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AN EMPIRICAL STUDY OF RATIONAL EXPECTATIONS AND THE NEUTRALITY PROPOSITION AS APPLIED TO JAPAN AND KOREA

by

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Abstract

AN EMPIRICAL STUDY OF RATIONAL EXPECTATIONS AND THE NEUTRALITY PROPOSITION AS APPLIED TO JAPAN AND KOREA

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The present study reexamines the MRE hypothesis by reviewing the previous empirical MRE models. Among the models considered, our particular interest goes to those of Barro (1977, 1978), Barro-Rush (1980) and Mishkin (1982, 1983). For this reason, we examine these studies in the context of Japanese and Korean data.

The results obtained reveal that for the Barro-Rush framework the MRE hypothesis is rejected in both Japan and Korea except the limiting cases. In the context of the Mishkin model, the MRE hypothesis is not rejected only in the Japanese case where the shorter lags of seven are considered. In this case the acceptance of the MRE hypothesis is due to the presence of the RE.

Nelson and Plosser (1982) argued most macro time series, especially real GNP series, are nonstationary or have a unit root. We have not been able to reject the possibility which real macroeconomic variables for Japan and Korea are nonstationary. This casts some doubts on our results regarding the NP (as well, or course, as Barro's and Mishkin's). However, neither is the evidence conclusive which these data are better described by DS or more general classes of nonstationary process than by some temporary process which would render the testing procedures we have used appropriate.

Preface

Barro (1976), Lucas (1972, 1973), and Sargent (1976), Sargent and Wallace (1975) pioneered what economists have called the rational expectations revolution during the seventies. While very active during the period, the debate seems to have ended early in the eighties. Many economists now do not accept the Macro Rational Expectations (MRE) hypothesis - which consists of rational expectations and the neutrality or policy ineffectiveness proposition. Yet, only a few analytical or empirical studies of alternative policy proposals have been conducted. Few efforts have been made to synthesize various proposers, or even delineate specific reasons for disagreement.

The present study reexamines the MRE hypothesis. The first area of the present study is to review the empirical MRE models. We examine the MRE models under the assumption that the money supply is exogenous. Among the models considered, our particular interest goes to those of Barro (1977, 1978), Barro-Rush (1980), and Mishkin (1982, 1983), as these studies have been very paid a great deal of attention in this literature.

The second of the present study is to examine theses studies in the context of Japanese and Korean data. These have rarely considered in this literature. The studies of Darby (1980), Hoffman and Schlagenhauf (1982) utilized the data of OECD countries. On the other hand, Noh (1986) used the Korean data for his study.

The final area of the present study is to raise the issue encountered with Nelson and Plosser's (1982) work. These economists argued most macro time series, especially GNP series, are nonstationary or have a unit root. Their finding is of importance since it implies the paths of those series are fundamentally stochastic. Many studies of rational expectations literature, for example, Barro (1977, 1978), Gordon (1982), and Mishkin (1982), assumed that the movements of output and unemployment rate are stationary. For this reason, those studies used a time trend variable to measure the natural rate output. If the series at hand are nonstationary, then those studies must be reconsidered. To avoid this problem, for example, McGee and Stasiak (1986) used an autoregressive vector model using growth rate of the variables such as real GNP, money, and price rather than their levels. After Nelson and Plosser's work, there have been many studies in this area. In the recent literature there have been some studies which question the result of Nelson and Plosser (1982). This led us to reexamine the series under the present study by simply adopting the Dickey-Fuller (1979) method, as Nelson and Plosser (1982) did, and raising the issue of how the test of the Mishkin model would be affected in this context.

Acknowledgments

First of all, I would like to thank God for His continuing guidance. He has always given me the way out of different difficult crises. In the past seven years, Dr. Thurston has guided and motivated me to have my interest in the field of Macro/Monetary Economics. I would like to thank him for his patience, encouragement and guidance. Without his assistance I would not be able to achieve this goal. Also, I would like to thank my family for their support which makes this mission possible. Finally, my special thanks goes to Dr. Grossman who has supported me throughout the years.

Contents

List of Tables

Chapter 1
INTRODUCTION

The theory of rational expectations (RE) which is originally due to Muth (1961), coupled with the natural rate hypothesis (NRH) [Friedman (1968)], led the literature to the 'New Classical' (NC) or 'Equilibrium Business Cycle' (EBC) view, superheaded by a series of influential papers by Lucas (1972, 1973), Sargent (1973), Sargent and Wallace (1975), and Barro (1976). This NC or EBC theory not only questioned the traditional "Phillips curve" relationship, but forced a reinterpretation of implications for short run macroeconomic policy. The fundamental policy proposition of NC economists results from the RE assumption[1] - the policy ineffectiveness or neutrality proposition (PIP or NP, henceforth, NP). The propositions of these RE and NP were dubbed the Macro Rational Expectations (MRE) hypothesis by Modigliani (1977).

The MRE hypothesis has led to major controversies between rational expectationists and other macroeconomists during the 1970s and 1980s. There have been several objections[2] to the MRE hypothesis in the literature. The debates are directed to the information availability. Even though the hypothesis seems unrealistic, most economists have accepted this as a working hypothesis for analysis of stabilization policy (Grossman 1980), issue of whether the MRE hypothesis is relevant to the U.S.

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[1] This is one of requirements for the NP in the NC economists' view. In addition to this, they assumed: (a) market clearing, and (b) incomplete one-period lag information. Whenever we mention rational expectations assumption, the other assumptions are implicit.

[2] McCallum pointed out two strong objections to the proposition. One has to do with 'persistence' of positive or negative values of output or unemployment. The other one has to do with 'sticky' prices [McCallum (1979), pp. 241-242].

economy. McCallum[3] (1979, 1980) evaluated and summarized the debate over the MRE hypothesis at the end of the 1970s. McCallum (1980, p. 738) argued that it seems difficult to sustain the position that the MRE hypothesis is applicable to the U.S. economy. On the contrary, Taylor (1986) pointed out that the controversies over the MRE hypothesis seems to be ended in the early 1980s, and only a few analytical or empirical studies of alternative policy proposals have been conducted since then. More importantly, little effort has been made to reach agreement among the various proposers, or even delineate specific reasons for disagreement.

Even though the NRH had challenged the traditional Phillips curve relationship (Phillips 1958) in which lower (higher) levels of unemployment (output) associated with higher rate of inflation and the terms of this trade-off was implicitly assumed to be independent of both past and current monetary and fiscal actions, Sargent and Wallace (1976) noted that the NRH still resembles the traditional Keynesian active policy program, for it still leaves room for government stabilization policies. For instance, the NRH coupled with the adaptive expectations hypothesis (AEH)[4] only limits what government can accomplish. The introduction of the rational expectations hypothesis (REH) coupled with the natural rate models (Friedman 1968), however, drastically questioned the Keynesian view by arguing that the anticipated changes of aggregate demand policy will have been takon into account already in the behavior of economic agents and will evoke no further output or employment response. Only the unanticipated changes of aggregate

[3] McCallum (1979) mentioned three empirical studies of those years which he considered notable - Sargent (1976a), Barro (1977a), and Neftci and Sargent (1978). See these studies in the next section.

[4] The adaptive expectations hypothesis (Cagan 1956) postulates that economic agents use the information on past forecasting errors to revise their current expectations. It, therefore, allows us to unobservable expectations purely in terms of past observations on the relevant variable.

demand policy will affect the level of aggregate variables such as output and unemployment. Whatever government or monetary authority takes as its policy, its systematic component could not affect the level of output or unemployment.

The REH postulates that economic agents do not make systematic mistakes in forecasting their future. The principle feature of the hypothesis lies in its assumptions about information availability. Even though the hypothesis seems unrealistic, most economists have accepted this as a working hypothesis for analysis of stabilization policy [Grossman (1980), McCallum (1979)]. This can be justified in two ways (McCallum 1979): (a) there is no a priori reason to believe that the hypothesis is terribly inaccurate, empirically, at the macroeconomic level, and (b) every alternative assumption like the AEH requires the existence of some particular pattern of systematic expectational error (McCallum 1980).

The REH and the NP, it should be emphasized, two separate issues so that we need to carefully discuss these at their theoretical and empirical levels. The papers of Lucas (1972, 1973), Sargent (1973), and Sargent and Wallace (1975) represent the bulk of the literature. The weakness of this NC approach is, as Gordon (1980,[5] 1981, 1982) indicated, that the approach does not address alternatives to the REH. In this sense, tests of rational expectation approach are not valid (Lovell 1986). One example of an alternative theory was proposed by Gordon (1982) which will be taken into consideration further on. Another problem in the recent literature comes from the evidence (Nelson and Plosser 1982) that GNP and other macroeconomic time series are nonstationary.

The first purpose of the present study is to closely reexamine the MRE hypothesis. The second purpose is to test the MRE hypothesis with different data sets in Japan and

[5] See, Fischer (1980, pp. 55-63).

Korea - a task which has been rarely undertaken in this literature - selecting some of the well-known models, including especially, Mishkin's (1982) model. The final purpose is to address the issue of nonstationarity or unit root in the recent literature. According to Nelson and Plosser (1982), as mentioned earlier, most macroeconomic time series, especially GNP series, are nonstationary. In the recent literature, however, there have been studies to cast doubt on the original finding of Nelson and Plosser (1982).[6] This motivates us to test the series under the present studies on whether or not they are nonstationary.[7] Then, we will reconsider the Mishkin (1982, 1983) model in the presence of Nelson and Plosser's (1982) suggestion.

The rest of the present study is organized as follows. In the next chapter the MRE hypothesis will be more rigorously addressed. The previous empirical studies over it will be discussed in the third Chapter. In Chapter 4 we will carefully examine Nelson and Plosser's work (1982) for our own purpose. If their suggestion is valid - that is, if the series under the present study is nonstationary, how could the types of models like Mishkin's (1982, 1983) be reconciled with this framework? We raise the issue, however, the solution to this direction is not pursued in the present study. In the present study we simply, as did Nelson and Plosser (1982) initially, test nonstationarity by utilizing Japan, Korea, and the U.S. data, though with shorter sample span than that of their original work. Once the results are obtained, we discuss the nonstationarity or unit root problem associated with the Mishkin type models. For the most part in Chapter 5, we conduct

[6] See, Walton (1987). He indicated this point, tested the U.K. case, and found that the U.K. series under his study is no doubt stationary.

[7] In the present study we do not take a position to actively test whether or not the series like real GNP are stationary. Our aim is that we simply raise the issue of nonstationarity or unit root into the MRE models, for example, the Mishkin model. For this reason, we used a shorter sample span of 19 yearly data of countries considered.

empirical analysis by applying the models of Barro (1977, 1978) and Mishkin (1982) to Japan, Korea, and the U.S. (U.S. case in Appendix C and D, respectively). In the final chapter we summarize, conclude the present work, and suggest a further study.

Chapter 2
THE MACRO RATIONAL EXPECTATIONS (MRE) HYPOTHESIS

2.1 Phillips Curve Relationship

The Phillips curve relationship has been questioned and debated during the decades since Phillips (1958) had invented it for the first time in its explicit form.[1] This relationship was first challenged by the NRH (Friedman 1968) in the literature. Friedman asserted that economic agents could not be fooled all the time, so the relative importance of aggregate demand policy is accordingly reduced because the economic agents' expectational effects could not be neglected. This still resembles, however, the conventional Keynesian idea because there is still a chance for government to stabilize the economic performance. In other words, 'in the long run' effect are implicitly agreed upon by all economists regardless of their schools.[2] For this reason, monetarists' version of absence of long-run Phillips curve relationship is not far from that of the Keynesian one.

Lucas (1972, 1973) had, however, pioneered the NC or EBC approach by asserting that the irregular fluctuations[3] in an economic activity or business cycle could be explained only by the supply side disturbances if the NRH coincided with the REH. Lucas (1972, 1973) set his model in a way that the economic agents' confusion[4] comes

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[1] Sargent (1987, p. 438) pointed out that this relationship had long been mentioned by the business cycle analysts, e.g., Fischer.

[2] As Stein (1984) mentioned, Keynesian, Monetary, and NC economists agree that the steady state of inflation is closely related to the growth of the money supply, and that monetary policy cannot affect the equilibrium rate of unemployment or rate of growth of output. See, Stein (1984, p. 17).

[3] In the literature these have more often been explained as demand-side shocks.

[4] In Lucas (1973) model economic agents respond only to their relative price because they are spatially isolated from each other. This asymmetrical information among economic agents caused them to confuse their relative prices from the general price movements. Under the rational expectations in forming their price forecasts (notice the difference between expectations and (continued...)

solely from the supply side - Lucas-Sargent supply equation[5] which has, since then, played an important role in the NC approach. Lucas (1973) tested the natural rate theory coupled with the REH, and concluded that monetary policy could affect the aggregate variables such as output and unemployment to the extent that economic agents misconceive the general price level in favor of their relative prices.

As Grossman (1980, pp. 9-13) points out, we can perceive the following from the Lucas model. First, the model implies the drastic policy implication identified earlier with the NP. That is, the model implies that monetary policy cannot systematically affect the economic aggregates such as output and unemployment if economic agents form expectations rationally or fully use the information given to them.[6] Secondly, the model leads us to a corollary of the NP which is called the 'variance' hypothesis in the literature. The latter implies, the larger the variance of monetary and fiscal behavior, the smaller the effects of given unpredictable and unperceivable monetary and fiscal actions on aggregate output and unemployment. This 'variance' hypothesis leads to a third point which implies a possibility of nonneutrality. This is known as the 'misallocation' hypothesis. The last implies, the larger the variance of monetary and fiscal behavior, the more likely are private economic agents to misconceive the economic disturbances and to fail to make the

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[4](...continued)
forecasts), any systematic part of price changes will be forecasted rationally in the sense of Muth (1961). Therefore, the nature of Lucas-Sargent supply equation insures that the anticipated price changes will not affect the supply of output.

