation of leads and lags should also be reversed. To illustrate, the first number in the table (-0.0898) can be equivalently interpreted as a negative correlation between ΔY_t and ΔBM_{t-4}, or between ΔBM_t and ΔY_{t+4}.

The results presented in Table 4.1 provide strong support for the predictions made in this study regarding the signs of the relationships (1)-(6). In general, the results are consistent across the four data samples investigated. The predicted signs clearly dominate across relationships and samples. Few correlations have signs opposite to the predicted ones, as shown by non-bold numbers. Most deviations from the general

[12] Cross-correlations for lags (t-5) to (t-8) and leads (t+5) to (t+8) were also calculated, in general, they are consistent with the patterns described in Table 1 The results are available upon request

pattern are found for the sub-sample 1960.1-1979.4, mainly for the relationship Y-BM. These deviations are not strong enough to justify the rejection, for this period, of the general predicted pattern Notice the strong negative contemporaneous correlation (-0.35) between Y and BM for the most recent subsample

The strongest correlations in the table are those between base money and the money multiplier, between QT ratio and the money multiplier, and between QT and the base money. Notice how the negative relationship between base money and the money multiplier, never reported in the existing literature, is confirmed, without exception, across all samples. The contemporaneous correlations between BM and MM range between –0.38, for the earliest period, and –0.71 for the most recent subsample. The contemporaneous correlations between QT and MM exceed 0.55 for all samples, whereas those between QT and BM are stronger than -0.52 for all samples except the earliest. These findings provide strong support for the theoretical hypothesis tested in this essay, which assumes significant interactions between QT, base money, and the money multiplier.

While some of the predicted relationships may be weaker over the sub-sample 1960.1-1979 4, they are broadly consistent with the general pattern. Some of the correlations presented vary in magnitude across samples, but their signs are in general as predicted. This finding suggests that the structural and policy regime changes that occurred in the US economy over the 38 years of the period analyzed did not dramatically alter the key relationships between macroeconomic variables investigated

here[13] The results in this subsection, indicating relatively stable signs of the key relationships investigated, provide valuable corroborating evidence for the results of the main analysis.

The same relationships will be further analyzed through impulse response functions. As pointed out earlier, cross-correlations and the IRFs for the variables of interest exploit differently the same information. Cross-correlations simply describe co-movements of variables. IRFs describe the behavior of a variable following a one-time innovation in another variable, thus providing significantly higher analytical content. The conclusions regarding the generic relationships of interest would appear even more convincing if the results obtained using both instruments were similar. The investigation undertaken in the following sections will show that the results in Table 4.1 are consistent with those provided by the IRFs. Both support the theoretical hypothesis tested in this essay. The next chapter outlines the main econometric procedures employed to answer the questions addressed in this Part, and describes data specifics.

[13] This conclusion is important for the investigation undertaken throughout this study, since, due to degrees of freedom constraints, the multivariate analysis used here could not be pursued if data needed to be split to sub-samples Specifically, the minimal period for estimating the VECM with 5 variables and 12 lags, of the subsequent empirical analysis, is 1960 1-1980 1 Moreover, this is just the period strictly necessary to solve mathematically the model A significantly longer sub-sample is required for an efficient estimation of the model

Chapter Three

Econometric Procedures and Data

This chapter surveys the main econometric procedures employed and their specific purposes. A detailed motivation for the choice of these procedures can be found in Section 1.2 of Part One. A description of the data concludes this section.

The main goal of this investigation is to test empirically the implications of the theoretical hypothesis formulated in Chapter Two. The hypothesis that portfolio redistributions are relevant for the assessment of the short run interactions between the monetary variables and output is based on specific assumptions regarding the pattern of the relationships between outside money, the money multiplier, output, and the ratio of quasi-money to transactions deposits (QT). Impulse response functions (IRFs) and variance decomposition (FEVD) derived from a vector-error correction model (VECM) will be employed to assess the sign and, respectively, the quantitative importance of all six relationships identified in Section 2.4[1].

Another issue of interest is the exogeneity status of outside money. In the first essay, it was found that base money is superexogenous for the output, meaning that changes in outside money do not alter the structural parameters of the output equation. As Engle et al (1983) suggest, this result may be interpreted as a causal connection running fom outside money to output. Does this result still obtain when a new relevant variable, namely the QT ratio, is included in the model? This question will also be

[1] These relationships are Y-BM, BM-MM, MM-Y, Y-QT, QT-MM, and QT-BM

answered here

The VECM is the chosen framework because, in contrast to standard VARs, it allows the analysis of short-run dynamics to be performed separately from the long-run relationships. The short-run and long-run relationships are identified and separated through cointegration analysis, using Johansen's (1988) methodology.

Cointegration analysis will also provide information necessary to identify the weakly exogenous variables. A more efficient estimation of the model will be obtained by conditioning the endogenous variables on the weakly exogenous variables. Depending on the weak exogeneity results[2], superexogeneity of base money will be tested using the procedure developed by Engle and Hendry (1993).

The efficiency of the estimation is further improved by estimating the VECM as seemingly unrelated regressions (SUR). To calculate the IRFs and FEVDs, the structural innovations of the multivariate model will be identified through a Sims-Bernake decomposition (Sims, 1986, and Bernake, 1986) The advantages of Sims-Bernake method over the commonly used "Choleski decomposition" are presented in Section 1 2 of Part One.

The analysis is carried out using quarterly US data for the period 1960.1-1997.4. Five variables are included in the vector error-correction model. Output (Y) is measured as the log of real GDP. The log of the St. Louis monetary base (BM) stands as the measure of outside money. The money multiplier (MM), capturing inside money, is

[2] Weak exogeneity is a necessary condition for superexogeneity

calculated as the ratio of the monetary aggregate M2 to the monetary base. The interest rate (R) is calculated as the spread between the 3-month Treasury bill rate and the 'own return on money', i.e. the weighted average of the rates received on the assets included in M2. The ratio QT of quasi-money (i.e non-M1 components of M2) to transactions deposits is calculated as (M2 – M1) / D, where D represents total checkable deposits included in M1.

Output and money are the main variables of interest, and their short run interactions constitute the focus of investigation in this study. The decomposition outside money-inside money (the monetary multiplier) reflects a central point of this study, that the two components of the money stock are heterogeneous and therefore their interactions with output should be distinctively analyzed. The interest rate is included since many empirical studies (for instance, Sims, 1986, and Litterman and Weiss, 1985) showed that the explanatory power of money for output variations is significantly altered when the influence of the interest rate is incorporated. Finally, the QT ratio plays a central role in the proposed explanation of the pattern of short run dynamics of output, outside money, and the money multiplier. The very purpose of the investigation here is to provide empirical evidence for the assessment of this explanation. All raw data are obtained from FRED, the database of the Federal Reserve Bank of St Louis The estimation results, together with a step-by-step description of the estimation procedures, are presented in the next chapter.

Chapter Four

Estimation and Results

Six important relationships between relevant macroeconomic variables are investigated here with the purpose of clarifying the nature of the short run interactions between the monetary variables and output. The relationships analyzed are (1) Y-BM, (2) BM-MM, (3), MM-Y, (4) Y-QT, (5) QT-MM, (6) QT-BM. The signs and the quantitative importance of these interactions are assessed by means of innovation accounting (IRFs and FEVDs). In addition, a test for the superexogenity of base money with respect to output is performed. The sequence of results, together with the econometric procedures employed in estimation, is presented below. Since the same procedures are used throughout this study, they will be discussed in less detail here; for a more detailed description, the reader is referred to Section 1.2 of Part One and Chapter Three of Part Two.

Some preliminary analysis is necessary to assess the order of integration of the variables of interest Augmented Dickey-Fuller unit root tests (Dickey and Fuller, 1981) for both levels and first differences revealed that Y, BM, QT, and MM are I(1), whereas R is I(0)[1]. Since there are no I(2) variables, the conditions for the validity of the subsequent cointegration analysis are met.

The investigation starts with the most general data generating process (DGP), namely a standard (unrestricted) VAR. In the spirit of the general-to-specific modeling,

[1] ADF tests were run using the URADF procedure in RATS, that chooses the optimal lag length for the ADF regression using the BIC model selection criterion

a series of restrictions are tested and imposed on the initial model

The first step involves the choice of the lag length for the model. VARs with 12, 8, and 4 lags were estimated. Likelihood ratio tests for reduced lag structure from 12 to 8 and from 12 to 4 lags were performed. The p-values obtained were, respectively, 0.003 and 0.031. Both the last 4 lags and the last 8 lags are jointly significant at 5 percent significance level, suggesting unambiguously the choice of the 12-lag model. All equations of the 12-lag model perform well in terms of the required residual properties (normality, no serial correlation, and no heteroskedasticity)[2]. These properties are important since the validity of most subsequent tests requires white noise errors in the maintained hypothesis. It is worth noticing that the same lag structure was found for the estimated models of all three essays. These consistent results suggest that the macroeconomic processes involving the variables analyzed have relatively long memory.

Cointegration analysis is performed next, in order to identify and separate the short-run dynamics of the system from the long-run relationships. This type of analysis requires the estimation of the model in a vector error-correction form (VECM). Standard VAR procedures do not distinguish between short-run and long-run dynamics. VECM is therefore a better choice for assessing interactions between macroeconomic variables over the business cycles, which is the primary interest here.

The standard VAR is reparameterized as a VECM as follows:

$$\Delta y_t = \Gamma_1 \Delta y_{t-1} + \ldots + \Gamma_{k-1} \Delta y_{t-k+1} + \Pi y_{t-k} + u_t \qquad (4.1)$$

[2] The results of the residual analysis, not included here, are available upon request

where Δy_t is the vector including DQT, DBM, DR, DY, and DMM, i.e the first differences of the variables of interest, $\Gamma_i = -(I - A_1 - \ldots - A_i)$, $(i = 1, \ldots, k-1)$, $\Pi = -(I - A_1 - \ldots - A_k)$, and I is an identity matrix of order *n* (in this case, n = 5).

The term Πy_{t-k} captures the long run relationships between variables in y_t. The rest of the model, (the differenced variables), represents the short run component. The long run (cointegration) analysis will provide the framework for tests of weak exogeneity. The results of these tests are used to re-estimate the system conditional on the weakly exogenous variables, thus increasing the efficiency of estimation. The analysis of short run dynamics will provide answers to the questions regarding the sign and the quantitative importance of the interactions among the variables of interest.