[5] The term is adopted from Begg (1982).

[6] As mentioned earlier, to set his model, Lucas (1973) assumed incomplete one time lag information. This assumption led to the possibility of nonneutrality which is, however, not contradictory to the NP, as Grossman pointed out. See more details in Fischer (1980) and elsewhere.

adjustments in resource allocation that these other disturbances would otherwise call for.[7]

Sargent and Wallace (1975) further advanced the Lucas model by assuming symmetrical information between the monetary authority and economic agents.[8] They examined the effects of monetary policy on economic performance under two alternative expectational schemes: rational and adaptive ones. They showed under the REH monetary policy cannot systematically affect the level of aggregate variables such as output and unemployment. Therefore, the traditional optimal control theory which had been popular during the 1960s loses its role,[9] and under the AEH the opposite is true.

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[7] The misallocation hypothesis is also implied by Friedman (1968). Friedman (1968) argued that monetary policy must be performed in a predictable way. If so, it can prevent money itself from being a major source of economic disturbance.

[8] They argued that the asymmetrical information assumption between monetary authority and economic agents does not produce any simple trade off between the means of output and the price level. See more details in their paper (1975, pp. 251-253).

[9] This is due to a Lucas Critique or policy evaluation which is another proposition resulted from the RE. Lucas (1976) asserted that changes in policy variables will result in changes in the behavioral relation in estimated models. In other words, Lucas pointed out the traditional econometric policy has a wrong policy implication.

2.2 The Propositions

2.2.1 Why Rational Expectations?

The first component of the MRE hypothesis is concerned with the RE assumption. As McCallum (1980, p. 217) pointed out, the basic idea of the REH is simply, economic agents behave 'purposefully' in collecting and using information as they do in other activities. He argued, therefore, that it is hard for economists to reject that hypothesis without considerable embarrassment.

McCallum (1980, pp. 717-719) made it clear the reason expectations are rational. First, each alternative hypothesis, such as AEH, posits implicitly or explicitly the existence of some particular patterns of systematic expectational errors. This is very unattractive because the errors are costly. Thus, purposeful economic agents have the incentive to week out all systematic errors. Secondly, the REH seems essentially appropriate for analyzing macroeconomic stabilization policy since policy is inherently forward looking. Thus, the relevant question is, what pattern of expectational error will be found in the future. Even though it is hard to believe any policy maker would want to base his action on the presumption that some particular error pattern will be obtained in the future, some such pattern is implied, for any chose policy from an ad hoc hypothesis like AEH. Furthermore, it is not clear whether policy actions designed to exploit a 'known' error pattern enhance social welfare.

An objection to the REH exists on the ground that individuals have different expectations from each other (McCallum 1980). It is true that expectations actually differ across individuals. As Muth (1961) pointed out, however, these differences would be unimportant in the aggregate unless they were significantly correlated with other cross-sectional differences among agents. Abstracting from such differences is not entirely uncommon in the analysis of macroeconomic variables. For this reason, the REH became more common than the ad hoc rule like the AEH in the macroeconomic analysis. Frydman and Rappoport (1985), however, asserted that the different information set between economic agents and investigator, where the information set of the latter is smaller than that of the former, may lead to a different policy implications (see Chapter 3).

Rational expectationists, for example, Begg (1980) raised the problems of ad hoc rules like the AEH. First, it is not desirable to imagine that the only variable to be considered are past values of the variable at the time of expectations formation. That is, such partial equilibrium analysis does not fit comfortably within traditional macroeconomics where the general equilibrium or system-wide effect are of great importance. Secondly, as mentioned earlier, all mechanistic backward looking extrapolative rules allow the possibility of systematic forecasting errors for many periods in succession.

2.2.2 The Neutrality or the Policy Ineffectiveness Proposition

To clearly understand the NP, we posit the simple macroeconomic model which was advanced by McCallum (1980).[10] That is,

$$y_t = a_0 + a_1[i_t - E_{t-1}(p_{t+1} - p_t)] + v_{1t}, \ a < 0 \tag{2.2.2A}$$

$$m_t - p_t = c_0 + c_1 y_t + c_2 i_t + v_{2t}, \ c_2 < 0 < c_1 \tag{2.2.2B}$$

$$y_t = \alpha_0 + \alpha_1(p_t - E_{t-1}p_t) + \alpha_2 y_{t-1} + u_t, \ \alpha_1 > 0, \ 1 > \alpha_2 \geq 0 \tag{2.2.2C}$$

$$m_t = \mu_0 + \mu_1 m_{t-1} + \mu_2 y_{t-1} + e_t \tag{2.2.2D}$$

where all variables in the equations are in logs. The variables of y_t, p_t, m_t and i_t denote logarithms of aggregate output, the price level, the money stock, and one-period nominal rate of interest, respectively. $E_{t-1}x_{t+j}$ here denotes the mathematical expectation of x_{t+j} (for $j = 0,1,...$) which is computed from the equations of the model and the values of all relevant variables realized in periods t-1 and earlier. The symbols v_{1t}, v_{2t}, u_t and e_t denote random disturbance terms intended to represent unsystematic forces impinging on the economy in unpredictable ways.

The equation (2.2.2A) presents a simple version of IS-type expenditure function that is associated with the quantity of output demanded for consumption and investment with the real rate of interest. For convenience, the fiscal policy variables have been excluded as in McCallum (1980). As McCallum (1980) pointed out, one of the objections

[10] McCallum (1980) advanced the given model in the context of Sargent and Wallace's (1975) version. This version is very strict in the sense that not only mean, but also variance of real variables, such as unemployment rate and output, can not be affected by way of monetary policy.

to the NP has to do with the equation (2.2.2A). Opponents[11] argued that the equation (2.2.2A) is missing a real balanced term, and thus, the NP result is due, in part, to this dubious assumption. The equation (2.2.2B) indicated that the demand for real money balances is related to real income and inversely to the nominal rate of interest. In the equation (2.2.2C) the Lucas-Sargent supply function is introduced where monetarists' version of the accelerations or natural rate notion is already included. In other words, supply of output is affected by the price level only to the extent that the latter differs from its expected value. The equation (2.2.2D) describes policy behavior as a linear feedback rule that relates m_t to past values of the model's variables such as y_{t-1}, y_{t-2}, and so forth. The random disturbance, e_t, is a stochastic disturbance that has mean zero and constant variance, and is stochastically independent of past values of all variables and disturbances (including itself). As mentioned earlier, monetary authority and economic agents have symmetrical information since the current money stock, m_t, can be determined only by the past values of m_t and y_t.

With this simple model, we are now ready io represent the NP in a more formal way. The solution[12] of the model can be written as

$$y_t=\alpha_0+\alpha_2 y_{t-1}+\frac{\alpha_t v_t+\beta_t \mu_t+\alpha_t \beta_t e_t}{\alpha_t+\beta_t}$$

(2.2.2E)

where

$$\beta_t=\frac{a_1}{a_1 c_1+c_2}.$$

[11] As McCallum recommended, see the series of papers done by Fischer (1977), Fair (1978), Blinder and Fischer (1978), and others. See McCallum (1980) for exact citations.

[12] To solve our basic model, we can use two alternative methods: (a) undetermined coefficient method, and (b) simple algebraic manipulation. To get an idea of how to get the solution, refer to the appendix of McCallum (1980).

As in the solution, the policy parameters, μ's, do not appear in it. Thus, the time path of output, y, is affected only by the variances of disturbance terms, v_t, u_t, and e_t, and by the nonpolicy parameters, α's, and β_t. In other words, the monetary authority's choice of values for μ's has no effects on the evolution of output, y_t, path which is called as the NP in the literature.

As noticed earlier, the NP has caused several lines of objections in the literature even in the characteristic of stochastic steady states. One of them[13] implies that, in reality, high or low measured unemployment rates tend to persist in an economy. Lucas (1975), Sargent (1987), Blinder and Fischer (1982), and McCallum (1979) have, however, developed models in which the NP and persistence coexist.

One of the most prominent objections to the NP is associated with the fact that the prices are assumed perfectly flexible. Along this line, opponents to the NP [Fischer (1977), Phelps and Taylor (1979), Taylor (1979)] advanced their models by arguing, there are institutional constraints to the price changes such that economic agents can set their nominal wage in one or two period(s) earlier. As McCallum (1979) pointed out, this objection was the most telling in the literature. Barro and Rush (1980, pp. 26-27)[14], however, indicated there is no solid economic rationale for contract of this sort.[15] Gordon (1982) also criticized perfect price flexibility, and set up his model by admitting the price

[13] The other apparent source refuting the NP is price indeterminancy under interest rate targeting. See more details in McCallum (1980).

[14] See this in Fischer (1980).

[15] Barro and Rush (1980, pp. 26-27) provided the evidence that the contract type of theories seem to account only for a pattern of price stickiness that corresponds to the patterns of output and unemployment stickiness. Based upon their estimates of output, unemployment, and price equations, they stressed that the appearance of sluggish price adjustment does not correspond to the pattern of output and unemployment persistence that appears in their output and unemployment equations.

inertia in his model. Gordon (1980) asserted that a series of Barro papers provides no test at all of the short-run NP of the MRE hypothesis that would distinguish it from the widely-accepted long-run 'natural rate' NP.[16]

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[16] See, Fischer (1980, pp. 57-59). There, Gordon lists three reasons for this matter: (a) there is no explicit empirical test of the leading competing natural rate hypothesis and gradual adjustment of price (NRH-GAP) hypothesis upon which the orthodox stabilization literature rests its case, (b) far from attempting to distinguish the NP and NRH-GAP hypothesis, Barro compares as determinants of output on the one hand unanticipated change and on the other hand raw money change, and (c) not only do Barro's output and unemployment equations fail to provide any evidence supporting the NP hypothesis, but, worse yet, his price equations strongly undermine the theoretical rationale of the NP hypothesis by validating the competing NRH-GAP hypothesis.

Chapter 3
REVIEW OF THE PREVIOUS MRE STUDIES

3.1. Introduction

In this section the important empirical studies on the MRE hypothesis are reviewed. The first major study was done by Sargent (1976a), the second by Barro (1977a, 1978) and Barro-Rush (1980), and the final by Neftci-Sargent (1978) following the method originally suggested by Sargent (1976b).[1] As McCallum (1979) indicated, the results of these studies are not inconsistent with the NP, yet, they are not entirely clear-cut. After these, therefore, there have been more studies including Mishkin (1982), Frydman and Rappoport (1985), McGee and Stasiak (1986), and Romer and Romer (1989) in the literature.

Among them, the Barro's (1977a, 1978) and the Barro-Rush (1980) motivated further research along this line. In their studies Barro (1977a, 1978) and Barro-Rush (1980) tested the MRE hypothesis under the maintained REH. They assumed a fitted OLS (ordinary least square) regression designed to predict money growth equation is the same as the investigator's. Mishkin (1982a, 1982b, 1983), however, argued that for the test to be valid, it must be a joint test making use of the off-diagonal information matrix of forecasting money growth and output or unemployment equations. Both Barro-Rush's (1980) and Mishkin's (1982, 1983) studies suggested that it is very important to distinguish the anticipated and the unanticipated components of the money growth equation. In contrast, Frydman and Rappoport (1985) presumed that the information set of the investigator is smaller than the agents'. They asserted this distinction of anticipated and

[1] Even though McCallum (1979) mentioned only the study of Barro (1977a), it is better to include the studies of Barro (1978) and Barro and Rush (1980), for the latter is the extended version of Barro (1977a) study.

unanticipated components of money is not important at all, and the short-run effect of nominal variables on aggregate real output is irrespective of whether their movements are anticipated. For this reason, they advanced the hypothesis of 'Irrelevance of the Anticipated-Unanticipated Distinction' (IAUD). Under the IAUD the different information sets between economic agents and investigator are a building block to set up the model. On the contrary, Barro and Mishkin including Gordon assumed the above information set was as same between economic agents and investigator.

Gordon (1981, 1982)[2] advanced a different approach to test the NP. This alternative approach termed the 'NRH-GAP' (natural rate hypothesis and gradual adjustment of prices), states that prices respond fully in the long run, but only gradually in the short run, to nominal aggregate demand disturbances. Gordon (1980) argued the Barro-Rush (1980) study failed to provide any evidence supporting the MRE hypothesis, and what is worse, their price equations strongly undermine the theoretical rationale of the MRE hypothesis by validating the competing NRH-GAP approach. The troubling aspect of this NRH-GAP approach in explaining output persistence and price sluggishness is, however, as Thurston (1983) asserted, the length of adjustment lags it is called upon to explain. It is difficult, for example, to attribute four-to-six year adjustment lags to delays in one's theory the notion of rational (or just 'reasonable') agents.

As McCallum (1982) has pointed out, there is another difficulty with both of the studies of Mishkin (1982a, 1982b) and Gordon (1982). These studies presume movement in output and employment (unemployment) are best represented as stationary fluctuations around deterministic trends. This is in contrast to evidence given by Nelson and Plosser

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[2] Gordon (1982), however, thought that the distinction between anticipated and unanticipated components of money should be stressed.

(1982)[3] which suggest these variables are nonstationary processes that have no tendency to return to a deterministic path. If these series are nonstationary processes, then the distribution theory implicit in the hypothesis tests of the Gordon (1982) and the Mishkin (1982, 1983) does not apply and their results are open to question.

In addition, McCallum (1982) also points out that in the Mishkin (1982, 1983) and the Gordon (1982) studies the methods of overcoming the observational equivalence difficulty initially mentioned by Sargent (1976b) are not entirely satisfactory. These studies are actually forced to make some untested restriction in order to distinguish the anticipated from the unanticipated components of the policy variables in their models.[4] While these restrictions may, or may not, be appropriate, it is useful to see if these results hold under an alternative methodology. From this standpoint, McGee and Stasiak (1986) advanced these difficulties raised by McCallum (1982) about the Mishkin (1982, 1983) and the Gordon (1982), and presented the results from an alternative framework to test the validity of the MRE hypothesis.

Romer and Romer (1989) advanced the test on the validity of the MRE hypothesis focusing not on purely statistical evidence but on evidence derived from the historical record-evidence based on what they call the 'narrative approach' in the sense of Friedman and Schwartz (1963).[5] They argued the reason purely statistical tests, such as regressions of output on money [Sargent (1976a), Neftci and Sargent (1978)], studies of the effects of the anticipated and unanticipated money [Barro (1977a), Mishkin (1892a, 1982b), Gordon (1982), and Frydman and Rappoport (1985)], and vector autoregressions

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[3] We will see this issue in Chapter 4.

[4] We examine this in detail in the next section.

[5] See exact citation in Romer and Romer (1989).

[McGee and Stasiak (1986)], probably have not played a crucial role in forming most economists' views about the real effects of monetary disturbances is that such procedures cannot persuasively identify the direction of causation.

These are the empirical studies on the MRE models which are most prominent in the recent literature. We are now in a position to address these studies in a deeper way. To do this, this chapter is arranged as follows. The beginning two sections deal with studies of regressions of output or unemployment on money. The studies of Sargent (1976a), and Neftci and Sargent (1978) are addressed in this part. The next three sections review the studies which are associated with the effects of anticipated and unanticipated money. In this part, studies performed by Barro (1977a), Mishkin (1982a, 1982b, 1983), and Frydman and Rappoport (1985) will be considered. The last group criticized the rest by asserting, results for policy proposals of those studies may come from the assumption of the same information set between economic agents and investigator. The fifth section closely reexamines the NRH-GAP approach taken by Gordon (1982). The sixth will review a study of McGee and Stasiak (1986), not only with respect to the observational problem of models of Mishkin (1982, 1983) and Gordon (1982), but with respect to suggestion for an alternative framework where the time path of aggregate variables such as output and unemployment has been proceeded in a nonstationary way. The Romer and Romer (1989) study which took a nonstatistical approach will be considered in the next to last section. In the last section we will summarize our conclusion.

3.2 Review of the MRE Models

3.2.1 The Sargent Model

Sargent (1976a) developed and estimated a simple macromodel: (a) to find a simple device capable of generating unconditional forecasts of key economic aggregates such as unemployment rate, price level, and interest rate, and (b) to test the hypothesis underlying the model (NRH) as part of the process. The underlying hypothesis, however, is much weaker than the one developed by Sargent and Wallace (1975)[6] in the sense that the former does not necessarily imply the entire distribution of the innovation in unemployment rate or output is independent of the feedback rule for policy - only that the conditional mean is. For example, suppose that the logarithm of the money supply at t, m_t, is determined according to the deterministic, very general feedback rule

$$m_t = f\ (\theta_{t-1})$$

where θ_{t-1} = past values of monetary and fiscal policy variables, and f = some (perhaps very complicated) function that determines the monetary authority's rule. Then underlying hypothesis in Sargent's paper implies that the choice of f has no effect on the mean of the unemployment, conditional on past data. Sargent (1976) indicated that his empirical tests are of neutrality-in-conditional mean propositions.

To advance his mode, Sargent (1976a) first defined the NRH in a statistical way, and then, tested it by using two statistical theories of Granger (1969) and Sims (1972) in the context of unemployment and interest rates. In the interest of expositional brevity, we

[6] Sargent and Wallace (1975) advanced a stronger NP by asserting that the entire probability distribution of some real economic variables with respect to the policy rule is invariant, and obtains in some macro-model. Sargent's (1976) neutrality-in-conditional-means propositions have a very strong implication about the conditional mean of the unemployment rate, one that denies, for example, that policy makers have any scope to trade a lower expected unemployment rate for a higher expected rate of inflation.

stick to the unemployment rate. To define the NRH statistically, Sargent (1976a) used the univariate Wold representation of the unemployment, UN_t. That is, if the series under the study like UN are indeterministic and covariance stationary, we can represent

$$UN_t = \sum_{j=0}^{\infty} a_j w_{t-j}\ ,\ \sum_{j=0}^{\infty} a_j^2 < \infty, \tag{3.2.1A}$$

where the w's are serially uncorrelated with mean zero and finite variance, and a's are a vector of parameters. The model in equation (3.2.1A) is obviously intended to apply to deviations of the unemployment rate from its mean and any deterministic components. To set up his model, Sargent (1976a) assumed: (a) the w's and the other white noises of other variables such as price, wage, and money supply, are serially independent,[7] (b) UN series have stationarity and invertibility properties (the roots of $a_j\lambda^j = 0$ lies outside the unit circle), (c) in its univariate Wold representation [eq. (3.2.1A)], the innovation w_t obeys

$$E(w_t \mid \theta_{t-1}) = 0 \tag{3.2.1B}$$

so that the innovation in the unemployment rate is statistically independent of each component of θ_{t-1} and so cannot be predicted on the basis of the information in θ_{t-1}. Here θ_{t-1} = past values of monetary and fiscal variables.

Under these assumptions Sargent (1976a) employed the very strict versions of the NRH which posits, the best forecast of w_t conditional on all past data is simply its unconditional mean of zero, for θ_{t-1} includes past values of monetary and fiscal variables. In other words, such variables are asserted to offer no aid in predicting the unemployment

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[7] Sargent assumed this for simplicity. As he points, dropping the assumption that the w's and other white noises are serially independent, but only serially uncorrelated would necessitate replacing conditional mathematical expectations with linear least-square forecasts in his subsequent analysis.

rate, once lagged unemployment rates are considered. Furthermore, the equation (3.2.1B) implies that the current value of any control variable determined via a deterministic feedback rule on θ_{t-1} is also useless in predicting the unemployment rate.

To test the underlying hypothesis, Sargent (1976a) used, as mentioned earlier, two statistical theories suggested by Granger (1969) and Sims (1972). According to the former, the unemployment rate is caused, in Granger's sense, by no other variables.[8] According to the latter, testing the underlying hypothesis involves what is called an econometrician's definition of statistical exogenuity. According to this theory, the other variable, for example, the GNP deflator could be expressed as a one-sided lag of UN series. In other words, UN series are not caused by GNP deflator series. Sargent tested this stricter version of the NRH for quarterly data on the dependent variables spanning the period 1952:II to 1972:II. The results drawn were mixed: (a) from the direct Granger casualty test, money supply (m) and wage (w) turned out to cause UN, and UN series are also caused by the variables such as federal, state, and local purchases of goods and services in 1958 dollars (g), and federal. state, and local purchases in current dollars (g$), and (b) from Sim's exogeneity test, m or w did not cause UN. Mishkin (1982b), however, showed that the result - UN is not caused by the GNP deflator - comes from the fact that Sargent's sample period did not include the period 1974-75. As we see later, Mishkin (1982b) obtained the results against the underlying hypothesis by including the 1974-75.

Sargent (1976a) concluded that even though some evidence for rejecting the NRH

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[8] As candidates for Y variable, Sargent (1976a) adopted the following ones: the logarithm of the money supply, currency plus demand deposits (m), the federal, state, and local government surplus on the national-income-accounts basis in 1958 dollars (surp), the logarithm of the GNP deflator (p), a straight-time wage index in manufacturing (w), federal, state, and local purchases of goods and services in 1958 dollars (g), and federal, state, and local purchases in current dollars (g$).

model has been revealed, it was far from being overwhelming and decisive. The evidence that seems most damaging to the model comes from the role that the money wage apparently plays in causing unemployment and the long-term interest rate. On the other hand, the tests showed there is little evidence requiring us to reject the key hypothesis of the model that government monetary and fiscal policy variables do not cause unemployment or interest rate.[9] Sargent (1976a) commented, the fact that such evidence has been hard to demonstrate ought to disconcert users of the existing macroeconometric models, since, as usually manipulated, these models imply monetary and fiscal policy help cause unemployment and the interest rate.[10]

As McCallum (1979) pointed out, Sargent's (1976a) work was impressive for its time. McCallum argued, however, that to avoid observational equivalence (see the next section) suggested by Sargent (1976b), Sargent's (1976a) model imposed an auxiliary assumption. To see this, we write

$$y_t = \sum_{i=1}^{k} a_i \,(p_{t-i} - \mathrm{E}_{t-i-1}(p_{t-i})) + \sum_{j=1}^{k} b_j y_{t-j} + e_t \,, \tag{3.2.1C}$$

$$y_t = \sum_{i=1}^{k} a_i (p_t - \mathrm{E}_{t-i-1} p_t) + \sum_{j=1}^{k} b_j y_{t-j} + e_t \,, \tag{3.2.1D}$$

where y_t = output or unemployment, p_t = price at time t, e_t = random disturbance at time t, E_{t-i-1} (p_{t-i}) = expected price at time t-i formed at the time t-i-1 and a's and b's are

[9] Sargent (1976a) found that UN does not cause, nor is it caused by the GNP deflator. Mishkin (1982b) showed, however, it is due to excluding the period 1974-75. Including this period, Mishkin (1982b) found that there exists a negative relation between them.

[10] If it is better to monetary authority or government to stick to its rules and feedback, it should have empirical evidence to show some existing macroeconometric model can outperform models of the class in Sargent paper. Sargent argued, however, in his impression such evidence does not yet exist.

constant. The above equations are forms of Lucas-Sargent supply function. McCallum (1979) pointed out that it is extremely difficult to distinguish the above equations by simple inspection in empirical ways. In part, this is because the NP is compatible with the function (3.2.1C) which is more general than the following one.

$$y_t = a_0(P_t - E_{t-1}P_t) + \sum_{i=1}^{k} b_1 Y_{t-1} + e_t \, , \qquad (3.2.1E)$$

The function (3.2.1C) is more general than the (3.2.1E) in that it includes lagged one-period expectational errors (lagged 'innovations'). The NP is not, on the other hand, consistent with a formulation that includes multiperiod expectational errors as in (3.2.1D).

McCallum (1979) pointed that Sargent's (1976a) identifying restrictions are imposed by the adoption of a supply function of type (3.2.1C). Since the equation (3.2.1D) has more than one-time lagged expectational errors, Sargent implicitly assumed that the parameters a_1, a_2, a_3...a_k are all equal to zero. Thus, the neutrality property alone places no restrictions on time series data taken from a single policy regime. That is, Sargent (1976b) had shown that, without the use of additional a priori information of some type, it is logically impossible to distinguish between (3.2.1C) and (3.2.1D), or, more generally, between models in which the NP is valid and invalid. As McCallum further pointed out, Sargent emphasized innovation in policy variables, such as the log of money stock, m_t, rather than p_t. In addition, as Sargent noted, it may be appropriate to interpret y and m as vectors of variables.

Sargent (1976a) also made another auxiliary assumption to develop his model. He assumed that the equation's disturbance terms is free of serial correlation. This crucial assumption excluding of lagged expectational errors led Sargent to the implication that y_t is, given the effect of lagged y's, uncorrelated with past values of policy variables. Sims

(1977) argued, however, that this auxiliary assumption excluding of lagged expectational errors is totally arbitrary. For this reason, Sims (1977) argued that while Sargent's results may not be totally uninformative, they should probably be regarded as shedding little light on the validity of the NP.

3.2.2. The Neftci and Sargent Model

Sargent (1976b) asserted the empirical evidence from a single estimation period alone cannot settle things between advocates of rules with feedback and advocates of rules without feedback. That is, he pointed out, there are always alternative ways of writing the reduced form, one is observationally equivalent with the other, so that each is equally valid in the estimated period. In other words, there are no restrictions on the reduced form of the models to distinguish the difference between natural[11] and unnatural rate versions of the models. This point was inspired by a Lucas (1976) critique of econometric policy evaluation. Lucas (1976) emphasized there the critical invariance assumption behind the usual argument for rules with feedback, and showed that invariance assumption fails to hold in models with the RE.

It should be emphasized Sargent (1976b) only showed that reduced forms estimates over a given estimation period cannot settle the policy rules controversies. He did not mean to say there is no way empirical analysis can be brought to bear on the question. By estimating reduced forms for various periods - the approach taken by Neftci and Sargent (1978) - or countries - taken by Lucas (1973) - across which policy rules differ systematically, empirical analysis on the invariance assumption can be conducted. Neftci and Sargent (1978) performed a test of the NP by adopting a suggestion of Sargent (1976b). To advance the test, they presented two alternative representation for y_t, m_t, where y_t is real output at time t, and m_t is a stock of money at t.

The first of these is as follows.

$$y_t = \sum_{i=0}^{\infty} a_i m_{t-i} + \sum_{i=1}^{\infty} b_i y_{t-i} + e_t \ . \qquad (3.2.2A)$$

[11] Gordon (1982) argued that it is a mistake to call NC or EBC as natural rate model.

$$m_t = \sum_{i=1}^{\infty} c_i m_{t-i} + \sum_{i=1}^{\infty} d_i y_{t-i} + u_t \ , \tag{3.2.2B}$$

where the a_i, b_i, c_i, and d_i are constant parameters, where e_t and u_t are serially uncorrelated random variables with mean zero and finite variances, and where $Ee_tu_s = 0$ for all integer t and s, so that u_t and e_s are orthogonal at all lags.