Cointegration analysis is performed using Johansen's (1988) methodology. The (nxn) matrix Π in equation (4.1) is decomposed into two (nxr) matrices α and β, such that $\Pi = \alpha\beta'$. The columns of β (β_i's, i = 1, . ., r) represent the cointegrating vectors (long-run relationships). The α matrix represents the matrix of parameters that measure the speed of adjustment of the variables in the model following a deviation of the system from the long-run equilibrium[3].

The cointegration rank (r) and the deterministic components of the model are jointly determined through the test procedures described in Johansen and Juselius (1992) and Johansen (1992). The results of the tests suggest a model with three cointegrating vectors (β_i's) and a constant in the short run model[4]. Therefore, r = 3 is the

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[3] The rank of Π, the number of cointegrating vectors, and the number of columns of α and β, all equal *r*
[4] Both λ_{trace} and λ_{max} statistics (Johansen and Juselius, 1990) select r = 3 The joint test for r and deterministic components (Johansen, 1992) selects a model with a constant and r =3 at all conventional significance levels

first restriction imposed on equation (4.1) model, where a vector of constants is added[5]. On this model restrictions on β and α can be tested.

Restrictions on β are necessary for a unique identification of the parameters of β and α[6] Using the procedures developed by Johansen and Juselius (1992,1994), various possible restrictions on β_i's were tested. The cointegration vectors selected by the likelihood ratio tests are then used to generate the error correction terms (ECTs) included in the equations of the endogenous variables (see below)[7].

Having identified the parameters of the cointegrating vectors, tests of weak exogeneity can be performed by imposing restrictions on the rows of matrix α. A variable is weakly exogenous for the parameters of the equation of another variable if the process generating the first variable can be estimated without knowledge of these parameters. Identifying the weakly exogenous variables is useful for two reasons. First, conditioning the system on the weakly exogenous variables improves the stochastic properties of the model (Harris, 1995) Second, weak exogeneity is a necessary condition for superexogenity. The significance of superexogeneity will be discussed shortly.

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[5] The vector of constants allows for a linear trend in (some of the) level variables.

[6] For any ω non-singular matrix of dimensions (r x r), $\alpha\beta' = \alpha\omega^{-1}\omega\beta' = \alpha^*\beta^{*\prime}$ It follows that $\Pi = \alpha\beta' = \alpha^*\beta^{*\prime}$, meaning that the parameters of α and β are not identified

[7] The cointegrating vectors represent long-run equilibrium relationships between variables However, these relationships do not have an explicit causal interpretation (Rao, 1994) More specifically, since β_i's are obtained from reduced forms, they cannot be interpreted as structural equations (Dickey et al , 1994) By imposing specific restrictions on β, theoretical hypotheses about long-run relationships may nevertheless be tested However, this is not the goal of this study, where the cointegrating relationships are identified with the limited purpose of separating them from the short-run relationships to be estimated Therefore, the parameters of β_i's are not presented and discussed here They are available upon request

The framework for test is given by equation (4.1), where the matrix Π is written as $(\alpha\beta')$·

$$\Delta y_t = \Gamma_1 \Delta y_{t-1} + \ldots + \Gamma_{k-1} \Delta y_{t-k+1} + \alpha\beta' y_{t-k} + u_t \qquad (4.1')$$

If the row i of matrix α is a zero vector, then the variable i does not adjust endogenously in response to the deviations from the long run equilibrium induced by the other variables, i.e. the variable i is weakly exogenous. Therefore, testing weak exogeneity amounts to test zero restrictions on α. At five percent significance level, the null hypothesis of weak exogeneity was rejected for Y, QT, R, and MM (with p-values of, respectively, 0.00, 0 00, 0.01, and 0.04) and accepted for BM (p-value = 0.31).

The results of these tests confirm the finding of Part Two that base money is weakly exogenous. The interest rate, which was also found weakly exogenous in Part Two, no longer exhibits this property under the specification here[8].

The tests of weak exogeneity concluded the cointegration analysis. The remainder of the analysis will focus on the short run dynamics. The model is re-estimated conditional on the weakly exogenous variables, using seemingly unrelated regressions (SUR) estimation procedures. As compared to OLS, SUR improves the

[8] In the analytical framework elaborated by Engle et al (1983), adopted for exogeneity analysis in this study, the concept of weak exogeneity is not interpreted in terms of genuine causality; it rather describes a statistical property that allows conditional estimation This approach is different from the traditional approach to econometric modeling, where a concept closely related to, but not identical with, weak exogeneity is that of pre-determinedness. Pre-determined variables are a priori assumed to cause the endogenous variables. In Engle et al (1983), the a priori assumptions play little role. More structural content than weak exogeneity is assigned, in this approach, to the concept of superexogeneity, to be addressed shortly

efficiency of estimation when the residuals are correlated across equations The model in general form is described by equations (4.2) and (4.3)

$$\Delta y^*_t = \Gamma_0 \Delta z_t + \Gamma^y{}_1 y_{t-1} + \ldots + \Gamma^y{}_{k-1} \Delta y_{t-k+1} + \alpha(\beta' y_{t-k}) + u_{yt} \quad (4.2)$$

$$\Delta z_t = \Gamma^x{}_1 y_{t-1} + \ldots + \Gamma^x{}_{k-1} \Delta y_{t-k+1} + u_{xt} \quad (4.3)$$

where the vector Δy^*_t includes the endogenous variables Y, QT, R, and MM (in first differences). The Δz_t term is the first difference of the weakly exogenous variable BM. The term $(\beta' y_{t-k})$ represents the error-correction terms (ECTs). ECTs, that capture the long run relationships between variables, were estimated in the cointegration analysis. They are included now in equation (4.2) as deterministic variables, and the subsequent analysis is performed based on the short run coefficients captured in the matrices Γ^9.

In terms of specific variables here, the general model of equations (4.2) and (4.3) can be written as:

$$DY = k_1 + w_{11}\,DBM + a_1(L)DY + a_2(L)DBM + a_3(L)DMM + a_4(L)DQT +$$
$$+ a_5(L)DR + \alpha_{11}\,ECT_1 + \alpha_{12}\,ECT_2 + \alpha_{13}\,ECT_3 + u_1 \quad (4.4)$$

$$DQT = k_2 + w_{21}\,DBM + b_1(L)DY + b_2(L)DBM + b_3(L)DMM + b_4(L)DQT +$$
$$+ b_5(L)DR + \alpha_{21}\,ECT_1 + \alpha_{22}\,ECT_2 + \alpha_{23}\,ECT_3 + u_2 \quad (4.5)$$

$$DMM = k_3 + w_{31}\,DBM + c_1(L)DY + c_2(L)BM + c_3(L)DMM + c_4(L)DQT +$$
$$+ c5(L)DR + \alpha_{31}\,ECT_1 + \alpha_{32}\,ECT_2 + \alpha_{33}\,ECT_3 + u_3 \quad (4.6)$$

$$DR = k_4 + w_{41}\, DBM + d_1(L)DY + d_2(L)DBM + d_3(L)DMM + d_4(L)DQT +$$

$$+ d_5(L)DR + \alpha_{41}\, ECT_1 + \alpha_{42}\, ECT_2 + \alpha_{43}\, ECT_3 + u4 \quad (4.7)$$

$$DBM = k_5 + e_1(L)DY + e_2(L)DBM + e_3(L)DMM + e_4(L)DQT +$$

$$+ e_5(L)DR + u5 \quad (4.8)$$

where k's are constants, (L) denotes lag polynomials, and the time subscripts are omitted.

As compared to Part Two, here the specification of the estimated model reflects the change in focus, by including QT as a relevant variable. It is interesting to compare, at this point, the degree to which the key variables are explained under the alternative specifications. A comparison of the (centered) R-squares for each equation is presented below.

Part Two		Part Four	
Equation	R-sq.	Equation	R-sq.
dY	0.66	dY	0.62
BM	0.47	dBM	0.63
dMM	0.87	dMM	0.88
dR	0.47	dR	0.70
ddP	0.55	dQT	0.88

Notice that while the changes in output and the money multiplier are explained in similar proportions under both specifications, the changes in base money and the interest rate are significantly better explained under the current specification. In addition, the equation for the new variable introduced, QT, exhibits high goodness of fit. These results indicate that the inclusion of the quasi-money movements, captured by

[9] Autocorrelation, normality, and heteroskedasticity tests on the residuals of the above model show satisfactory results as regards the fulfillment of the white noise criterion Test results are available on request

the QT ratio, allows a better description of the relationships between the key variables than does the inflation information.

Under the model specification in Part Two, it was found that base money was superexogenous for output. Here, superexogeneity of BM with respect to output would imply that changes in the first two moments of the stochastic process generating BM (equation 4.8) do not change the parameters of the output equation (4.4). One interpretation of this condition is that policy actions do not alter the behavior of economic agents. If this is the case, then policy actions may be expected to be effective in producing desired effects on non-behavioral macroeconomic parameters. However, this interpretation of superexogeneity is not relevant here. As argued in Part Three, base money is not an appropriate measure of intentional policy actions. An alternative interpretation of superexogeneity was suggested by Engle et al. (1983). The authors argue that superexogeneity "seems to satisfy the requirement for causality", if one accepts Zellner's (1979) definition of causality as "predictability according to a law". Under this interpretation, if base money is superexogenous for output, then base money causes output. Evidence regarding the superexogeneity of base money with respect to output is provided next. Conclusions based on this evidence, however, should be regarded as tentative. Confirmation of the suggestion of Engle et al (1993) or alternative suggestions regarding empirical tests for structural causality can hardly be found in recent literature.

The superexogeneity test is performed as explained in Chapter Two of Part Two. Equation (4.4) is augmented with regressors that measure the mean and variance of the

policy variable These variables are obtained from equation (4 8)[10]. The test equation is the following[11]:

$$DY = k_1 + w_{11}\,DBM + a_1(L)DY + a_2(L)DBM + a_3(L)DMM + a_4(L)DQT +$$
$$+ a_5(L)DR + \alpha_{11}\,ECT_1 + \alpha_{12}\,ECT_2 + \alpha_{13}\,ECT_3 +$$
$$+ m\,RES3 + p_1FITSQ + p_2RESQ + p_3FITRESQ + u_1 \quad (4\ 9)$$

where RES3 is a proxy for (conditional variance x residuals), FITSQ is the squared fitted value of DNBRX, RESQ is the proxy of conditional variance, and FITRESQ = (fitted values x RESQ).