For the same series (y_t, m_t), there exists a second representation of this form. That is,

$$y_t = \sum_{i=1}^{\infty} a'_i \ (m_{t-i} - E_{t-i-1} m_{t-i}) + \sum_{i=1}^{\infty} b'_i \ y_{t-i} + e_t \ , \tag{3.2.2C}$$

$$m_t = \sum_{i=1}^{\infty} c_i m_{t-i} + \sum_{i=1}^{\infty} d_i y_{t-i} + u_t \ , \tag{3.2.2D}$$

where $E_{t-1} \ m_t$ = the linear least squares projection of m_t on m_{t-1}, m_{t-2}, ..., y_{t-1}, y_{t-2}, ..., where the a'_i, b'_i are constant, and the c_i, d_i, u_t and e_t are identical with those in (3.2.2A) and

(3.2.2D). Since the e_t, u_t process in (3.2.2A)-(3.2.2B) and (3.2.2C)-(3.2.2D)are identical, the model (3.2.2A)-(3.2.2B) is observationally equivalent with the model (3.2.2C)-(3.2.2D), i.e., the models fit equally well.

Along with the above two representations, Neftci and Sargent (1978) performed the test for the NRH by identifying distinct periods across which there occur changes in the policy regime. Thus, the test is to see whether (3.2.2A) or (3.2.2C) remains invariant across such periods. In this way, there is some hope of testing the critical invariance assumptions required to draw policy implications from a model like the (3.2.2A)-(3.2.2B) or the (3.2.2C)-(3.2.2D).

The key to the test for the NRH of Neftci and Sargent is whether or not changes did occur in policy regime. They performed the test with two separate periods, prewar and postwar, split into two subperiods for the test. The invariance tests of (3.2.2A) and (3.2.2C) indicate the null hypothesis of stability of the (3.2.2A) is rejected at higher confidence levels than is the hypothesis of the stability of the (3.2.2C). The marginal significance levels show the equation (3.2.2C) - invariance across regimes of the (3.2.2C) - is supported by the data. All in all, the Neftci and Sargent (1978) work is not inconsistent with the NP.

McCallum (1979) noted the main weaknesses of Neftci-Sargent (1978) procedure is the absence of any formal statistical basis[12] for reaching conclusions and (again) the difficulty of characterizing policy behavior. If the monetary authority's policy feedback rule changes at some point of time, there should be a shift in the distribution-lag relationship of y_t on actual m_t values if the NP is true, but not if it is false, with this implication reversed for a relationship between y_t and innovations in m_t. To locate a policy break, as McCallum points out, we should first characterize policy behavior, and test the preposition with a sounder statistical basis than Neftci and Sargent used.

[12] To find a policy break in the U.S. data, they regressed their models across different sample periods with trial and error basis. Using quarterly U.S. data for 1949-74, they located a policy break at the start of 1964, and then obtained Chow-type test statistics that are reasonably supportive of the NP.

3.2.3. The Barro Model

Barro (1977a, 1978) and Barro-Rush (1980) advanced the hypothesis that only the unanticipated movement of money affect the level of unemployment and output. As Barro (1977a, p.101) noted, the hypothesis that only the unanticipated component has real effects is more general than the specific setting of the models by Lucas (1972, 1973), Sargent and Wallace (1975), and Barro (1976a) since Barro distinguished the anticipated and unanticipated components in his money growth equation. This general framework led Barro and Rush not merely to obtain that the fully anticipated components of monetary policy can not influence the real economic variables, but also to avoid the Sargent's observational problem by distinguishing the unanticipated from the anticipated part. To do this, however, they imposed untestable identifying restrictions. That is, Barro tests his model under the constraints that the coefficients of money stock and anticipated components of money are the same. Leiderman (1980) relaxed this constraint to test his model, and obtained the same conclusion as Barro and Rush (1980).

To test the hypothesis that only the unanticipated part of money affects the real variables, Barro (1977a) took a two-step procedure: (a) to quantify the concept of anticipated and unanticipated part of the money growth equation at an empirical level, (b) to regress unemployment or output on the unanticipated movement of money growth. Barro tested the NP under the maintained hypothesis of the RE in which he considered the fitted part of OLS (ordinary least square) estimates of money growth equation the same as an investigator's form of the RE.

The key to the Barro model is to find the proper money growth equation to allow one to distinguish the basic two components, anticipated and unanticipated, of money. Using annual observations from 1941 to 1973, he found that the variables such as a measure of federal government expenditure relative to normal, lagged unemployment, and two lagged values of money growth turn out empirically to have a systematic effect on U.S. money growth. Then, he assumed anticipated money growth is the prediction that could have been obtained by exploiting the systematic relation between money growth and this set of independent variables. Barro's (1977a) money growth equation can be written as follows;

$$DM_t = c_0 + c_1 DM_{t-1} + c_2 DM_{t-2} + c_3 FEDV_t + c_4 U_{t-1} + u_{1t} , \tag{3.2.3A}$$

where DM = the annual growth of average M1, FEDV = an index of the deviation of actual government expenditure relative to the normal value, U = an index of the annual average unemployment rate, and c's = fixed parameters. The basic implications [13] of the equation (3.2.3A) are: (a) the effect of the lagged rate of money growth presumably is to pick up any element of serial dependence or lagged adjustment which have not been captured by the other explanatory variables, (b) a measure of federal government expenditure relative to normal is to capture an aspect of the revenue motive for money creation, and (c) a lagged measure of the unemployment rate is to reflect the countercyclical response of money supply and optimal public finance considerations.[14]

The second step of Barro's study is, as mentioned earlier, to utilize the equation (3.2.3A) to analyze the following unemployment equation.

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[13] See, Barro (1977a, p. 104).

[14] Barro argued that a positive response of money growth to the lagged unemployment rate could reflect two elements: (a) there could be a contercyclical policy response of money to the level of economic activity, and (b) a decline in real income lowers holdings of real balances, which would reduce the amount of government revenue from money issue for a given value of the money growth rate. He pointed out, however, that his empirical analysis does not separate out these two possible sources of countercyclical money response.

$$UN_t = a_0 + a_1(DM - \hat{DM}_t) + a_2(DM_{t-1} - \hat{DM}_{t-1}) + a_3(DM_{t-2} - \hat{DM}_{t-2}) + a_4 MIL_t + a_5 MINW_t + u_2 t \, , \quad (3.2.3B)$$

where UN = an index of the annual average unemployment rate, $\hat{DM}$ = the fitted value of DM using the systematic part of equation (3.2.3A), MIL = a measure of military conscription, MINW = a minimum wage variable, and a's = fixed parameters.

Equation (3.2.3B) indicates the unemployment rate depends on current and lagged values of unanticipated money growth, and on two exogenously treated variables: a measure of military conscription, and a minimum wage variable.[15] This equation suggests only the unanticipated movement of money growth can affect the unemployment rate. In other words, the fully anticipated component of the rate of money growth has no influence the actual rate of unemployment. For this hypothesis to be operational, we need to specify a scheme of agents' formation of money growth anticipations. Under RE a forecasting money growth equation is formed by using the systematic component of equation (3.2.3A) which is assumed to represent the model's conditional expected value of money growth as a function of the variables relevant for its determination, i.e., the variables in the right-hand side of equation (3.2.3A).

With this two-step procedure Barro performed the test using annual observations of the U.S. time series from 1941 to 1973. The result was very supportive for his prior hypothesis - only the unanticipated part of money movement has real effects on the unemployment. Barro drew some policy implications, one of which implies the systematic feedback from unemployment to money growth appears in equation (3.2.3A), has no implication for the time path of unemployment itself - a result that accords with the theoretical NP in Sargent and Wallace (1975) and Barro (1976).

[15] Barro (1977a, pp. 106-107) explained the rationale for including these variables.

Barro (1978) extends his earlier study (1977a) up to the point of analyzing output and inflation with the same econometric procedure. The analysis of output is, therefore, more similar to unemployment reviewed earlier, except (a) sample periods are extended up to 1976, and (b) World War II observations are now less heavily weighted[16] than postwar values.

The noticeable extension of the Barro (1978) study, however, relates to the price level or GNP deflator. The price determination is much more complicated than output determination because both anticipated and unanticipated movements of money are involved. Once Barro (1978) estimated output and price equations, he had derived the dynamic[17] Phillips curve relationship. He argued, however, this could not be used as a policy menu since it could not guarantee the improvement of welfare.[18] Although a period surrounding a discrete change in policy structure might be marked by substantial uncertainty and difference of opinion, as Barro pointed out, it seems just as likely average expectations would lead rather than lag, the actual actual changes in policy.[19]

The Barro-Rush (1980) study extends the previous two studies of Barro (1977a,

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[16] Barro argued this differential weighting is appropriate because of the larger error variance which apparently prevailed during the war. See, Barro (1978, p. 550).

[17] This dynamic relationship could be derived from the simultaneous test of output or unemployment and price equations, so the coefficients of each equation, can be compared.

[18] Taylor (1975) has a different view in which unanticipated monetary changes can be engineered by the monetary authority in a systematic, presumably countercyclical manner. This approach assumes, first, that individuals do not appreciate that the monetary authority is pursuing a policy of systematic deception (which could produce an unstable situation) and, secondly, the private sector is in a reactive position vis-a-vis an activist, independent policymaker. Under these two conditions, the economic agents are naturally viewed as adopting its expectations gradually to shifts in policy. For these reasons, Taylor has a different interpretation of the dynamic Phillips curve: the average expectation would always lag, rather than lead, the actual changes in policy.

[19] Barro argued, if policy changes themselves reflect the workings of the political process or developments in the domestic or international economy, there is no reason to believe the (average) expectation of change in policy structure would lag behind the actual change.

1978). The main extensions were associated with the following: (a) to compare the results of annual to quarterly data, (b) to update and refine the earlier studies (Barro 1977a, 1978), and (c) to concern joint, cross-equation estimation and testing of the money growth, unemployment, output, and price equation. Barro (1977a, 1978) performed a number of tests of the NP in which money influences real economic variables such as unemployment, and which output only operate in the form of unanticipated movements, DMR = DM - $\hat{DM}$, where $\hat{DM}$ is estimated money equation from a relation of the form of equation (3.2.3A). These tests imply that fully perceived changes in money have an one-to-one, contemporaneous effect on the price level. Barro-Rush (1980) argued, however, the best way to test these hypothesis is to jointly estimate the money growth, unemployment, output, and price equations. This joint estimation appropriately allows as to estimate the coefficients in the money growth equation to take into account the effect on the fit of the other equations through the calculation of DMR values.[20] In the two-step procedure described in equations (3.2.3A) and (3.2.3B), the coefficient estimates of the (3.2.3A) consider only the fit of the money growth equation.[21] This is because, as mentioned earlier, Barro (1977a, 1978) had imposed restrictions that the coefficients of money stock and anticipated part of money are the same.

To do this, they simply rewrote the (3.2.3A) as follows. That is,

$$DM_t = F(X_t) + DMR_t \,, \qquad (3.2.3C)$$

[20] With respect to this point, Leiderman (1980) extended the Barro and Rush (1980) study by using the FIML (Full Information Maximum Likelihood). To see the difference between Barro and Rush (1980) and Leiderman (1980), refer to Leiderman's paper (1980, pp. 73-80). With this FIML method Leiderman could not reject the null hypothesis that only the unanticipated movements of money can affect the real variables such as unemployment and output. The disadvantage of this method, as in Mishkin (1982), is that it does not allow to correct the degree of freedom problem.

[21] See Leiderman (1980) for a discussion of this matter.

where X_t is a set of explanatory variables of money equation, that is,

$$F(X_t) = c_0 + a_1 DM_{t-1} + a_2 DM_{t-2} + c_3 FEDV_t + c_4 \log(U/1-U)_{t-1}.$$

With the condition, $DMR_t = DM_t - F(X_t)$, they substituted the right-hand side of it into the place of DMR in unemployment, output, and price equations. The system could be estimated in an unrestricted manner by allowing separate coefficients on the variables - DM_{t-1}, DM_{t-2}, ... contained in $F(X_t)$, $F(X_{t-1})$, etc., in each of the equations. The underlying unanticipated money growth hypothesis, which corresponds to a set of nonlinear coefficient restrictions across the equations, is that $F(X_t)$ in the unemployment, output, and price equations amount to the coefficients in the money growth equation. They used a likelihood ratio test to check whether the imposition of these restrictions on this joint test estimation implied by the anticipated money growth hypothesis is statistically significant or not.

With this procedure they improved the fit of the unemployment and output equation relative to the equations estimated by the two-step procedure. Even though coefficients of DM_{t-1} were reduced (.44 to .36)[22], the estimated standard error of the lagged unemployment rate coefficient declines sharply. The joint test of three equations - money growth, unemployment, and output equations - could not reject the hypothesis which only unanticipated component of money has a real effect on real variables such as output and unemployment. Interestingly enough, however, this hypothesis could be rejected if the price equation is included.[23]

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[22] See, Barro and Rush (1980, pp. 24, 28).

[23] Barro (1978) and Barro-Rush (1980) accepted that their price equation is not well specified. Gordon (1980) criticized the Barro and Rush price equation because they failed to distinguish (continued...)

A number of objections have been focused on the Barro (1977a and 1978), Barro-Rush (1980) works. Small (1979) criticized Barro's (1977a) work in the following ways. Small first noticed Barro's (1977a) money growth equation could be differently specified by carefully considering the government expenditure (FEDV in Barro model). That is, the different policy results could be obtained by treatingly differently the periods before and after World War II. Small (1979) argued money creation should be greater over the given time interval in the case of the temporary increase.[24] This implies that the coefficient on FEDV should be greater when the increase in federal expenditures being measured by FEDV is temporary. The failure to allow this coefficient to vary may result in a systematic underprediction of the rate of growth of the money supply during periods of temporary increases in federal expenditures since Barro's (1977a, p. 103) sample period includes 'periods of wartime during which there are sharp temporary increases in government budget'. The second criticism concerns the natural rate of unemployment of Barro's model by carefully reconsidering MIL variables.[25] Small asserted, an increase in the estimated natural rate of unemployment due to a change in the MIL seems to be a major reason for the ability of Barro's unemployment equation to track the increase in the actual unemployment rate[26].

23(...continued)
between short run neutrality of NC view and long run neutrality. From this fact, Gordon (1982) actually advanced the model of NRH-GAP approach. See this in the section (3.2.6).

[24] Assuming investment is subject to increasing marginal costs, increased taxation is less attractive when given increase in expenditures is temporary rather than permanent.

[25] Barro (1979) disagreed with the first criticism, but he accepted Small's second criticism by concluding 'the analysis of real determinants of unemployment is less secure'. We will discuss the natural rate of unemployment in Barro's model when we examine Mishkin's (1982) work below.

[26] See Small (1979, p. 1000, footnote 10).

Many other economists also criticized Barro's series of works. Among them, there are Blinder (1980), Gordon (1980), Weintraub (1980) who attended the workshop of RE and economic policy.[27] Most of the criticisms concern Barro's specification of money growth and price equations. As we saw earlier, Gordon showed that the entire battery of econometric tests used in the three papers of Barro (1977a, 1978) and Barro and Rush (1980) is useless for purposes of distinguishing the radical implications of the MRE model from the familiar conclusions which emerge from NRH-GAP model based on inertia in the adjustment of prices. Rush (1986) challenged Barro's model by arguing that there is a possibility of money endogenuity. As an alternative, Rush used the base money as the monetary aggregate. This controls in part for possible endogenuity of the M1 money supply typically used by other researches. The results from Rush's paper gave strong support for the view that RE models provide insight into the causes of the business cycle, particularly during the normal period. The RE emphasis on unexpected monetary shocks is, though, incapable of explaining the depression during the 1930s.

[27] See more details in Fischer's (1980, pp. 55-63) editing book is in the reference.

3.2.4. The Mishkin Model

Mishkin's model can be described as follows.

$$y_t = y_{nt} + \sum_{i=0}^{\infty} d_i(M_{t-i} - M^e_{t-i}) + w_t , \tag{3.2.4A}$$

$$M_t = Z_t b + u_t , \tag{3.2.4B}$$

$$M^e_t = Z_t b , \tag{3.2.4C}$$

$$y_t = y_{nt} + \sum_{i=0}^{\infty} d_i(M_{t-i} - Z_{t-i} b) + w_t , \tag{3.2.4D}$$

Where y_t = unemployment or output at time t, y_{nt} = natural level of unemployment or output at time t,[28] M_t = money growth at time t, M^e_t = anticipated M_t conditional on information available at time t, d_i, b = vectors of coefficients, w_t, u_t = error term, and Z_t = a vector of variables know at time t-1. Here u_t is assumed to be uncorrelated with any information available at the time t which includes Z_t or u_{t-i} for all i≥1, and hence, u_t is a white noise.

Equation (3.2.4A) is Mishkin's basic one. Equation (3.2.4B) is used to generate optimal, linear forecasts. Equation (3.2.4C) is an optimal forecast for M_t conditional on information available at time t-1. The equation (3.2.4D) results from substituting the equation (3.2.4C) into the one (3.2.4A).

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[28] For equation (3.2.4A) to be operational, we need a proxy for the natural rate of output or unemployment. To do this, Barro and Mishkin both used a proxy variable for the natural level of output or unemployment such as a constant and linear time trend. There are, however, other possible proxy variables like labor productivity where technical progress is another determinant of the natural rate of output.

In estimating this type of NC model, there exist two identification problems: (a) an orthogonality condition is required to identify the d-coefficients, and (b) observational equivalence problem can not be avoided if the vector, Z, included only lagged values of M_t and at the same time there are no restrictions upon the lag length.[29] The model in the (3.2.4D) is observationally equivalent to natural and unnatural rate of unemployment or output models since they, as mentioned in earlier pages, could not be distinguished from each other (Sargent 1976). To overcome this observational equivalence problem, therefore, at least the lagged values of one other variable besides money, which does not enter the equation (3.2.4D) separately from the $\sum_{i=1}^{\infty} d_i(M_{t-i} - Z_{t-i}b)$ term, must be included.

In contrast with the models in the previous sections,[30] Mishkin imposed two sets of restriction, neutrality and rationality to jointly estimate the equations (3.2.4B) and (3.2.4D). The neutrality restriction implies the vector of coefficients of anticipated part of money must be zero. That is, we could formally write the equation (3.2.4D) as

$$y_t = y_{nt} + \sum_{i=0}^{k} d_i (M_{t-i} - Z_{t-i}b) + \sum_{i=0}^{k} c_i M^{*}_{t-i}b + w_t , \qquad (3.2.4E)$$

[29] Because of the observational equivalence problem, Grossman (1979) cannot, and does not, test using Barro's (1977) procedure for determining whether the anticipated nominal GNP growth variables significantly add to the explanatory power of this output equation model. Instead, Grossman reports results supporting the MRE hypothesis which rely on flimsy grounds for identification, namely the assumption that the lag length on the nominal GNP growth cuts off at six quarters.

[30] Leiderman (1980) also estimated his model with a joint estimation procedure which enabled him to relax the untested constraints of the same coefficients of money stock and the anticipated component of money because Barro (1977a, 1978) tested his models under this untested restrictions.

where c_i = vector of coefficients for the expected component of money. The latter constants could be represented as

$$y_t = y_{nt} + \sum_{i=0}^{k} d_i (M_{t-1} - Z_{t-i} b^*) + \sum_{i=0}^{k} c_i M_{t-i} b^* + w_t , \tag{3.2.4F}$$

where b = b*. Therefore, the joint test for these restrictions involves a likelihood ratio test of whether the equations (3.2.4B) and (3.2.4D) system satisfied the rationality constants (b = b*) as well as the neutrality conditions (c_i).

The test-procedure that Mishkin adopted was a nonlinear least-square estimation which enabled him to impose the necessary covariance restrictions and a desirable degree-of-freedom correction which result in more conservative likelihood ration statistics; this would not have been possible with a standard FIML package. With this procedure Mishkin conducted the estimation of the constrained equations (3.2.4B) and (3.2.4D) system with the usual identifying assumption used in the earlier studies on this issue, that the unemployment or output equation (3.2.4D) is a true reduced form. In the case where only the contemporaneous M - M* appears in equation (3.2.4D), the imposition of this assumption, even if it is untrue, will not invalidate the test statistics on the rationality and neutrality hypotheses. Mishkin could not, however, be certain that this desirable result - the above assumption does not matter to the test here - carries over the case where lagged M - M* enters the equation (3.2.4D).

The advantage of Mishkin's estimation method was that it enabled him to see whether the rejection of the joint hypothesis of neutrality and rationality are due to nonrational expectations or to the fact that anticipated policy matters.[31] The construction of a likelihood ratio test could be conducted as follows: (a) test for neutrality alone under the maintained hypothesis of rational expectations, and (b) test for rational expectations alone under the maintained hypothesis of neutrality. In his settings, Mishkin conducted a likelihood ratio test of the former in a way that the rationality cross-equation restrictions are imposed, and the constrained system would be the equations (3.2.4B) and (3.2.4D), while the unconstrained system the equations (3.2.4B) and (3.2.4F). For the latter to be tested, the constrained system is (3.2.4B) and (3.2.4F) imposing the condition $b = b^*$, and the unconstrained system is the equations (3.2.4B) and (3.2.4F) with the relaxed rationality condition. In the course of estimation, Mishkin faced three problems because of his sample: (a) degree of freedom, (b) length of lag pattern, and (c) the serial correlation properties of the error term, w_t, of the equations (3.2.4D) and (3.2.4F).[32]

As is usual in the literature, the first important feature of Mishkin's study is a specification of money growth equation since theory of RE implies the anticipated money growth variable in equation (3.2.4A) is an optimal, one period-ahead forecast, conditional on available information. If equation (3.2.4A) is assumed to generate a true forecast of money growth, then the degree of its prediction power should rely only on lagged independent variables of the right-hand side of the equation (3.2.4B).[33]

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[31] This is important since this enables him to find the relevance of rational expectations to neutral policy result. In other words, this led him to find whether neutral policy result solely comes from the rational expectations. From this, we can find the alternative models such as Fischer (1977) in the literature.

[32] To see how to correct these small sample problem, refer to Mishkin (1982, pp. 27-29).

[33] Since economic theory does not, as Mishkin indicated, provide the proper length of lag pattern, an atheoretical or empirical statistical procedure might be superior to economic theory for deciding on the specification of money growth equation.

The other important feature is that Mishkin allowed more lags in his output or unemployment equation by arguing, 'experimenting with plausible, but less restrictive models is a necessary strategy for verifying the robustness of results'. This differs significantly from earlier studies as well as the estimated procedure. Further, a rejection at a standard significance level in a less restrictive model is even stronger evidence against the null hypothesis in the sense that rejections for it are less likely when the power of a test is reduced by the addition of irrelevant variables. These facts would justify the suggestion that models with longer lag-length are worth studying.

Mishkin's resultant money growth equation is quite different from the earlier ones. That is, his money growth equation could be written as

$$\begin{aligned} M1G_t = \; & \text{constant} + a_1 M1G_{t-1} + a_2 M1G_{t-2} - a_3 M1G_{t-3} - a_4 M1G_{t-4} \\ & - b_1 RTB_{t-1} + b_{t-1} 2RTB_{t-2} - b_3 RTB_{t-3} + b_4 RTB_{t-4} \\ & - c_1 SURP_{t-1} - c_2 SURP_{t-2} + c_3 SURP_{t-3} - c_4 SURP_{t-4}, \end{aligned} \tag{3.2.4G}$$

where M1G = average quarterly rate of M1 growth, RTB = average treasure bill rate, SURP = employment surplus, and a's, b's, c's = fixed parameters.[34] With this specification it passed the significance level of F-test, the Chow-test to check whether the coefficients of the equation are stable.

With this money growth specification Mishkin conducted the tests for the joint hypothesis of rationality and neutrality constraints. In every area of the tests, surprisingly enough, he obtained results exactly opposite to earlier studies: anticipated monetary

[34] Weintraub (1980) also found the money growth equation which included the interest rate by questioning the rubustness of the Barro and Rush (1980) money growth equation.

policy seems to matter.[35] The rejections of the null hypothesis come from the neutrality rather than the rationality constraints. Furthermore, these different policy results are sensitive to both the length[36] of lag structure and different econometric methodology adopted. Therefore, Mishkin's study not only casts doubt on the previous studies in this line, it indicates further research into the reasons for such long lags under RE is needed. We can see that the policy results are very sensitive to the dynamic structure of the model.

Mishkin's stuoy also suffers from two difficulties. First, if the different policy results are due to the different specification of output or unemployment equation, then its robustness would be questioned. Secondly, as McCallum (1982) pointed out, Mishkin assumed stationary movements of output or unemployment . If this is not true, then Mishkin's study can be questioned.

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[35] Mishkin (1982) also conducted a series of tests of the joint hypothesis using fiscal policy variables such as GNP, however, we will exclusively focus on the effects of money on output or unemployment.

[36] When the length of lags is restricted up to the seven, the results supported the joint hypothesis, but did not in longer than 20 lags.

3.2.5 The Frydman and Rappoport Model

Frydman and Rappoport (1985) argued the distinction of anticipated and unanticipated money has nothing to do with policy results of neutrality or nonneutrality. Their argument that a mismeasurement of RE, when investigator's information set is smaller than the agents', questions the studies we have discussed in the previous sections. Therefore, they advanced the hypothesis which has since called 'irrelevance of the Anticipated and Unanticipated Distinction (IAUD)'. The hypothesis is that the values of coefficients of anticipated and unanticipated movement of money are exactly the same in the presence of a mismeasurement of RE.

To see this, the model could be set up as

$$y_t = y_{nt} + \sum_{i=0}^{k} d_i(M_{t-i} - M_{t-i}^{*}) + \sum_{i=0}^{k} c_i M_{t-i}^{*} + w_t \ , \tag{3.2.5A}$$

$$M_t = Z_t b + u_t \ , \tag{3.2.5B}$$

This is exactly the same as in the Barro and Mishkin models. The hypothesis of the IAUD is then simply, d = c, where both are vectors of coefficients. If this is true, then the output or unemployment equation could be rewritten as

$$y_t = y_{nt} + \sum_{i=0}^{k} h_i M_{t-i} + w_t \ . \tag{3.2.5C}$$

Equation (3.2.5C) simply raises the question of whether money affects output or unemployment, that is, whether h = 0. This hypothesis can be tested. However, this is very complicated because the hypotheses of d = c and h=0 are nested each other. For this reason, Frydman and Rappoport (1985) provided more easily interpretable evidence by testing d = c = 0.