The null hypothesis of superexogeneity, H_0: $p_1 = p_2 = p_3 = 0$, is rejected at the five percent significance level (p-value = 0.044). If the interpretation of Engle et al. (1983) is accepted, this result does not support the hypothesis that base money causes output. If a true causal connection running from outside money to output does not exist, then base money cannot qualify as an appropriate policy variable.

The main question in this Part surrounds the nature of several key short run relationships. The nature of these relationships is assessed by means of innovation accounting, based on the estimated model of equations (4 4)-(4.8).

Before innovation accounting is performed, a proper identification of the structural innovations is required. In the reduced form of equations (4 4)-(4.8), the error terms (u's)are linear combinations of the underlying structural innovations. The

[10] White's (1980) heteroskedasticity test on the residuals of equation (4 8) fails to reject the null hypothesis (p-value = 0 43) This result allows the conditional variance of BM to be approximated by the squared residuals of BM equation (Charemza and Deadman, 1987, p 240)
[11] CUSUM and CUSUM of squares tests (Brown et al, 1975) show that both equations (4 4) and (4 8) exhibit satisfactory parameter stability over the sample period Therefore, hypothesis testing in equation (4 9) is valid

procedure suggested by Sims (1986) and Bernake (1986) is used to recover the structural innovations.

The relationship between the reduced-form and the structural innovations is given by:

$$u_t = \Lambda^{-1} v_t \tag{4.10}$$

where u_t is the (5x1) vector of reduced-form innovations in equations (4.4)-(4.8), v_t is the (5x1) vector of the structural innovations, and Λ is a (5x5) matrix of the contemporaneous relationships between the variables of interest. Unlike u's, the v's are assumed to be uncorrelated (orthogonal) across equations, representing genuine structural shocks.

As pointed out by Sims (1980b), any a priori structure imposed on a simultaneous equations system is debatable and may involve "incredible restrictions". Therefore, it is worth emphasizing that in modeling the matrix Λ (equations 4.11-4.15 below) the *a priori* considerations were employed mainly to select candidate structures, whereas the final choice is made based on testing restrictions[12]. The structure of matrix Λ, based on the results of these tests, is presented below[13].

[12] Some restrictions imposed on matrix Λ are consistent with previous results from weak exogeneity tests and SUR estimation Specifically, the innovations in BM are allowed to be correlated with innovations in endogenous variables if the estimated coefficients w_{i1} in equations (4 4)-(4 7) are statistically different from zero Alternative assumptions for additional restrictions were made, based on common theoretical insights regarding possible patterns of the contemporaneous correlations among structural innovations These possible patterns were subjected to tests of overidentifying restrictions This modeling strategy, made possible by the Sims-Bernake procedure, is not available when using the Choleski decomposition, the latter imposing a priori a rigid structure where the system is strictly identified.

[13] The alternative patterns were rejected at all conventional significance levels. If tests results showed that more than one structure is supported by data, then the selection of the final model would still require a priori judgement This is not the case here, since tests results rejected the alternative structures

$$u_{1t} = v_{1t} + \lambda_{13}v_{3t} + \lambda_{14}v_{4t} \quad (4.11)$$

$$u_{2t} = v_{2t} + \lambda_{25}v_{5t} \quad (4.12)$$

$$u_{3t} = \lambda_{31}v_{1t} + \lambda_{32}v_{2t} + v_{3t} + \lambda_{34}v_{4t} + \lambda_{35}v_{5t} \quad (4.13)$$

$$u_{4t} = \lambda_{42}v_{2t} + v_{4t} \quad (4.14)$$

$$u_{5t} = \lambda_{52}v_{2t} + v_{5t} \quad (4.15)$$

where λ_{ij} is the row *i*, column *j* element of Λ.

Equation (4.11) shows that innovations in output are correlated within the quarter with money multiplier and interest rate innovations[14]. This result is consistent with most theoretical frameworks Equation (4 12) implies that innovations in QT and base money are contemporaneously correlated[15], as implied by the theoretical hypothesis tested here. Innovations in the money multiplier (equation 4.13) are contemporaneously correlated with innovations in all other variables[16]. This suggests, in agreement with most theories, that the money multiplier is 'the most endogenous' variable in the set. The interest rate shocks (equation 4.14) are contemporaneously correlated with innovations in QT ratio[17]. The interpretation of this equation is not very clear, but alternative restrictions were rejected by the tests. A reasonable interpretation is that the portfolio redistribution reflected by changes in QT alters the conditions on the loanable funds market and thus induce interest rate fluctuations. Finally, equation (4.15) shows that the innovations in base money and QT are correlated, consistent with our

[14] Although BM is exogenous for the output equation, the coefficient w_{11} in equation (4 4) is not statistically significant at 5 percent (p-value 0 551)
[15] The coefficient w_{21} in equation (4 5) is statistically significant at 5 percent (p-value = 0 000)
[16] The coefficient of the weakly exogenous variable in equation (4 6), w_{31}, is statistically significant (p-value = 0 000)
[17] In equation (4 7), the coefficient of BM, w_{41}, is not significant (p-value = 0 149)

theoretical hypothesis

Matrix Λ includes 11 restrictions and therefore one overidentifying restriction[18]. A likelihood ratio test of the null hypothesis that the restrictions are valid was performed The p-value obtained is 0.724, showing that the structure imposed on the model is strongly supported by the data over the sample period. The results of innovation accounting, based on the above identification of the structural innovations, are presented next.

At this point, it is important to remind the reader that the remainder of the discussion is focused on short-run dynamics *and all variables are specified in first differences*. To smooth the exposition, the variables will continue to be referred to as output, outside money, the money multiplier, the interest rate, and QT. However, Y, BM, and MM should be interpreted as growth rates, R as change in the interest rate, and QT as change in the ratio of quasi-money to transactions deposits.

The IRFs describe the behavior of variables of interest over time, following a one standard deviation shock to one of these variables. The theoretical hypothesis tested here is that fluctuations in output are accompanied by changes of the same sign in to the ratio of quasi-money to transactions deposits (QT). In terms of first differences, increases in QT would in turn be associated with decreases in base money and increases in the money multiplier. Six relevant relationships are involved in this hypothesis. (1) Y-BM, (2) BM-MM, (3), MM-Y, (4) Y-QT, (5) QT-MM, (6) QT-BM. The hypothesis implies that the relationships (1), (2), and (6) are negative, whereas (3), (4), and (5) are

[18] For exact identification, only n(n-1)/2 restrictions are necessary, i e 10 restrictions in our model.

positive. To assess the signs of these relationships in the context of the proposed explanation, the IRFs generated by innovations in base money and output are calculated and presented in Figures 4.1 and 4 2.

The effects of portfolio redistributions on monetary dynamics should be reflected by the interactions between BM, QT, and MM. Both portfolio redistributions and the money multiplier can be affected by various factors, not all of them necessarily related to base money changes. However, to test the predictions of the theoretical hypothesis formulated in this study, it is necessary to assess the nature of changes in QT and MM in the presence of shocks to BM. The IRFs generated by an innovation in BM are therefore calculated. Figure 4.1 shows that movements in BM are indeed negatively related with those in QT and MM, as our hypothesis predicts. Recall that the preliminary evidence presented in Section 2.4 (Table 4.1) indicates negative correlations between BM, on one hand, and QT and MM, on the other hand. The cross-correlations, however, associate fluctuations of BM, QT, and MM that are the net effects of *all* factors affecting these variables. In contrast, the IRF results pictured in Figure 4.1 show that QT and MM are negatively associated with a positive innovation in BM, *given zero innovations in any other variable except BM.* While cross-correlations found are consistent with the hypothesis under investigation, the IRFs provide a direct and more meaningful test of the predicted relationships. Together, these results support the hypothesis that portfolio redistributions imply a short run negative relationship between outside money and the money multiplier.

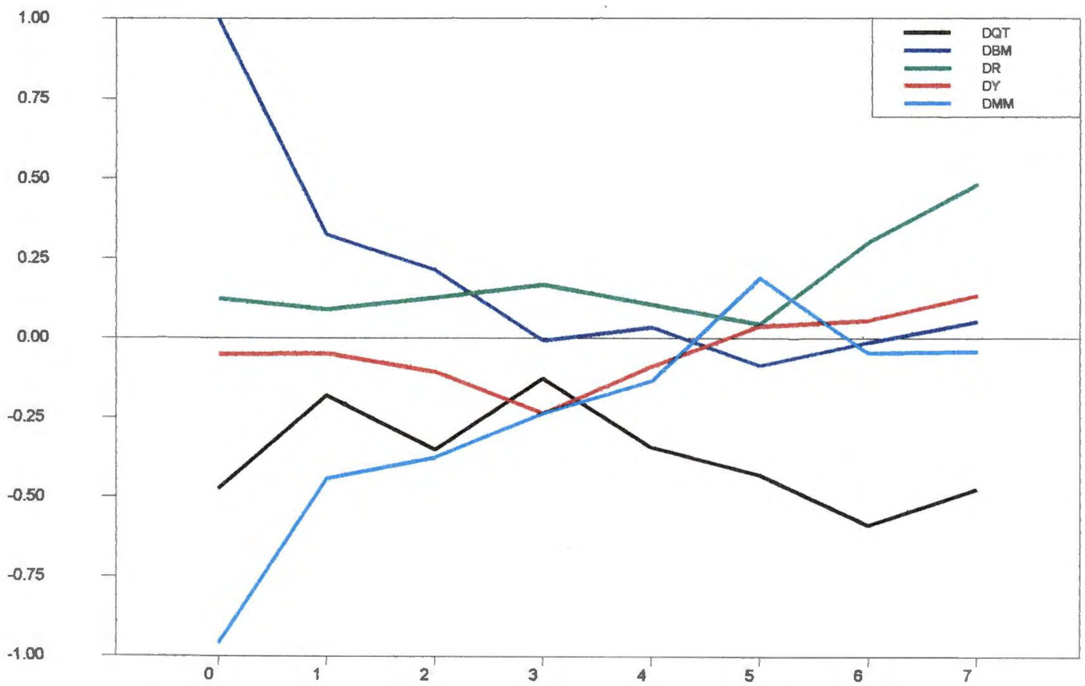

Figure 4.1: Part Four - Responses to a One Standard Deviation Shock to Base Money Changes

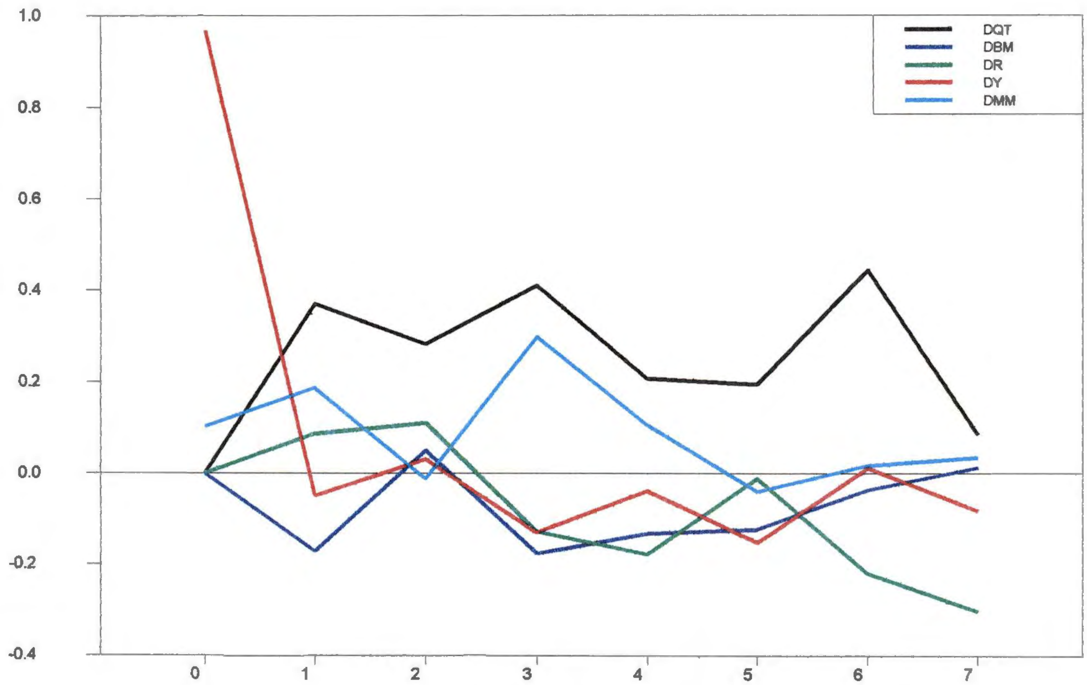

Figure 4.2: Part Four – Responses to a One Standard Deviation Shock to Output Changes

The theoretical hypothesis associates portfolio redistributions with output fluctuations. Examination of the hypothesis that QT fluctuations are pro-cyclical requires therefore that the relationships (1)-(6) be assessed in the presence of a shock to output. Figure 4.2 presents the IRFs that describe the behavior of BM, QT, MM, and R, following a one-standard-deviation innovation in output. These IRFs are relevant whether the sequence of events starts with an innovation in actual output, or in expected (or planned) output[19].

Figure 4.2 shows that a positive innovation in output corresponds to increases in QT. This result provides direct evidence supporting the prediction of pro-cyclical behavior of QT. In fact, all IRFs in Figure 4.2 are consistent with the predictions of the proposed scenario [20]. An innovation in output is followed by a decrease in the growth rate of base money and an increase in the growth rate of the money multiplier, confirming the patterns described in Figure 4.1. In addition, output and the interest rate are initially positively associated. This result may reflect the fact that, in an expanding economy, the demand for loanable funds increases, driving up the interest rate. Overall, the IRF results here are consistent with the theoretical hypothesis formulated in this

[19] It is true that the expectations and the intentions cannot be directly observed. However, if the expectations are rational, then actual output can be used as a proxy for the expected output. Similarly, if the actions of the private sector lead, in general, to the intended results, then actual output can be used as a proxy for the planned output.

[20] The reader may be used to see smoother IRFs, as they appear in most studies that derive the IRFs from VARs in levels. These procedures do not distinguish between short-run and long-run dynamics. The presence of the long-run relationships, relatively stable as compared to the short-run fluctuations, smoothes out the path of variables. IRFs presented here are based only on the short-run coefficients of a VECM, thus properly reflecting the short-run dynamics. This very feature also explains the relatively erratic behavior of IRFs from a VECM. For an illustrative comparison, see Figures 2.1 and 2.5 in Part Two, that depict IRFs obtained from a VECM and, respectively, a VAR in levels, using the same data set.

study These results corroborate the evidence from cross-correlations (Table 4.1), indicating that all six key relationships have the predicted signs.

Forecast error variance decomposition (FEVD) measures the proportion of the variation in a variable explained by innovations in the other variables of the system. The FEVDs based on the estimated model are presented in Tables 4.2-4.6. Some general patterns are noticeable. Output and the interest rate are explained primarily by own innovations. Relatively strong interactions between outside money, QT, and the money multiplier can be detected. The explanatory power of Y and R for BM, QT, and MM is relatively low, with some exceptions noted below. These patterns suggest that the interactions between the real and monetary variables are rather weak.

Focusing first on the FEVD for output (Table 4.2), notice that output variations are explained to a large extent by own innovations. Concerning base money and output interactions, recall that, in Part Two, innovations in base money were found to explain a large proportion of output variation. Under the specification employed here, where the QT ratio is included as a relevant variable, the explanatory power of base money for output drops significantly, to a maximum of 5 percent at the 8-quarter horizon. A similar percentage of output variation is explained by the money multiplier; in this case, the result is consistent with the explanatory power of MM for Y found in both Part Two and Part Three. Overall, the findings summarized in Table 4.2 provide little support for the theories assuming substantial effects of changes in monetary variables on output.

Another interesting observation is that changes in base money and the QT ratio

Table 4 2 Part Four - FEVD for DY

FH	DQT	DBM	DR	DY	DMM
1	0 58	0 51	5 37	92 99	0 54
2	0 64	0 93	7 54	90 28	0 61
3	1 58	0 96	7 32	85.71	4 43
4	5 57	1 79	6 87	80.93	4 84
5	7 10	4 26	6 50	76 79	5 34
6	7 06	4 35	8 26	75 11	5 23
7	7 22	4 28	10 31	73 01	5 18
8	7 67	5 13	11 88	70 29	5 02

Table 4 3 Part Four - FEVD for DBM

FH	DQT	DBM	DR	DY	DMM
1	89 74	10 26	0 00	0 00	0 00
2	86 51	9 03	1 06	2 23	1 17
3	83 73	9 50	3 39	2 29	1 10
4	80.76	9 70	3.51	4 70	1 33
5	74 77	9 08	4 61	5 96	5 57
6	70 58	8 65	8 94	6 57	5 26
7	65 73	8 13	15.00	6 21	4 93
8	59 55	7 34	20 32	5 61	7 18

Table 4 4 Part Four - FEVD for DQT

FH	DQT	DBM	DR	DY	DMM
1	2.02	97 98	0 00	0 00	0.00
2	1 49	90.20	0 13	8 17	0 00
3	2 02	87 76	0 10	9 59	0 53
4	1 80	83.14	1 19	12.92	0 94
5	2 63	78 34	1 36	12 58	5 09
6	3 50	75 64	1 19	11 60	8 07
7	5 71	71 02	1.02	13 53	8 72
8	6 35	66 67	2 63	11 78	12.57

Table 4 5 Part Four - FEVD for DMM

FH	DQT	DBM	DR	DY	DMM
1	31.90	26.50	0 76	1 48	39 36
2	29 67	24 90	6 37	2 99	36 07
3	30 48	26 67	5 88	2 75	34 22
4	28.55	27.49	5.88	5.75	32.33
5	27.92	27 68	5 76	6 05	32 59
6	28.57	27 02	6 52	5 94	31.94
7	28.22	27 03	6 87	5 89	31.99
8	26 09	25.21	8 14	5.58	34 98

Table 4 6 Part Four - FEVD for DR

FH	DQT	DBM	DR	DY	DMM
1	0 20	7 46	92 34	0 00	0 00
2	0.51	7 05	90 81	0 51	1.12
3	1 27	7 24	84 89	1 72	4 87
4	1 35	12 69	70 48	1 98	13 51
5	1 15	16.59	67 41	3 29	11.56
6	1 15	15.41	69 63	3 06	10 74
7	2 05	20 30	63 25	3 93	10 47
8	4 44	29.32	51 75	5 79	8 70

Note.

Y = output, R = the interest rate, QT = the ratio of quasi-money to transactions deposits, MM = the money multiplier, BM = base money. D denotes first differences and FH = forecast horizon

Each row shows, for the forecast horizon indicated in the first column, the proportion of the variance in the variable at the top of the table explained by the innovations in column variables The row numbers sum up to 100 (save for rounding errors)

explain substantially each other's variations (see Tables 4.3 and 4.4). Each variable is better explained by the other, rather than by its own innovations. This is an uncommon pattern for FEVD results. The most plausible interpretation of this result seems to be that the interactions between BM and QT are indeed very strong and/or their fluctuations are synchronized[21]. Notice that this strong interaction between BM and QT is consistent with our hypothesis that portfolio redistributions within M2 are closely associated with base money fluctuations. Also consistent with the proposed scenario is the finding that innovations in Y explain a relatively significant proportion of QT variation, especially after three quarters (12-13 percent). At the 8-quarter horizon, money multiplier innovations explain 13 percent of QT variation. Output and the money multiplier explain relatively small proportions (up to seven percent) of outside money variation. After six quarters, interest rate innovations become important for outside money, their explanatory power reaching 20 percent at the 8-quarter horizon.

Additional evidence supporting an apparent close interaction between BM, QT, and MM is provided by the explanatory power of outside money and QT ratio for the money multiplier variations (Table 4.5). Both BM and QT explain MM in proportions exceeding 25 percent at any horizon. Comparatively, the proportions explained by the interest rate and output variations are rather small, not exceeding 8 percent and, respectively, 6 percent at any horizon.

[21] A similar pattern was found in Part Three between the fluctuations in the policy variable NBRX (i e the proportion of non-borrowed reserves in total reserves of the banking system) and total reserves (TOTR). As in case of BM and QT, NBRX and TOTR are closely related to one another, and their fluctuations are clearly synchronized

Finally, Table 4 6 shows that the interest rate variation is explained substantially by own innovations at short horizons At horizons exceeding three quarters, however, outside money takes on rising importance in explaining interest rate movements (up to 29 percent) This result is expected, since changes in base money are related to the interest rate via the effects of total reserves fluctuations on the federal funds market.