To test these nested hypotheses, we need to have a proxy variable for expectations, M^*. Following the practice of Barro and Mishkin, Frydman and Rappoport take $Z_t b$ in equation (3.2.5B) as their measure of expectations. This is typically described as the assumption of RE, although $Z_t b$ is not an exact measurement of RE when the agent's information set is larger than Z_t. In order for the output equation to be rewritten correctly once this substitution is made, it is necessary to decompose agents' RE money into measured and unmeasured parts. Frydman and Rappoport define, M^{r*}, as

$$M^{r*} = M_t - e_t, \tag{3.2.5D}$$

where e_t = a white noise from agents' RE. The projection of M^{r*} on the smaller information set used by the investigator yields

$$M^{r*} = Z_t b + v_t, \tag{3.2.5E}$$

where Z and v are contemporaneously orthogonal by construction. Here v, which is not necessarily a white noise, is the investigator's error in measuring RE, since the 'instrument' $\hat{Z}_t b = \hat{M}^*$ is used to proxy RE. Substituting $\hat{M}^*$ into (3.2.5A) yields

$$y_t = y_{nt} + \sum_{i=0}^{k} d_i (M_{t-i} - \hat{M}^{r*}_{t-1}) + \sum_{i=0}^{k} c_i \hat{M}^{r*}_{t-i} + n_t \,,$$

or equivalently,

$$y_t = y_{nt} + \sum_{i=0}^{k} d_i (M_{t-i} - Z_{t-i} b) + \sum_{i=0}^{k} c_i Z_{t-i} b + n_t \,, \tag{3.2.5F}$$

$$n_t = \sum_{i=0}^{k} (c_i - b_i)\, v_{t-i} + w_t \,, \tag{3.2.5G}$$

The decomposition of equation (3.2.5D) leads one to rewrite the corresponding output or unemployment equation (3.2.5F). The equation (3.2.5E) represents the money growth equation of the investigator in the presence of a measurement error of his or her RE. The equation (3.2.5F) is a resultant output or unemployment equation in this situation. The basic model to be estimated is represented by the system of equations (3.2.5B) and (3.2.5F). As in the equation (3.2.5G), however, the problem of a measurement error of rational expectations would disappear if and only if d = c. This fact guarantees the validity of the statistical inferences on the estimation of output equation (3.2.5F).

Frydman and Rappoport (1985b) argued that two-step procedure is as efficient as the FIML under the IAUD hypothesis.[37] Intuitively, this occurs because the IAUD hypothesis reduces (3.2.5A) to (3.2.5C) where expectations are not involved. Since their errors are assumed to be uncorrelated with each other, that is, $Cov(u_t, w_t) = 0$, the FIML estimation results in statistics with the same properties as single equation estimation. For these reasons, they used the two-step procedure. While the first step allows proxies or the regressors in the equation (3.2.5A) related to the expectations, this could not be regressed until a proxy for the natural level of output or unemployment is found. Thus we might write the output or unemployment equation as

$$y_t = \sum_{i=0}^{k} d_i (M_{t-i} - \hat{M}^{re}_{t-i}) + \sum_{i=0}^{k} c_i \hat{M}^{re}_{t-1} + N_t f + e_t \,, \tag{3.2.5H}$$

where N_t = a list of variables, on which data are available and to which y_{nt} is related, and f = vector of parameters. Here e_t is assumed

$$e_t = \sum_{i=0}^{k} k_i e_{t-i} + w_t \,, \tag{3.2.5I}$$

where k_i's are parameters. Then the natural rate of output or unemployment could be

[37] For better discussion of the point, refer to their paper (1985b, pp. 8-10).

written as

$$y_{nt} = N_t + \sum_{i=1}^{k} k_i e_{t-1} \ , \tag{3.2.5J}$$

The parameters of equations (3.2.5H) and (3.2.5I) could be estimated jointly by iterative generalized least squares (GLS) after submitting the resultant equation from the first-step into output or unemployment equation (3.2.5H). In sum, their estimation procedures are as follows:

(a) Estimate the equation (3.2.5B) by OLS, to yield $Z_t b$ where $\hat{b}$ = estimate of b,

(b) Substitute $\hat{M}^{e}$ into the output or unemployment equation (3.2.5H) and

(c) Estimate the equations (3.2.5H) and (3.2.5I) jointly by GLS.

The first step (a) is quite similar to the approach of the earlier studies such as Barro and Mishkin. Frydman and Rappoport, however, considered three new decisions of specifications of output and/or unemployment equation (3.2.5H) as follows:

(i) The nature of natural rate of output or unemployment,

(ii) The degree of the order of the autoregressive model in the equation (3.2.5I), and

(iii) The length of the lag distributions on the anticipated and unanticipated money growth in the equation (3.2.5A).[38]

With this in mind, they found that the IAUD hypothesis is supported by the data

[38] To see this more, refer to their paper (1985b, pp. 12-14).

except in a model with longer lag distributions.[39] Once we know that the IAUD hypothesis is supported by the data, we need to estimate equation (3.2.5C). From this, they found the coefficient of the equation (3.2.5C), h_i is statistically significant. That is, in the context of their framework, the null hypothesis that money has no effect at any lag (h = 0) is soundly rejected in all cases. They also present the results on the hypothesis that the permanent effect of money growth on output is zero (h_i = 0).[40] In their framework, therefore, money is nonneutral both in the short and in the long run in light of their sample period. Comparing it to the models of Barro and Rush (1980), and Mishkin (1982), as they argued, the results drawn from the IAUD hypothesis suggest that there are (although there is an exception of the longer lag distributions) no grounds for believing the effects on output or unemployment of anticipated and unanticipated money growth are different.

[39] They found that the IAUD hypothesis is only rejected where the lag length is extended up to 25 quarters over their data (1954:I - 1976:IV). The results are slightly more ambiguous for the models of Barro and Rush (1980), and Mishkin (1982). See more of these in their paper (1985b, p.15, table II).

[40] The hypothesis is rejected at the 5% level for all models, although at the 1% level it is survived in the twenty-lag case. See the table V (Frydman and Rappoport 1985b, p. 17).

3.2.6 The Gordon Model

The studies in the previous sections assumed that prices are perfectly flexible under RE. Fully perceived movements in the money stock have equiproportional and contemporaneous effects on the price level (Barro 1978). Gordon (1982), however, took a different approach to test the NP. He proposed an alternative hypothesis in which prices respond fully in the long run, but only gradually in the short urn, to nominal aggregate demand disturbances. In this respect, his model is fully compatible to the one of the long run NP of Friedman (1968).[41] Gordon focused on the difference between anticipated and unanticipated components of money.

Gordon (1982) contributed to the literature in the following ways: (a) he compared and tested the NP[42] of Lucas (1972, 1973), and Sargent and Wallace (1975) with the plausible alternative competing hypothesis underlying conventional analysis of monetary policy, that is, prices adjust gradually to nominal demand changes whether anticipated or not, (b) he has his extended sample span of 1890 to 1980, which is of course independently interesting, and (c) he suggested three alternative methods of introducing persistent output effects into the 'NC' feature.

To begin with, Gordon (1932) advanced the model by assuming, as mentioned earlier, that price changes deviate or adjust gradually from the inherited rate of price change in response to either demand or supply shocks. To represent this, Gordon (1982) presumed the equation as below. That is,

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[41] Gordon (1982) referred to his model as natural rate hypothesis and gradual adjustment of prices (NRH-GAP) which is the hybrid of the Friedman's long run neutrality and gradual price adjustment.

[42] Gordon (1982) called this as the LSW (Lucas-Sargent-Wallace) policy ineffectiveness proposition.

$$P_t = a(L)P_{t-1} + b_0\hat{Q}_t + b_1\hat{Q}'t + b_2Z_t + e_t\ ,$$

(3.2.6A)

where $\hat{Q}$ = difference between log of output (Q_t) and log of natural rate of output (Q^*_t), $\hat{Q}'$ = change of this ratio, P = price, Z_t = supply shock variable, a(L) = polynomial in the lag operator (to represent the influence of inheritant price change by a general lag distribution on past prices), and e_t = serially independent error term with mean zero.[43] If the sum of the a(L) coefficients is unity, then it combines gradual price adjustment with long run neutrality (NRH-GAP) since, in this case, the rate of price change remains constant when $\hat{Q}_t = Q_t - Q^* = 0$ and $Z_t = 0$.

To directly (and conveniently) compare his model to the one of Lucas (1972, 1973), Sargent (1973), and Sargent and Wallace (1975), Gordon (1982) rewrote the equation (3.2.6A) as

$$P_t = c(L)P_{t-1} + d_0\mathrm{E}\hat{y}_t + d_1U\hat{y}_t + d_2Q_{t-1} + d_3Z_t + u_t,$$

(3.2.6B)

where c(L) = polynomial lag operator, E = anticipated, U = unanticipated, and d_i = parameters. With this equation (3.2.6B), Gordon (1982) tabulated two alternative views of 'NC' approach and 'NRH-GAP' approaches. That is, Gordon (1982) argued, as in Table (3.2.6A1), the NP in the sense of 'NC' approach is a special case of the equation (3.2.6B).[44]

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[43] The theoretical justification for the equation (3.2.6A) was examined in Gordon (1981).

[44] Here we do not show the equation resulted form the derivation of the equation (3.2.6A) by using the identity that the nominal output could be split into real output and price, y = P + Q in Gordon's version. Accordingly, the coefficients in the Table V is rough. for further discussion, See Gordon (1982).

Table 3.2.6A1: Comparison of NC and NRH-GAP approaches

Variable	Coefficients in NRH-GAP Hypothesis	Coefficients in Special NC view
P_{t-1}	$c_i > 0$	$c_i = 0$
$E\hat{y}_t$	$d_0 < 1$	$d_0 = 1$
Uy_t	$d_1 < 1$	$d_1 < 1$
$\hat{Q}_{t-1}$	$d_2 < 1$	$d_2 < 1$

From the above (3.2.6A1), we found three important differences between these two approaches: (a) since the NC approach assumed no price inertia (perfect price flexibility), the sum of coefficients on the lagged price change, c_i, is zero whereas, it is positive in the NRH-GAP approach, (b) the NP implies that the elasticity of price change to an anticipated change in nominal demand is exactly unity (Barro, 1978), with other determinants of output held constant, whereas, it must be less than unity in the NRH-GAP approach, and (c) the coefficients on unanticipated demand changes in the NC approach must be less than unitary response to anticipated changes, whereas in the alternative approach the response of prices to anticipated and unanticipated changes is identical. Because of the identity that nominal output could be split into real output and price, we could obtain a dual output equation for the (3.2.6B). That could be written as

$$\hat{Q}_t = - c(L)P_{t-1} + (1 - d_0)E\hat{y}_t + (1 - d_1)Uy_t + (1 - d_2)\hat{Q}_{t-1} - d_3Z_t - u_t. \quad (3.2.6C)$$

Gordon's purpose (1982) is, then, to estimate[45] the equations (3.2.6B) and (3.2.6C) so

[45] To estimate these equations, Gordon faced the problems as follows: (a) observational problem due to lagged unanticipated output or unemployment (Uy) in the right-hand side of each (continued...)

as to enable a check of the fit of the two alternative hypotheses. In other words, the econometric estimation of the dual equations (3.2.6B) and (3.2.6C) is to determine whether the estimation of coefficients, c and d, are consistent with the given hypothesis.

Gordon (1982) conducted the estimation with the two-step procedure. At the first stage of the estimation, he split up observed changes in nominal GNP and money into their expected and unexpected components in which the right-hand side variables included four lagged values of changes in nominal GNP, money, GNP deflator, and two lagged values of the commercial paper rate. The important findings at this stage for his subsequent analysis are not the values of their estimated coefficients but: (a) within the given sample period the fluctuations in all variables are greater before the year 1954 than after, with some exceptions,[46] (b) the variances of expected money change in every period and all period but two for nominal GNP change,[47] and (c) nominal GNP were much more variable thereafter.[48]

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[45](...continued)
equation; most of the previous empirical studies have attempted to identify the coefficients in equations for output and unemployment by constraining particular variables to influence expected money growth but not to affect output directly, and (b) the decomposition of aggregate demand growth into its anticipated and unanticipated components ($E\hat{y}_t$ and Uy_t) and the selection of proxy variables to represent systematic supply shocks (Z_t). To avoid the former, Gordon accepted the suggestion of McCallum (1982) that lagged values of Uy_t are excluded from the output or unemployment equation, which would, thus, constrain lagged values of y_t to enter only to the extent they are significant at the first stage equation used to predict $E\hat{y}_t$.

[46] Refer to Gordon's (1982, p. 1100) Table 1.

[47] The NP does not necessarily require that expected money have a low variance, but only that its movements are completely reflected in price changes and uncorrelated with output movement. For this reason, it is interesting to note that the standard deviation of output changes was double or triple that of price changes in some of the periods and was lower only in 1915-22.

[48] Gordon (1982) also conducted the stability test of nominal GNP and money obtained from the first stage estimation by following the Sargent's (1976b) suggestion. This kind of test was first performed by Neftci and Sargent (1978) as in the section (3.2.2). Gordon obtained a little different result from them. See, Gordon (1982).

At the second stage Gordon directly tested the equations (3.2.6B) and (3.2.6C) by fitting in the results from the first stage estimation. He found that the NP is unambiguously rejected, and that the NRH-GAP hypothesis is conformed in all sample periods. The coefficients on Ey_t in both price and output equations are highly significant. Furthermore, lagged prices are highly significant in all equations, with the signs as predicted by the NRH-GAP hypothesis and with a tendency of the sum of lagged price coefficients to increase over time (from .40 in 1892-1929 to 1.06 in 1954-1980) which suggests that there is a growing role of inertia in the price adjustment process.