Overall, the results from innovation accounting provide convincing evidence supporting the theoretical hypothesis under investigation Portfolio redistributions appear to be relevant in explaining the pattern of short run monetary dynamics. The pro-cyclical behavior of the quasi-money to transactions deposits ratio provides a coherent interpretation of co-movements of monetary variables and output.

This study proposes a new theoretical interpretation of the short run macro dynamics. Some empirical findings consistent with this hypothesis are also new in the literature. These findings include the negative short run relationships between outside money and output, between outside money and the money multiplier, and between the ratio of quasi-money to transactions deposits (QT) and outside money, as well as the positive relationship between QT and output.

The majority of empirical studies in the existing literature have neglected the decomposition outside money-inside money emphasized here. Thus, there are few studies against which results here can be compared. The few studies that accounted for this decomposition, such as Manchester (1989) and Cagan (1993), did not use the most appropriate econometric procedures. Manchester (1989) used a standard VAR in first differences, which is known to imply a mis-specification of the model when variables of interest are cointegrated. In addition, Manchester used the Choleski identification of

structural disturbances, which assumes rigid causal patterns. Cagan (1993) analyzed the relationships between output, outside money, and the money multiplier in a simple regression framework, where the simultaneity bias is neglected. These drawbacks are circumvented in this study, where the analysis is carried out in a multivariate, VECM framework, where the structural innovations are identified using a Sims-Bernake decomposition.

With the caveat that the relevance of comparisons is limited by differences in the methodology of analysis, some of the results here can be confronted with the evidence provided elsewhere. The low explanatory power (up to five percent) of both base money and the money multiplier for output, found here, is broadly consistent with the results of Sims (1980), Litterman and Weiss (1985), Friedman and Kuttner (1993), and Thoma (1994). The results of these studies, that measure money as the aggregate M1 or M2, show that money innovations explain a small proportion of output variations. Manchester (1989), finds that base money innovations explain 10 percent of output variation, a higher percentage than found here. She also found that the explanatory power of the money multiplier for output is higher than that of the base money. In this respect, the evidence provided in this study is closer to Cagan's (1993) results, that show similar effects of base money and the money multiplier on output. It is worth noticing an interesting result presented in Manchester's study, namely the strong negative correlation found between the innovations in base money and the money multiplier. That result is consistent with the same negative relationship found here Unfortunately, the study omits any interpretation of that finding.

As a general assessment, the empirical findings here are broadly confirming the results of those previous studies that found weak effects of money on output. The next chapter provides a summary and a concluding interpretation of all empirical results presented here.

Chapter Five

Interpretation

The investigation in Part Four provides empirical evidence for a theoretical hypothesis that explains the pattern of the short run dynamics of output, outside money, and the money multiplier The investigation is based on U.S. data for the period 1960.1-1997.4. The hypothesis under investigation is consistent with the results in Part Two. It was found there that the short run relationships outside money-output and outside money-money multiplier are negative, and the relationship output-money multiplier is positive.

While the latter relationship is widely confirmed in the literature, the first two are previously undocumented. The hypothesis formulated here to explain this pattern assumes that fluctuations in output are positively associated with changes in the ratio of quasi-money to transactions deposits of the banking system (QT). These changes reflect portfolio redistributions among the monetary assets included in the aggregate M2. Specifically, they imply that, when output increases (decreases) private agents increase (decrease) the share of their holdings of non-M1 (or quasi-money) assets and, correspondingly, decrease (increase) the share of their holdings of M1 assets This scenario generates predictions about the signs of six relevant relationships among *changes* in output (Y), outside money (BM), the money multiplier (MM), and the QT ratio. These relationships, with the predicted sign indicated in brackets, are the following. (1) Y-BM [-], (2) BM-MM [-], (3), MM-Y [+], (4) Y-QT [+], (5) QT-MM [+], (6) QT-BM [-].

The empirical findings confirm the predictions of the proposed scenario. Supporting evidence was provided by two alternative econometric procedures Preliminary analysis (Table 4.1) examined the cross-correlations among changes in Y, BM, MM, and QT at 4 lags, contemporaneously, and 4 leads. The predicted signs clearly dominate the cross-correlations for the whole sample (1960.1-1997.4), as well as for the sub-samples 1960.1-1979.4, 1985.1-1997.4, and 1975.1-1997.4

In the main analysis, based on a VECM framework, the signs of the relationships (1)-(6) are provided by impulse response functions. Both IRFs generated by innovations in outside money (Figure 4.1) and those generated by innovations in output (Figure 4.2) depict dynamic relationships that exhibit the predicted signs.

It is worth emphasizing that the cross-correlations and the IRFs do not provide identical information. The cross-correlations describe comovements between the variables of interest. IRFs describe the behavior over time of a variable, following a one-time shock to another variable, and assuming zero innovations in all other variables. It is possible that cross-correlations and IRFs exhibit different signs for the same generic relationship. However, the results obtained here confirm the predicted signs for the relationships (1)-(6) at both informational levels. These results provide corroborative evidence for the hypothesis tested. This aspect is particularly important for those results that were not previously documented. Specifically, the negative relationships between output and base money and between base money and the money multiplier may appear counter-intuitive. However, the IRF results, derived from a specifically structured model, are confirmed by simple cross-correlations. This fact shows that the overall results are not model specific and supports their reliability.

Forecast error-variance decomposition was employed to assess the magnitude of the interactions between the variables of interest. The FEVD results provide further support for the proposed scenario, which assumes significant interactions between QT, BM, and MM. Specifically, it was found that QT and BM substantially explain each other, and that innovations in both BM and QT explain significant proportions of the money multiplier variation.

A prime objective of the entire study is to assess the mutual interactions between the monetary variables and output. The FEVD results of this Part suggest rather weak connections between money and output. The explanatory power of both outside money and money multiplier innovations for output variation is relatively low, not exceeding five percent at any horizon within two years. The innovations in output also explain modest proportions of base money variation (up to seven percent) and the money multiplier variation (up to six percent)

To what extent can these results be interpreted in causal terms? In general, the existing literature reflects skepticism regarding the possibility of direct empirical tests for genuine causality. Likewise, the findings of this study do not warrant strong conclusions about genuine causal connections. However, the competing theories of business cycles are based on strong causal assumptions. How can the empirical results be brought to bear in solving theoretical controversies? The approach taken in this study is that conclusions about causality may only be formulated in terms of *consistency or otherwise* of a priori causal assumptions with the empirical evidence. In other words, causal hypotheses cannot be firmly confirmed or rejected, but the empirical evidence may be more consistent with some causal assumptions than with others.

This approach can be illustrated when assessing the FEVD results. For instance, finding that base money innovations explain a relatively high proportion of output variations would be consistent with, but would not directly confirm, the hypothesis that base money causes output Conversely, a low explanatory power of base money for output is more consistent with lack of causality from money to output, while not necessarily warranting this conclusion. The latter case, however, allows more useful *practical* conclusions than the former. Specifically, even if genuine causality from base money to output does exist, low explanatory power of money for output means that the effects of money on output are not economically significant. In light of these considerations, the results here provide little support for the monetary theories that assume relatively strong short-run effects of money on output

The RBC theory, while agreeing that base money does not have relevant effects on output, predicts substantial effects caused by (expected) output on inside money (the money multiplier). The monetary theories also acknowledge a positive relationship between output and inside money, assuming that the causation runs from money to output or, alternatively, both ways. Both theories seem to imply that the relationship between output and the money multiplier is strong. However, this hypothesis has not been previously subjected to extensive empirical testing. As noted repeatedly in this study, the decomposition "outside money-inside money" has largely been neglected by previous empirical studies. This study does utilize the decomposition of the money stock into outside money and inside money (captured by the money multiplier) .The results here confirm the positive sign of the relationship between output an the money

multiplier However, results indicate that direct causal effects between Y and MM, *if any*, are unlikely to be of significant magnitude.

As reflected in most theoretical controversies, three possible causal patterns between money and output are commonly given consideration: (a) Y⇒ M, (b) M ⇒ Y, and (c) Y ⇔ M. However, these alternatives are not collectively exhaustive. What is left out most of the time is the logical possibility of no direct causal connection between output and money. A priori, it is perfectly possible that the correlated fluctuations of money and output are the common effects of third factors. In fact, the empirical evidence provided in this study seems more consistent with this final alternative, rather than with any of the possibilities (a) – (c). The possibility that fluctuations in monetary variables and output are the effects of third factors is also consistent with (although not necessarily implied by) the theoretical hypothesis formulated here This hypothesis assumes that fluctuations of the QT ratio are pro-cyclical, but no assumptions are made about a direct causality between Y and QT.

The above considerations naturally raise the question: Which are those third factors that represent the common cause of output fluctuations and of the portfolio redistribution associated with changes in base money and the money multiplier? Three possible explanations of the pro-cyclical behavior of QT were suggested in Section 2.3. The factors explaining the changes in QT and affecting both outside money and the money multiplier may be the same as those causing changes in output. As explained in detail in Section 2 3, common causes of monetary and output fluctuations may include changes in preferences and intertemporal optimizing actions of households, firms, or commercial banks, as well as fiscal or productivity shocks. The possibilities of

including explicit measures of these fundamental factors in empirical investigations are very limited. Nevertheless, ignoring the potential direct effects of these factors on the variables explicitly included in analysis may lead to invalid conclusions.

One more finding of Part Four is worth mentioning. It was shown earlier that the economic literature provides little guidance regarding possible methods of direct empirical tests for genuine causality. One exception is represented by the study by Engle et al. (1983), where the authors suggest that superexogeneity "seems to satisfy the requirement for causality," if one accepts Zellner's (1979) definition of causality as "predictability according to a law." Under this interpretation, if base money is superexogenous for output, then base money causes output. Following this suggestion, superexogeneity of base money was tested here. It was found that the evidence in favor of base money superexogeneity is weak[1]. The implication of this result is consistent with the possibility suggested earlier, that the short run co-movements of outside money and output may not reflect direct causal relationships between BM and Y. However, the conclusion based on the superexogeneity test is only tentative, since the suggestion of Engle et al (1983) was not subjected to extensive scrutiny in the literature.

The empirical evidence provided in Part Four supports the hypothesis that fluctuations in the ratio of quasi-money to transactions deposits are pro-cyclical. The portfolio redistributions among the monetary assets explain the negative short run relationships between outside money, on one hand, and output and the money multiplier, on the other hand. The evidence further suggests that the interactions

[1] The null hypothesis of superexogeneity is rejected at 10 and 5 percent significance levels, while accepted at 1 percent (p-value = 0 044)

between monetary variables and output are rather weak. This conclusion is consistent with a pattern of causal relationships where fluctuations in output and money are the common effects of third factors, such as changes in private sector's preferences and real demand or productivity shocks. The conclusions of the investigation are summarized in the next chapter.

Chapter Six

Conclusions

Part Four completes the investigation of the relationships between the monetary and the real sector of the economy, undertaken in this study Here, a theoretical hypothesis is formulated. The hypothesis assumes an important role for portfolio redistribution in explaining the patterns of monetary dynamics. Further assumptions are made about the pattern of portfolio redistributions in relation to output fluctuations. An important goal of the empirical investigation is to test the predictions of the hypothesis. A second important objective is to assess the quantitative importance of the interactions between the monetary variables and output These interactions are investigated for the U.S. economy over the period 1960 1-1997.4. The variables of interest are output (Y), base money (BM), the money multiplier (MM), the ratio of quasi-money to transactions deposits in the banking system (QT), and the interest rate (R).

It is argued that a pro-cyclical behavior of QT can generate observable negative relationships between the growth rates of Y and BM and between the growth rates of BM and MM. This pattern may be explained by two facts. First, the required reserves ratio for transactions deposits is higher than the required reserves ratio for quasi-money deposits. Second, the opportunity cost of holding excess reserves is particularly high for the banks in an expanding economy Given these facts, when the private sector substitutes quasi-money assets for transactions deposits, required reserves for transactions deposits are replaced by excess reserves. However, excess reserves are costly and are therefore promptly reduced by banks, which increase lending If these

processes are recurrent over the business cycle, then decreases in the growth rates of total reserves and base money should be associated with increases in the growth rate of the money multiplier.

The hypothesis formulated above generates predictions regarding the signs of six short run relationships. Analyzed in terms of first differences, these relationships, with the predicted sign indicated in brackets, are the following: (1) Y-BM [-], (2) BM-MM [-], (3), MM-Y [+], (4) Y-QT [+], (5) QT-MM [+], (6) QT-BM [-].

Empirical evidence for the assessment of the signs of the relationships (1)-(6) was provided by two independent analytical methods. First, lag, contemporaneous, and lead cross-correlations between changes in Y, BM, MM, and Q were calculated. The core of the investigation is represented by the second method, where the analysis is carried out with a vector-error correction model (VECM). Based on the short run coefficients of the model, impulse response functions (IRFs) and forecast error-variance decompositions (FEVDs) were calculated. Results from IRFs are relevant for the sign of the relationships of interest. FEVDs offer a quantitative assessment of the interactions between variables.

The results of the investigation suggest that the empirical evidence is consistent with the proposed explanation of the short run interactions between output and the monetary variables The findings show that the relationships (1)-(6) exhibit the predicted sign over the sample period. Supporting evidence is provided by both cross-correlations and IRFs. Cross-correlations provide information about the sign and the degree of association between changes in two variables These changes are the net result of *all* shocks to the factors affecting the two variables. IRFs, on the other hand, describe

the behavior over time of a variable, when a one-time shock to *one* particular variable occurs. Thus, the evidence here comes from alternative methods that generate results with different informational content. The fact that both methods confirm the predicted signs provides convincing evidence supporting the assumptions about the nature of the generic relationships (1)-(6)

The results from FEVDs offer additional support for the significant interactions assumed to exist between BM, QT, and MM. This is illustrated by the findings that the innovations in base money and QT substantially explain each other' variations, and that innovations in base money and QT have substantial explanatory power for the money multiplier variation.

The FEVD results further suggest that the interactions between output and money are rather weak Overall, the findings of this essay provide little support for the existence of strong direct causal relationships between money and output. Some corroborating evidence for lack of causality running from base money to output is offered by the result of the superexogenity test.

Placing the issue of the direction of causality between money and output at the heart of macroeconomic debates, the contemporary schools of thought devote substantial efforts to provide arguments that either money causes output, or output causes money, or the causation is mutual. In the heat of the debate, the logical possibility that direct causal connections between money and output may be weak, or even not exist, is often ignored The findings of this investigation suggest that the empirical evidence is consistent with the latter possibility rather than with any other alternative. The co-movements of output and money over the business cycles may well

represent the common effects of third factors. Three possible scenarios of this type were suggested here. According to these scenarios, the fluctuations in money and output may be generated, alternatively, by adjustments in the private sector (households, firms, or commercial banks), or by fiscal or technology shocks. The assessment of these explanations requires further empirical investigation, indicating possible extensions of this research.

Two particularly interesting results were found in this study. First, the short run movements in output and base money, as well as those in base money and the money multiplier, are negatively associated. Second, portfolio redistributions among the M2 assets seem to play an important role in explaining these patterns. Similar findings were not previously documented in the literature. Such results could not have been obtained without an explicit distinction between outside money and inside money. Largely neglected by previous empirical studies, this distinction represents a central focus in this study. The results here warn against the common procedure to analyze macroeconomic relationships treating money as a homogenous aggregate. Earlier studies overlooked the important interactions revealed by the analytic approach adopted in this study. These results point to the important contribution brought by this dissertation to the empirical literature on the short run interactions between money and output.

Another important contribution of this study is theoretical. A new interpretation of the dynamics of the monetary variables and output was proposed here. This interpretation points to the potential importance of portfolio redistributions among monetary assets in explaining the pattern of co-movements of money stock components and output. Comparing the results in Part Two and Part Four illustrates the point. A

model that neglects portfolio redistributions (as in Part Two and in the existing literature) assigns to outside money innovations strong explanatory power for output. In contrast, a model that properly accounts for portfolio redistributions (as in Part Four) finds that outside money explains very little of output fluctuations. These contrasting results resemble the findings of Sims (1972, 1980), who found that the inclusion of the interest rate in a VAR substantially reduces the explanatory power of money for output. Sims' findings confirmed that the interest rate is a relevant variable for macroeconomic models. The results here suggest that theoretical and empirical macroeconomic modeling may avoid misleading oversimplifications by explicitly assessing the implications of portfolio redistributions.

REFERENCES

Bernake, B (1986),'Alternative explanations of money-income correlation', *Carnegie-Rochester Conference Series on Public Policy* 25

Brown, R.L , Durbin, J., and Evans, J.M. (1975),'Techniques for Testing the Constancy of Regression Relationships Over Time', *Journal of the Royal Statistical Society*, Series B, 37

Cagan, P. (1993), 'Does endogeneity of money disprove monetary effects on economic activity?', *Journal of Macroeconomics*, Summer, vol. 15, No.3.

Charemza, W.W. and Deadman, D.F. (1997), *New directions in econometric practice*, 2nd ed., Edward Elgar.

Dickey, D. and Fuller, W.A. (1981), 'Likelihood ratio statistics for autoregressive time series with a unit root, *Econometrica* 49.

Enders, W. (1995), *Applied econometric time series*, John Wiley & Sons, Inc.

Engle, R.F. and Hendry, D.F (1993),'Testing superexogeneity and invariance in regression models', *Journal of Econometrics* 56.

Engle, R.F., Hendry, D.F., and Richard, J.-F. (1983),'Exogeneity', *Econometrica* 51.

Freeman S. and Huffman, W. (1991), 'Inside money, output, and causality', *International Economic Review*, vol.32, No.3.

Friedman, B.M., and Kuttner, K.N. (1993), another look at the evidence on money-output causality', *Journal of Econometrics*, May-June.

Gauger, J. (1992), 'Portfolio redistributions effects within narrow monetary aggregate', *Journal of Money, Credit, and Banking*, May.

Gurley, J.G. and Shaw, E.S. (1960), *Money in a theory of finance*, Washington: The Brookings Institution.

Harris, R.D. (1995), *Using cointegration analysis in econometric modeling*, Prentice Hall/Harvester Wheatsheaf.

Hetzel, R., and Mehra, Y. (1989), 'The behavior of money demand in the 1980s', *Journal of Money, Credit, and Banking* 21, November.

Johansen, S. (1988),'Statistical analysis of cointegration vectors', *Journal of Economic Dynamics and Control*, 12.

Johansen, S (1992),'Identifying restrictions of linear equations', Institute of Mathematical Statistics, University of Copenhagen.

Johansen, S. and Juselius, K (1992),'Testing structural hypotheses in a multivariate cointegration analysis of the PPP and the UIP for UK', *Journal of Econometrics* 53.

Johansen, S and Juselius, K (1994),'Identification of the long-run and the short-run structure: an application to the ISLM model', *Journal of Econometrics* 63.

King, R.G., and Plosser, C.I. (1984), Money, credit, and prices in a Real Business Cycle', *American Economic Review*, June.

Litterman, R. and Weiss, L (1985), 'Money, real interest rates, and output: a reinterpretation of US postwar data', *Econometrica* 53.

Manchester, J. (1989), 'How money affects real output', *Journal of Money, Credit, and Banking*, Vol.21, No.1 (February).

Moore, G., Porter, R D., and Small, D. (1988), 'Modeling the disaggregated demands for M2 and M1 in the 1980s: the U.S. experience', Unpublished working paper, Board of Governors of the Federal Reserve System, December.

Patinkin, D. (1965*), Money, interest, and prices: an integration of monetary and value theory*, 2nd ed., New York: Harper and Row.

Plosser, C.I. (1989),'Understanding business cycles', *Journal of Economic Perspectives*, Summer.

Rao, BB.(ed.), (1994), *Cointegration for the applied economist*, Macmillan Press Ltd., Basingstoke.

Sims, C (1972), 'Money, income, and causality', *American Economic Review* 62 (September).

Sims, C. (1980),'Comparison of interwar and postwar cycles: Monetarism reconsidered', *American Economic Review* 70 (May).

Sims, C (1980b), 'Macroeconomics and Reality', *Econometrica* 48.

Sims, C. (1986), 'Are forecasting models usable for policy analysis?', *Quarterly Review*, Federal Reserve Bank of Minneapolis, Winter.

Thoma, M.A. (1994), 'Subsample instability and asymmetries in money-income causality', *Journal of Econometrics*, 64.

Zellner, A. (1979), 'Causality and econometrics', in Brunner, K and Meltzer, A.H. (eds), *Three Aspects of Policy and Policymaking*, Amsterdam, North-Holland.

PART FIVE

GENERAL CONCLUSIONS

Chapter One

General Conclusions

This dissertation investigates the short run dynamic relationships between the monetary variables and output The nature of the short run monetary impacts on output represents the bone of contention in the long lasting debate between the competing business cycle theories. The main purpose of this study is to provide empirical evidence that is relevant for properly assessing the main positions of the competing theories. The investigation is based on U.S. data for the period 1960.1-1997.4.