Gordon (1982) criticized the earlier tests of NP by arguing, only levels or changes in the money supply were used as the exogenous demand shift variable, without any attention to nominal GNP, for these tests implicitly assumed changes in velocity have no systematic effect on prices or output, that is, that velocity is a random serially uncorrelated variable. Gordon (1982) conducted alternative tests by creating an equivalent pair of variables of using the previously described series on anticipated and unanticipated changes in nominal GNP and money for velocity changes,

$$\mathrm{E}v_t = \mathrm{E}\hat{y}_t - \mathrm{E}\hat{\mathrm{M}}_t \; ; \; Uv_t = Uy_t - UM_t .$$

The second-stage equation is then reestimated by substituting these split terms in the nominal GNP term. If only money mattered and velocity were truly a random variable, then the coefficients on velocity changes would be equal to zero. Gordon, however, found this is not the case. Furthermore, the fit of the equations (3.2.6B) and (3.2.6C) with considering the velocity of money, is an improvement over the original ones. This may be, as noticed earlier, related to the fact that anticipated velocity changes are more volatile than anticipated money changes prior to the year 1954. Thus, relatively more of the variance of EV_t consists of a temporary component than that of $E\hat{M}_t$. Since the NRH-GAP hypothesis implies that prices respond more to anticipated permanent than anticipated transitory demand shifts, the pattern of coefficients seems supportive for that hypothesis. For this reason, the crucial weakness of the earlier studies in this line is the estimated coefficients of price and output response to anticipated in money have been estimated in the equations omitting velocity changes.

The final important feature of Gordon's work, is that he introduced a persistence of the Lucas-Sargent supply function with the lagged money supply.[49] This involves the inclusion in the output equation of a long distributed lag of past money supply. This method is popular in the literature [Barro (1977a, 1978), Barro and Rush (1980)]. Gordon argued that this method is rejected in two reasons: (a) to avoid the observational equivalence problem by adopting the McCallum's (1982) suggestion that bygones are bygones, and (b) to avoid a poor fit to the data on real output. To illustrate the second point, Gordon regressed the output ratio without the persistence variables used previously (the lagged output ratio and changes in inventories and unfilled orders) and the lagged price terms suggested by the NRH-GAP hypothesis. The resulting equation has a bigger standard error than that of the equation with the above variables. Even though this method is used by including a variable like Q_{t-1}, as Gordon showed, the persistent effect of output equation with lagged money surprises can be rejected.[50]

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[49] Besides this, Gordon introduced output persistence with the direct dependence of current and lagged output, and with an inventory and new order mechanism. See, further in Gordon (1982, pp. 1109-1111).

[50] For details, see, Gordon (1982, pp. 1110-1111).

Even though this NRH-GAP conformed to the evidence for the U.S. economy,[51] one must justify the length of adjustment lags (which econometric models showed the order of four to six years to get the eventual effects on price and output). In this context, there are two strands to justify the lag length: (a) contracting theory, and (b) the consequences of decentralized (microeconomic) price setting to attempt to make price-stickiness a system endogenous phenomenon.[52] Furthermore, Thurston (1983) showed that the study of Gordon (1982) suffers from the following problems: (a) the functional form of Gordon's NRH-GAP price-adjustment mechanism is hard to justify, and (b) his estimation method involves possible estimation bias due to the presence of lagged dependent variables. Thurston demonstrated that if Gordon's study were free of these problems, the price adjustment parameters would be increased from his original low values to high, but would still be imperfect, values.

[51] The U.S. economy, as Thurston (1983) argued, conformed to the facts that after changes in aggregate nominal demand (a) price move slowly toward their eventual long term values, that (b) output responses directly to these changes in demand, and (c) these output effects linger persistently over time.

[52] For the former, refer to Fischer (1977), Phelps and Taylor (1977), and Taylor (1979). For the latter, see, Drazen (1980). Refer to Thurston (1983) for the exact citation of Drazen (1980).

3.2.7 The McGee-Stasiak Model

The studies of Gordon (1982) and Mishkin (1982a, 1982b) were questioned by McCallum (1982): (a) if the movements in output and/or unemployment series, as Nelson and Plosser (1982) argued, are nonstationary[53], then the distribution theory embodied in the hypothesis tests of their studies does not apply and casts doubts on their results, (b) the observational equivalence problem in these studies is not satisfactory since they are forced to make some untested restrictions in order to distinguish the anticipated from unanticipated parts of the policy variables in their models, (c) the specifications of their models, especially money growth equations, are not general in the sense that there exist alternative ones, for example, the money growth equations of Barro and Rush (1980), and Mishkin (1982).

Following the McCallum's work, McGee and Stasiak (1986) studied the above problems and presented evidence from an alternative framework on the validity of the NP. They suggested the trivariate autoregressive (AR) representation of growth rates[54] in real GNP, the GNP deflator, and the money supply. To develop their model, they assumed a pure one-period delay[55] in information which enables their model to separate anticipated from unanticipated effects of money growth and inflation on output growth.

Their model can be specified as

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[53] McGee and Stasiak points out: evidence of nonstationarity in Gordon's output series comes from his result that the coefficient on lagged output is consistently close to unity. In Mishkin's work the first-order autocorrelation coefficient for the GLS adjustment for serial correlation is close to one in several cases. Both these results are consistent with Nelson and Plosser's (1982) finding that lagged and detrended output is a nonstationary series.

[54] As Nelson and Plosser (1982) indicate, growth rates of the variables do not exhibit the nonstationary tendencies that detrended levels of the variables exibit.

[55] This assumption follows McCallum's (1982) suggestion. McCallum asserted that this reflects the current RE literature.

$$\begin{bmatrix} y_t \\ p_t \\ m_t \end{bmatrix} = \begin{bmatrix} a_{11}(L) & a_{12}(L) & a_{13}(L) \\ a_{21}(L) & a_{22}(L) & a_{23}(L) \\ a_{31}(L) & a_{32}(L) & a_{33}(L) \end{bmatrix} \begin{bmatrix} y_t \\ p_t \\ m_t \end{bmatrix} + \begin{bmatrix} w_{1t} \\ w_{2t} \\ w_{3t} \end{bmatrix} \tag{3.2.7A}$$

where y_t, p_t, m_t = first differences of the natural logs of real GNP, the GNP deflector, and money supply, respectively, a_{ij} = coefficients of the autoregressive vector, L = lag operator, and w_{it} = random disturbances. To identify this trivariate AR representation, they set the following condition. That is,

$$a_{ij} = 0 \qquad for\ t \neq s,\ i,\ j = 1,\ 2,\ 3,$$

$$Cov\ (w_{it}\ ,\ w_{js}\ ) = 0 \tag{3.2.7B}$$

where i = index of the equation, j = index for indicating the lag, and t, s = time index. These conditions are chosen not only to correlate contemporaneous values of the random terms of the model, but also to make it comparable in the context of other tests of NP in the literature.[56] This is because they are the natural conditions to allow testing the various restrictions that are impied by specific structural reduced form equations that have been used to test the MRE hypothesis. McGee and Stasiak (1986) tabulated the restrictions implied by three alternative theories: pure classical, NC, and NRH-GAP approaches [McGee and Stasiak (1986), p. 21]. In this table they summarized: (a) under the pure classical system all adjustments are completed within one period, (b) under the NC system there is no effect of anticipated inflation or money growth on current output growth, and (c) under the NRH-GAP approach there are no long-run effects of the nominal variables on output.

[56] The identifying conditions dichotimize the past and present. All past influence is exerted on the present realization of the variables through the lag plynomials.

The model has major advantages over those of Gordon (1982) and Mishkin (1982) in the sense that one does not need to estimate the anticipated components of the nominal variables to test the MRE hypothesis. The equation for y_t in the system (3.2.7A)-(3.2.7B) is a reduced form of output equation where the coefficients in a_{12} and a_{13} represent the direct impact of anticipated nominal variables of money and price on output, under the assumption that only the current values of these nominal variables affect the output. In other words, the model provides an alternative to their models for dealing with the observational equivalence problem. They followed Gordon (1982) in adopting McCallum's (1982) one-period-delay solution to the observational equivalence. In addition, it allows one to test any exogenuity assumption of money growth and inflation as a natural consequence of model estimation by virtue of a vector autoregression. In terms of Granger's casualty, the MRE hypothesis implies that neither money nor inflation cause output growth. What is more, the model used growth rates rather than detrended levels of variables to avoid the problems posed when series in question is nonstationary. Finally, and perhaps most importantly, the model does not depend on a priori knowledge of the specific structural model representing the economy.[57]

With this framework they estimated their model with two alternative lag structures: (a) The first estimated the system with an equal number of lags of each variable in each equation, and (b) the second took account of those variables which contributed significantly to the overall regression as a result of a stepwise regression procedure. With these methods they examined residuals of the model by two cumulative autocorrelation tests on the residuals: (a) Box-Pierce Q-statistic which has chi-square distribution, and (b)

[57] In the recent Sims (1989) advanced more of AR vector model. See more features of AR model in his paper.

Durbin F-test which is cumulative equivalent of the Durbin h-statistic.

At the first stage, (a), of estimation they found a white noise property of residuals from the 24-lag case. Their results are basically consistent with the pure classical monetarist point of view about the relationship among the three variables. They could not reject the null hypothesis that the coefficients of each output equation lag polynomial are all zero. They could not reject the null hypothesis that the coefficients of each output equation lag polynomial sum to zero required for long-run neutrality to hold. Also, they could not reject the null hypothesis that coefficients of each output equation lag polynomial sum to zero is required for long-run neutrality to hold. These pieces are supportive for the pure classical and NC view about the effects of nominal variables on output equation. There is, however, a basic inconsistency in the results. This is because null hypothesis that all of the 'a' coefficients are zero is not rejected, and at the same time the contradictory hypothesis that those same coefficients sum to minus one of GAP-NRH approach is also not rejected. Neither test statistic is close to a reasonable rejection level. This contradiction in results indicates the tests are not powerful with 24 lags of each variable in each equation. As McGee and Stasiak (1986) pointed out, therefore, there is a bias toward the classical and NC view with this specification tests.

This problem led them to the second stage of estimation. With a stepwise estimation procedure of different lags of each variables they could identify sufficient variables to whiten the model residuals, although at the same time it eliminates the superfluous variables that weaken the power of the first stage of estimation. Their tests resulted in supporting for the Gordon's NRH-GAP approach in every aspect. Therefore, they could reject the hypothesis embodied in the MRE models.

McGee and Stasiak (1986) concluded that under their alternative approach their results support the findings of Gordon (1982) and Mishkin (1982) that anticipated policy actions influence output in the short run. In addition, they found support for the long-run NP which they were able to test directly in their approach. As McGee-Stasiak themselves point out, however, two caveats apply to their conclusions. First, they exclude all but three variables from our experimental universe. It is, however, possible that by omitting other variables that are important, they have not accurately differentiated the anticipated and unanticipated components of money growth and inflation. The second caveat concerns their solution to the observational equivalence problem. If information delays extend the duration of unanticipated nominal variables' direct impact beyond one period, "bygones are not bygones" and their conclusions are suspect.

3.2.8 The Romer-Romer Model

The previous sections are all concerned with the statistical approaches to testing the NP in the context of Lucas (1972, 1973), Sargent (1973), and Sargent and Wallace (1975). A problem with these studies, however, is that the direction of causality is not clearcut. Romer and Romer (1989) argued that such statistical approaches may be misleading. First, money could rise before output does, even though money had no causal role, if firms which are planning to expand their output first increase their demands for liquid assets (or for loans from commercial banks). Second, if the Federal Reserve were actively using monetary policy to offset the effects of other factors acting to change output, there might be no discernible relation between money and output, even though money had large real effects. The essential feature of their approach is to identify 'monetary shocks' from the historical record through the nonstatistical procedure, which they refer to as the 'narrative' approach.

Romer and Romer (1989) first critically evaluated Friedman and Schwartz's[58] study (who initiated this 'narrative' approach) to see how successful and persuasive the latter isolated independent monetary shocks are. Then, Romer and Romer (1989) applied this approach to the postwar period. Furthermore, they improved the study of Friedman and Schwartz by adopting their own definition of monetary disturbances. Since the prewar had gone through complicated changes in financial institution, monetary policy, and so forth, they exclusively focused on the postwar period.

The definition that Romer and Romer (1989) took for monetary disturbances was

[58] See Romer and Romer (1989) for the exact citation.

much narrower[59]compared to the one adopted by Friedman and Schwartz. Romer and Romer adopted the definition of monetary shocks as these episodes in which the Federal Reserve attempted to exert a contracitionary influence on the economy in order to reduce inflation.[60] They looked for times when concerns about the current level of inflation led the Federal Reserve to attempt to induce, what it might be called, a growth recession. With this definition of monetary shock, they selected six episodes: October 1947, September 1955, December 1968, April 1974, August 1978, and October 1979.[61]

With these episodes Romer and Romer (1989) tested their null hypothesis that money does not matter in two ways; using informal and formal statistical procedures.[62] To test the null hypothesis, they advanced the equation below. That is,

$$y_t = a_0 + \sum_{i=1}^{11} a_i M_{it} + \sum_{j=1}^{24} b_j y_{t-j} + \sum_{k=0}^{36} c_k D_{t-k} \, , \tag{3.2.8A}$$

where y = the change in log of industrial production or the level of unemployment rate, M = a set of monthly dummy variables for seasonal adjustment, and D = the dummy variables for contractionary monetary shocks.[63]

To test formally whether there is an identifiable statistical relationship between the

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[59] The definition of monetary shocks that Friedman and Schwartz used is a movement that is unusual given economic development, that is, a movement that would not have occurred in other periods or other circumstances given the pattern of real activity.

[60] The advantages of this narrower definition of monetary shock are: (a) to limit the role of judgement to identify monetary shocks, and (b) the fact that Romer and Romer believed policy decisions to attemot to cure inflation come as close as practically possible to being independent of factors which affect real output.

[61] To see the details in these episodes, refer to Romer and Romer (1989, pp. 21-30).

[62] Since we will exclusively focus on the formal statistical test, refer to Romer and Romer (1989, pp. 31-36) for the informal test results.