Important methodological features distinguish the investigation here from previous studies devoted to the same topic This study carries out a multiple-step analysis of the relationships between the monetary and the real sector of the economy, based on two important analytical distinctions. These distinctions are well documented by theoretical studies, while largely neglected in the existing empirical literature. The first distinction, between outside money and inside money, points to the potentially heterogeneous nature of the interactions between these components of the money stock and output. Since outside money and inside money are generated by different processes, it is likely that their relationships with output are also different. The second distinction, between money and monetary policy, is motivated by the fact that changes in the money supply are, to a considerable extent, affected by factors beyond the control of the policy makers. The vast majority of empirical results in the existing literature are based on analyses that ignore the decomposition "outside money – inside money", and identify monetary policy actions as changes in some monetary aggregate.

These studies cannot generate reliable conclusions about the true nature of the interactions between the monetary variables and output. The investigation here incorporates these important distinctions, thus providing more comprehensive evidence on monetary and macroeconomic interactions.

Another distinctive feature of this study is the econometric modeling strategy adopted. One element of this strategy is a general-to-specific approach that reduces the number of a priori assumptions embedded in the empirical model. Further, cointegration analysis and vector error correction models are employed to allow focus on the short run dynamics of the variables of interest, as required by a proper assessment of business cycle theories. The exogenous or endogenous nature of the variables within the multivariate framework is established here by formal tests rather than *ad-hoc* assumptions. Finally, the structural shocks affecting the relevant variables are identified using the Sims-Bernake procedure, which avoids the rigid causal implications of the commonly used Choleski decomposition. None of the previous studies applied the same combination of procedures for similar purposes. Together, these features assure a proper analysis, avoiding the ambiguities implied by alternative methodologies

This modeling strategy is applied at each stage of the investigation, in Parts Two through Four of this dissertation Part Two focuses on the relationships between money and output, employing the relevant decomposition of the M2 money stock into outside money and inside money (measured as the money multiplier). In Part Three, the monetary policy actions are identified as changes in the proportion of non-borrowed reserves in the total reserves of the banking system This measure properly

describes "the degree of pressure on reserves", through which the Fed influences the process of money creation. Based on this identification, the effectiveness of *intentional* policy actions for output stabilization is assessed. Part Four completes the analysis of the interactions between money and output initiated in Part Two, and builds upon some key results obtained in both Part Two and Part Three. Specifically, these results reveal a particular pattern of the short run relationships between outside money, output, and the money multiplier. A theoretical interpretation of this pattern is formulated, and the consistency between the proposed interpretation and the empirical evidence is evaluated in Part Four.

The main results of the investigation, across Parts Two through Four, are obtained from impulse response functions (IRFs) and forecast error variance decompositions (FEVDs). IRFs provide information about the sign of the relationships between the variables of interest, whereas the FEVDs evaluate the proportions in which a variable is affected by shocks to other variables.

The results of primary interest for this investigation, obtained in Parts Two through Four, are briefly presented next. Their implications for the general conclusions of the study are discussed thereafter.

The analysis of the relationships between outside money, inside money, and output is carried out in Part Two, using a multivariate framework given by output, outside money, the money multiplier, the interest rate, and the inflation rate. The most interesting finding here is that the growth rate of outside money is negatively related to the growth rates of output and the money multiplier. As shown shortly, this uncommon finding is confirmed by subsequent analysis. The relationship between the

growth rates of the money multiplier and output is positive, but the mutual explanatory power of these variables is rather low. Further results in Part Two indicate that outside money innovations explain a substantial proportion of output variation for horizons within two years. It was also found that outside money is superexogenous for output, suggesting, in the interpretation of Engle et al. (1983), a causal relationship running from outside money to output. However, as subsequent evidence shows, the last two results no longer obtain when a new relevant variable is included in the analysis.

The analysis in Part Three includes output, the policy variable (given by the proportion of non-borrowed reserves in the total reserves of the banking system), the total reserves, the interest rate, and the money multiplier. An important goal of the investigation is to assess the effectiveness of the policy variable for output stabilization. The effectiveness of a policy instrument depends on the fulfillment of three conditions: controllability, superexogeneity, and predictability. Controllability implies that the intentional actions of the policy-makers represent the single most important factor affecting the policy variable. Superexogeneity of the instrument with respect to the target (here, output) requires that changes in the instrument variable do not alter the parameters of the process generating the target variable. Predictability implies that the changes in the instrument Granger-cause changes in the target. The very choice of the proportion of non-borrowed reserves in total reserves (NBRX) as the relevant policy variable, motivated in Part Two on theoretical grounds, implies that the controllability condition is fulfilled. The task of the empirical investigation is to test the fulfillment of the second and third conditions. The results indicate that NBRX is superexogenous for output. However, the policy variable does not Granger-cause

output, implying that the predictability condition is not fulfilled. Further results indicate that the policy shocks have a very low explanatory power for output fluctuations, not exceeding one percent for horizons within two years. The output and the money multiplier explain each other's variations in relatively low proportions, similar to those found in Part Two. Another result of interest is the negative relationship found between the growth rates of output and total bank reserves Since total reserves represent an important component of outside money, this finding is consistent with the negative relationship between outside money and output found in Part Two.

The negative relationships found here between the growth rates of outside money and output, outside money and the money multiplier, and total reserves and output, are not documented elsewhere in the literature. The monetary theories of business cycles assume positive effects of outside money on output, whereas the RBC theory assumes no regular relationship between outside money and output. In general, the interactions between outside money and the money multiplier are either ignored by theory, or assumed to be negligible. The relationship between total reserves and output is generally assumed to be positive. On the empirical front, previous studies neglect the decomposition of the money stock into outside and inside money, and/or employ less complete econometric procedures than those adopted here. For these reasons, the results here are not directly comparable with the existing literature.

A clear interpretation of these findings requires the formulation of some plausible scenario of economic events, consistent with the patterns revealed. Part Four presents such a hypothesis and subjects it to empirical testing. The hypothesis states

that the dynamic patterns found here for outside money, output, and the money multiplier obtain if output fluctuations are in general associated with portfolio redistributions within the monetary aggregate M2 Specifically, the proposed scenario implies that increases in the output growth rate are accompanied by increases in the ratio of quasi-money to transactions deposits of the banking system (denoted here as the QT ratio). The analysis in Part Four includes the variables output, outside money, the QT ratio, the interest rate, and the money multiplier. The results of the investigation provide supporting evidence for the proposed explanation. The IRF results indicate that the signs of the relationships between output, outside money, the money multiplier, and the QT ratio are consistent with the predictions of the hypothesis under investigation. Additional evidence regarding the signs of these relationships is provided by the contemporaneous, lead, and lag cross-correlations calculated for these variables. The results show that the predicted signs clearly dominate the pattern of cross-correlations, for the whole sample period as well as for three sub-samples. Further confirmation of the proposed scenario comes from the FEVD results, which indicate strong interactions between outside money, the QT ratio, and the money multiplier Overall, the results in Part Four provide convincing evidence that portfolio redistributions play an important role for short run monetary dynamics.

Another major objective of Part Four is to reassess the interactions between money and output under the new specification of the model, including QT as a relevant variable. The FEVDs for output and the money multiplier indicate low mutual explanatory power, similar to that found in Parts Two and Three. However, two results

here are notably different from those obtained in Part Two. First, the explanatory power of outside money for output drops substantially when the model includes the QT ratio. Innovations in the growth rate of outside money explain less than five percent of output growth variations, at horizons within two years. Second, the superexogenity test rejects the hypothesis that outside money is superexogenous for output, suggesting lack of causality from outside money to output.

The overall assessment of the findings in Parts Two through Four generates the main conclusions of this investigation. An important conclusion is the evaluation of the effectiveness of monetary policy for output stabilization. Further, the evidence allows a general assessment of the nature of the short run relationships between outside money, the money multiplier, and output. Finally, the overall results suggest a tentative conclusion regarding the possible causal patterns among the monetary variables and output.

The results of Part Three suggest that intentional monetary policy actions, reflected by the degree of pressure exerted by the Fed on bank reserves, cannot be effectively used for output stabilization. The evidence indicates that, since policy actions do not accurately predict output fluctuations, the desired policy results are unlikely to be achieved. Moreover, the actual effects of policy shocks (regardless of their predictability) on output are of very small magnitude.

The interactions between the money multiplier and output have the positive sign predicted by most theories However, the mutual explanatory power of these variables is low. This result, robust across all three models estimated in this study, is rather surprising, since both monetary and RBC theories assume relatively strong

interactions between inside money and output. These theoretical beliefs, however, are based on strong causal assumptions. A different causal pattern than assumed by either the monetary or the RBC theories, to be discussed shortly, is more consistent with the magnitude of the interactions between output and the money multiplier found here.

Among the most interesting findings of this study are the negative short-run relationships between the growth rates of outside money and output, and between those of outside money and the money multiplier. This pattern receives direct supporting evidence in Parts Two and Four, and is also consistent with the negative relationship between the growth rates of total reserves and output, found in Part Three The hypothesis formulated to explain this pattern, based on the assumption that the ratio of quasi-money to transactions deposits has a procyclical behavior, receives convincing empirical support in Part Four. Together, these results are particularly important, since they suggest that portfolio redistributions among monetary assets might play an important role in explaining the short run dynamics of monetary variables.

In general, little attention is paid in the literature to the effects of portfolio redistributions on monetary dynamics. The empirical studies that examine the interactions between money and output do not include among the relevant variables any measure of portfolio redistributions. The evidence provided in this dissertation suggests that failure to account for portfolio redistributions may significantly affect the empirical results and therefore lead to invalid conclusions. A comparison of some results in Parts Two and Four of this study illustrates the point. In Part Two, where portfolio redistribution is ignored, it was found that innovations in the growth rate of

outside money explain a substantial proportion (about 35 percent) of output growth variation. In Part Four, where portfolio redistributions are accounted for by changes in the QT ratio, the explanatory power of outside money for output drops below five percent[1]. This suggests that the absence of the QT ratio from the model in Part Two alters the dynamics of the system in a way that creates the appearance of strong associations between the fluctuations of outside money and output. These spurious relationships may affect the FEVD results and thus lead to invalid conclusions about the interactions between money and output.

The conclusion that the results in Part Four, regarding the explanatory power of outside money for output, are more reliable that those in Part Two is supported by the fact that the results in Part Four are consistent with the findings of Part Three. To see this, the relationship between policy actions and outside money ought to be taken into consideration. As argued in Part Two, the stock of outside money is largely affected by demand-driven factors, which are beyond the control of the policy makers. However, the argument does not imply that intentional monetary policy (genuine supply shocks) has almost no effects at all on outside money, an incredible assumption. It was found in Part Three that the explanatory power of policy shocks for output is very low (below one percent). If outside money innovations explain less than five percent of output variation, as found in Part Four, then the *implied* explanatory power of policy impacts on outside money would be in excess of 20 percent, a reasonable figure In contrast, if outside money explains more than 35 percent of

[1] The exclusion of the inflation rate from the analysis in Part Four cannot account for this change in results, since the evidence in Part Two shows that the explanatory power of inflation for any other

output variation, as found in Part Two, then it follows that monetary policy explains very little (roughly, less than three percent) of outside money fluctuations. Clearly, this is hardly plausible Therefore, the result of Part Two, where the implications of portfolio redistributions are not analyzed, is inconsistent with the findings of Part Three. Based on the results in Part Four, which properly account for the influence of portfolio redistributions on monetary dynamics, the conclusion of this study is that the explanatory power of outside money for output is low.

The findings of this dissertation offer valuable insights for the assessment of the main tenets of the competing business cycle theories. The positions of the competing theories regarding the relationship between money and output are based on strong causal assumptions. To assess these positions, it is therefore necessary to interpret the empirical evidence in causal terms. This type of interpretation, however, ought to be subjected to a caveat that is too often ignored in the concluding sections of many empirical studies. In general, it is doubtful that the genuine causal connections assumed by theories can be observed and tested empirically. As Cagan (1993) admits, "It is doubtful that full effects of money on [economic] activity can ever be proved conclusively by a formal statistical test"[2]. A large number of empirical studies draw

variable is extremely low Therefore, the exclusion of inflation from analysis does not involve any significant redistribution of its explanatory power to other relevant variables

[2] The concept of causality is frequently used in the economic literature as describing some type of objective connection between variables Philosophers are more skeptical about the objective existence of causality Immanuel Kant wrote in his *Critique of Pure Reason* (1952, p 77). "[ ] the objective relation of the successive phenomena remains quite undetermined by means of mere perception [ ] The conception which carries with it a necessity of synthetical unity [ ] is the conception of 'the relation of cause and effect'[ ] It follows that it is only because we subject the sequence of phenomena, and consequently all change, to the law of causality, that experience itself, that is, empirical cognition of phenomena, becomes possible" In this view, the law of causality is just the way our mind organizes the perceived phenomena If Kant is right, then empirical testing of causality may not make any sense at all

causal conclusions based on Granger-causality tests. However, as Cooley and LeRoy (1985) convincingly proved, Granger-causality implies nothing more than predictability Suggestions about tests for genuine causality are extremely scarce in the literature. A notable exception is the study of Engle et al. (1983) that suggests the use of superexogeneity tests as tests for causality. Such tests were employed in this study. The superexogeneity test in Part Three indicates that the policy variable (NBRX) causes output, whereas the test in Part Four shows that outside money does not cause output Moreover, the FEVD results in Parts Three and Four indicate that both policy and outside money innovations explain a very small proportion of output variation. The conclusions based on these tests can only be tentative, given the conceptual problems mentioned earlier. However, these results suggest an important *practical* conclusion: whether or not genuine causal connections running from monetary variables to output exist, policy actions or changes in outside money are unlikely to induce output adjustments of economically relevant magnitude.

While the practical conclusion presented above is relevant for policy issues, it does not provide a clear evaluation of the competing theories Theoretical models can not be built without firm assumptions about genuine causal connections. Given the difficulties of assessing causal relationships empirically, how can empirical work be brought to bear on the relevance of theoretical assumptions? The position adopted in this study is that the empirical evidence, rather than firmly confirming or rejecting theoretical assumptions, can be interpreted in terms of *consistency or otherwise* with *a priori* causal beliefs. The evidence here can be assessed from this point of view. As reflected in most theoretical controversies, three possible causal patterns between

money and output are commonly given consideration. (a) $Y \Rightarrow M$, (b) $M \Rightarrow Y$, and (c) $Y \Leftrightarrow M$. The patterns (b) and (c) are most commonly associated with the monetary theories of business cycles, whereas the pattern (a) is advocated by RBC theorists. However, these alternatives are not collectively exhaustive. What is left out most of the time is the logical possibility of no direct causal connection between output and money *A priori*, it is perfectly possible that the correlated fluctuations of money and output are the common effects of third factors. In fact, the empirical evidence provided in this dissertation seems more consistent with this final alternative, rather than with any of the possibilities (a) through (c) This conclusion is suggested by FEVD results indicating that the interactions between output and both components of money are rather weak As illustrated by some hypothetical scenarios formulated in the concluding section of Part Four, the observed fluctuations in monetary variables and output might represent the common effects of events such as real demand or supply shocks, or behavioral adjustments of the private sector (households, firms, or commercial banks).

The general conclusions based on the empirical evidence can be summarized as follows. The short run impacts of changes in the monetary variables on output are weak, suggesting practical monetary neutrality. The monetary policy actions through which the Fed exerts pressure on the reserves in the banking system are not an effective instrument for output stabilization. The portfolio redistributions among monetary assets play an important role in explaining monetary dynamics. The cyclical fluctuations in money and output might represent common effects of other causal factors, rather than reflecting mutual causal relationships.

The conclusions of this study represent a contribution to the ongoing debate about the nature of the interactions between money and output. As is usually the case, the empirical results here ought to be regarded as provisional, subject to further investigation. However, these results clearly illustrate the benefits of an analytical approach that addresses multiple aspects of the relationships between the monetary and the real sector.

The most important contributions added by this dissertation to the body of the monetary and macroeconomic literature are primarily methodological. The investigation here clearly illustrates the relevance of the decomposition of the money stock into outside money and inside money for a better understanding of the complex interactions between the monetary and the real sector. Further, this study documents, with theoretical and empirical arguments, the potential relevance of portfolio redistributions among monetary assets in explaining monetary dynamics, an issue hitherto overlooked in the literature. In addition, the particular empirical modeling strategy employed here resulted in some empirical findings that are new in the literature. This fact alone may send a signal to the profession about the potential benefits of the research method of this dissertation. Finally, empirical and theoretical considerations in this study suggest that the efforts devoted by the profession to the debate on the direction of causality between money and output might be misdirected. Evidence here indicates that both theoretical modeling and empirical studies would benefit from acknowledging the possibility that monetary and output fluctuations are in fact common effects of third causal factors

The complexity of the relationships between the monetary and the real sector of the economy imposes unavoidable limitations on the scope of investigation for any single study. This dissertation examines the multiple dimensions of monetary and macroeconomic dynamics To complete the picture of the interactions between the key monetary and real variables, other potentially relevant issues remain for further investigation. Some extensions of the analysis are suggested next.

First, this study employs a proper decomposition of the money stock into heterogeneous components. Aggregate output, similarly, could be decomposed into elements with heterogeneous behavior. The major components of real aggregate demand, namely consumption, investment, and government spending, exhibit different volatility and short run dynamics. Potentially valuable insights may be revealed by examining the impacts of various monetary shocks on the various components of aggregate output. Of particular interest for the assessment of the competing business cycle theories are the interactions between the monetary variables, the interest rate, and investment. Further decomposition of investment into business fixed investment and residential investment may be needed to clarify the nature of monetary impacts on the behavior of firms and households, and the implications of these combined impacts on the overall economic activity

A second useful extension would focus on identifying the key causes of portfolio redistributions among monetary assets. This study documents the importance of portfolio redistributions for the interpretation of short run monetary and macroeconomic dynamics. Part Four of the dissertation provides convincing evidence supporting the hypothesis of pro-cyclical behavior of the ratio of quasi-money to

transactions deposits. Three scenarios of economic events that might explain this behavior were presented. Firms and households' decisions, commercial banks' optimizing behavior, and a fiscal-monetary policy mix were alternatively suggested as possible initial causes of the observed patterns. A useful future investigation would assess the empirical relevance of these scenarios Such an investigation may reveal whether the observed co-movements of monetary and real variables are primarily determined by private sector's decisions or emerge as unintended effects of various policy actions.

This study clearly establishes an important point: there are no simple ways to properly assess the nature of the relationship between money and output. The main message that this dissertation may send to the profession is that conclusions such as "money causes/doesn't cause output" are gross oversimplifications, bound to overlook more relevant aspects of the complex relationships linking the monetary and the real sector of the economy.

REFERENCES

Cagan, P (1993), 'Does endogeneity of money disprove monetary effects on economic activity?', *Journal of Macroeconomics*, Summer, vol. 15, No.3.

Cooley, T F., and LeRoy, S.F. (1985), 'Atheoretical macroeconomics', *Journal of Monetary Economics* 16.

Engle, R.F., Hendry, D.F., and Richard, J.-F. (1983),'Exogeneity', *Econometrica* 51.

Kant, I. (1952), *The Critique of Pure Reason*, Oxford University Press.

VITA

Cezar Botel was born in Bucharest, Romania on March 3, 1958. He attended schools in the public system of Bucharest. He graduated from the Economics High School in June 1977. He entered The Academy of Economic Studies in Bucharest in September 1998. In October 1982, he received the Bachelor of Arts degree in Economics. Between 1982 and 1986 he worked as an economist in state-owned enterprises in Romania. In May 1986, he joined The Institute of Finance, Prices, and Foreign Exchange (IFPFE) in Bucharest, as a researcher. He was promoted senior researcher in 1987. After the fall of communism in Romania, in December 1989, he became Research Director at IFPFE. In March 1993, he was offered the position of Head of Monetary Policy Division at the central bank (The National Bank of Romania). In 1994, he was appointed Deputy Director of The Monetary Policy and Research Department of the central bank. In 1995 he won a Fulbright Scholarship that allowed him to enroll as a graduate student at Western Illinois University (WIU) in Macomb, Illinois. In June 1996, he received the Master of Arts degree in Economics from WIU. He entered the Doctoral program in Economics at the University of Tennessee, Knoxville in August 1996. Throughout his time in the Ph.D. program, he worked as a graduate teaching assistant and graduate teaching associate in the Department of Economics. He defended his dissertation in June, 2000, and received the doctoral degree August, 2000.

Cezar currently lives in Knoxville with his wife, Adabella.