[63] For the unemployment equation, a simple linear time trend is also included. The sample period for the regression is from 1948 to 1987.

monetary shocks which we have identified and movements in real output, they employ the following test. To the simple univariate forecasting equations for industrial production or unemployment, they add current and lagged values of a dummy variable that is equal to one in each of the six months in which we have identified a change in Federal Reserve policy and zero in all other months. The impulse response function for this expended forecasting equation provides an estimate of the total effect of a policy change after some horizon. The standard error of the impulse response function provides a way of gauging whether the effects of the nominal disturbances are statistically significant.[64]

Overall, Romer and Romer (1989) found monetary shocks have potential real effects. The estimation results are: over two thirds of the coefficients on the monetary shock variable are negative and twelve of them have t-statistics less than -1.0. The predominance of negative monetary shocks do indeed depress real output. They also found by running the regression without lagged values of unemployment, their simple dummy variables for overt Federal Reserve policy decisions to create a recession could account for more than a fifth of the nonseasonal variation in the unemployment rate.[65]

Even though Romer and Romer (1989) study is informative, it suffers from two specific difficulties. The first, and more important possible difficulty, involves the isolation of monetary shocks. Inherently, there cannot be a completely mechanical rule for determining when the historical record indicates that a shock has occurred. Moreover, the identification of shocks generally occurs retrospectively, and thus, the researcher may

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[64] See more on the dummy variable which is a crucial indicator of monetary shocks in Romer-Romer (1989, pp. 36-37).

[65] This result might be distorted by the fact that the decisions by the Federal Reserve to try to create a recession might be correlated with other factors such as supply shocks, fiscal policy, and inflation itself (Romer and Romer, pp. 44-45). Romer and Romer, however, found that this is not the case. See, Romer and Romer (1989, pp. 42-43).

know the subsequent behavior of money and output. The fact that selection of disturbances is judgmental and retrospective introduces the possibility there may be an unconscious bias toward, for example, searching harder for negative monetary shocks in periods preceding sharp declines in money and output than in other periods. Such a bias could cause one to misclassify shocks and to conclude monetary disturbances had real consequences when they had none.

The second potential difficulty arises in determining whether the shocks which are identified are followed by unusual output movements. As Romer and Romer (1989) point out, neither Friedman and Schwartz, nor those who cite similar informal evidence in support of the importance of monetary disturbances, test formally whether the behavior of output in the aftermath of the disturbances which they identify is, in fact, systematically unusual. Romer and Romer indicate that Friedman and Schwartz explicitly deny that monetary shocks have consistent and precise real consequences, arguing their effects occur with long and variable lags. Putting it strongly, an absence of statistical tests, and a belief in irregular, and often quite long lags, could render the hypothesis that monetary shocks have important real effects void of the testable implications. More moderately, these factors could cause the strength and significance of the effect to be overstated, and could compound the effects of biases in the selection of shocks.

3.3 Summary Remarks

We have, so far, tried to capture the essential ideas of recent literature on the (empirical) controversies over the neutrality and rationality hypothesis. The trend of the literature over the last decade has been to put the NP in a doubtful light. Some pieces of evidence, as Mishkin (1982), showed that the rationality condition could survive as, at least, a working hypothesis of analyzing the stabilization of macroeconomic policy. Table (3.3A1) summarizes the studies reviewed in this section.

The fundamental problem of existing studies, except Gordon's (1982), on the empirical testing of neutrality and rationality is, these models have no alternative theories. In this context the results of these studies are open to question. In addition, as McCallum (1982) points out, those are also questionable if most macro time series, as Nelson and Plosser (1982) argued, are nonstationary. Nelson and Plosser's (1982) finding is of importance since it implies their paths are fundamentally stochastic. Since the original work of Nelson and Plosser (1982), there have been many studies which question their original finding. Thus, this leads a controversy in a study of the fluctuation of output during the eighties. We address these studies in the next section.

Table 3.3A1 : Previous MRE Models

	Tested Hypothesis	Econometric Methods	Extension of Study	Policy Results
Sargent (1976a)	money does not matter in the short run	Granger and Sim's statistical theories	short run for NRH of Friedman	neutral
Nefci and Sargent (1978)	money does not matter in the short run	kind of Chow's stability test	to avoid the observational equivalence problem	neutral
Barro (1977a)	unanticipated money matters	two-step procedure	more specific than Lucas setting	neutral
Barro and Rush (1980)	unanticipated money matters	two-step procedure	quarterly data joint estima - tion in unrestricted manner	neutral
Leiderman (1980)	unanticipated money matters	FIML	revised version of untested restriction	neutral
Mishkin (1982)	unanticipated money matters	nonlinear estimation	joint test of hypothesis with REH	nonneutral
Gordon (1982)	NRH-GAP	two-step procedure (GLS)	test with alternative	nonneutral
Frydman and Rapportport (1985)	IAUD	two-step procedure	irrelevance of the distinction between anticipated and unanticipated money	nonneutral

	Tested Hypothesis	Econometric Methods	Extension of Study	Policy Results
McGee and Stasiak (1986)	money does not matter	vector autoregression	more general framework	nonneutral
Romer and Romer (1989)	money does not matter	OLS	nonstatistical approach	nonneutral

Chapter 4
STUDIES OF EFFECTS OF NONSTATIONARITY ON OUTPUT FLUCTUATIONS

4.1 Introduction

In a recent paper Nelson and Plosser (1982) argued and provided evidence most macroeconomic, especially real GNP, time series are nonstationary. More specifically, they provided the evidence that these series are reasonably characterized as random walks with drift. This casts doubt on the traditional business cycle theories which basically assume: (a) the shocks to aggregate demand such as monetary policy, fiscal policy, and animal spirit, are assumed to drive the fluctuations in output, and (b) these shocks are assumed, at most, to have a temporary effect on output; in the long run the economy returns to the natural rate [Campbell and Mankiw (1987)]. Following traditional business cycle theories, the secular component of observed output moves very sluggishly relative to its cyclical part over a short period of time, say a year or quarter, if we decompose the observed output into secular and cyclical components.[1]

Nelson and Plosser (1982) argued, however, the secular component of output, the natural rate of output in our context, should not necessarily be modeled by a deterministic time trend. This implies the natural rate of output - the secular component - itself follows a stochastic process without tendency to be time-reverting while the cyclical component is assumed to be stationary. Under the assumption that any stochastic fluctuations in output of a permanent variety must be associated with the secular component, Nelson and Plosser (1982) infer from their empirical analysis that (a) real shocks associated with the secular component contribute substantially to the variation in observed output, and (b)

[1]This led the literature to the practice of 'detrending' time series by regression on time. In our context, Lucas (1973), Barro (1977, 1978), Barro and Rush (1980), and Mishkin (1982, 1983) also took this approach to test their models.

either these shocks are correlated with the innovations in the cyclical component or the secular component contains transitory fluctions (or both). Then, they concluded, macroeconomic models which focus on monetary disturbances as a source of purely transitory (stationary) fluctuations may never be successful in explaining a very large fraction of output fluctuations and stochastic variation due to the real factor is an element of any model of macroeconomic fluctuations. Their study, as Campbell and Mankiw (1987) indicated, challenged the (a) of traditional business cycle view.

Based upon Nelson and Plosser's (1982) work, Campbell and Mankiw (1987) argued, the extreme conclusion of Nelson and Plosser (1982) is not necessary since it is possible the real shocks may affect the economy through some Keynesian channel. This is because Campbell and Mankiw (1987, pp. 875-877) challenged the above (b) of the traditional business cycle view. That is, they asserted the output shocks persist permanently. Then, their study has a different implications for agents to forecast the output in the infinite future, say forty years or so. According to their modeling, agents change their forecasts accordingly once they believe these shocks are permanently persistent.

The present section raises the following questions by merging the MRE models with the recent studies on output fluctuation, i.e., Nelson and Plosser's (1982) approach. In the first place are, as Nelson and Plosser (1982) suggested, the GNP series under the present study really nonstationary? The recent results on the tests of nonstationarity in the U.S. time series are mixed. The results differ when the sample period is extended.[2] This motivates us to check whether the series under the present study are nonstationary. Although the studies with longer sample period counteract the original finding of Nelson

[2]See, Walton (1987).

and Plosser (1982), we simply address the nonstationarity issue by testing with a shorter sample span than that of Nelson and Plosser (1982). We examine the Japanese and Korean data including the U.S. with nineteen yearly data. In the second place, how could the studies, for example, Mishkin (1982,1983) and Gordon (1982), be affected in the context of Nelson and Plosser (1982)? In other words, how could these tests on the NP be changed under the condition that natural rate of output itself has a permanent stochastic process? This question makes us to see whether the output functions of Mishkin (1982, 1983) and Gordon (1982) are misspecified. Finally, could we find any different policy implications from these deterministic and nondeterministic business cycle theories, respectively? Intuitively, supply shocks could be perceived by agents if the natural rate of output is believed to change permanently. Then, is there a way of reconciling the studies in the previous sections, such as Mishkin's study, with the recent ones, such as Nelson and Plosser (1982) on the output persistence? Campbell and Mankiw (1987) suggested that perhaps the models of temporary nominal rigidities, such as Fischer's (1977) or misconceptions, such as Lucas' (1973) could be reconciled with findings of persistence by abandoning the natural rate hypothesis in favor of some highly potent propagation mechanism.[3] However, how could we build this type of model at our disposal? To the best of our knowledge, such a model building has not yet been attempted in the literature.

Thus, the rest of the present chapter is organized as follows. The next part presents three important groups of studies on output fluctuations in the literature, and we

[3]See, Blanchard (1987).

preview how we test this nonstationarity or unit root[4] in the present study. Then, in the third part we revisit Mishkin's (1982, 1983) model by embodying the line proposed by Nelson and Plosser (1982). Summary remarks appear in the final part.

[4] If the series has a unit root in its autoregressive representation, then, the series does not satisfy stationarity.

4.2 Nonstationarity of the GNP Series

Since Nelson and Plossar (1982) pioneered their study on nonstationarity in macroeconomic series, and provided evidence that most macroeconomic time series has a unit root, there have been many more studies in the literature.[5] Some studies cast doubt on the original finding of Nelson and Plosser (1982) as to when the sample period of the series is extended. As would be expected, this has lead to a major controversy in the study of output fluctuations.

Under the studies of Nelson and Plosser, and Campbell and Mankiw (1987), innovation to real GNP should affect agents' output forecasts into the infinite horizon. In other words, a one percent increase in the unanticipated change of today's GNP affects agents' forecasts in the far future, say forty years. This implies real GNP does not follow a trend as the traditional business cycle theorists argued. In pursuing this interpretation of the data, various researchers have tried to measure the long-run response of real GNP to a shock. Estimates of this response are often referred to as the 'persistence' of shocks to real GNP.

The literature on persistence has connected with recent controversies over the empirical plausibility of two important classes of statistical univariate time series models: trend stationary and different stationary models (see Chapter 5). Proponents of the view that shocks to real GNP are persistent build their case on the empirical plausibility of the hypothesis that real GNP is difference rather than trend stationary or, in other words, real GNP has a unit root.

In a recent paper Christiano and Eichenbaum (1989) argued, the possibility of providing a compelling case that real GNP is either trend or difference stationary seems

[5]The recent excellent summary on the present topic could be found in Schwert (1987).

extremely small, certainly on the basis of postwar data. This is because there is only one difference between these two types of processes, and that difference is completely summarized by the answer to the question, "How much should an innovation to real GNP affect the optimal forecast of real GNP into the infinite future?" If the answer is zero, then, real GNP is trend stationary. If the answer is not zero, then, real GNP is difference stationary. The competing hypotheses have no other testable differences. Once the question is posed in this way, it seems clear, economists ought to be extremely skeptical of any argument which purports to support one view or the other. Simply put, it is hard to believe a mere forty years of data could contain any evidence on the only experiment which is relevant (see Chapter 5).

To check whether or not the series under their study is nonstationary, Nelson and Plosser adopted the augmented version (Dickey-Fuller 1979) tests. Dickey and Fuller (1981), however, extended their earlier work to provide likelihood ratio tests of the unit root hypothesis. As Nelson and Plosser (1982) did, we pose two alternative hypotheses: trend stationary (TS) and difference stationary (DS) processes. They assumed the null hypothesis that the series in their study have DS processes. To test the null hypothesis, as mentioned above, they used an extended version of the Dickey-Fuller (1978) test. That is,

$$z_t = (\sum_{i=1}^{k} \psi_i)\, z_{t-1} + (\sum_{i=1}^{k} \psi_i)\,(z_{t-1} - z_{t-2}) + (\sum_{i=1}^{k} \psi_k)\,(z_{t-k+1} - z_t - k_{t-k}) + d + ct + u_t \,, \quad (4.2A)$$

Where z = series under the study, ψ's = coefficients in autoregressive polynomial, d = drift, t = time, and u = random error. To conduct the Dickey-Fuller test, Nelson and Plosser estimate the regression of the form of equation (4.2A) which may be rewritten as

$$z_t = d + ct + h_1 z_{t-1} + \sum_{j=1}^{p} h_j (z_{t-1} - z_{t-j}) + u_t \, . \tag{4.2B}$$

or equivalently,

$$z_t - z_{t-1} = d + ct + h_1' z_{t-1} + \sum_{j=1}^{p} h_j (z_{t-1} - z_{t-j}) + u_t \, . \tag{4.2C}$$

Nelson and Plosser (1982) used the equation (4.2B) to test their null hypothesis of whether the coefficient of $h_1 = 1$ or $h = 0$ and $c = 0$[6]. To specify the maximum lag length, they consider both the values which would be indicated by the autocorrelations of first differences and by the partial autocorrelations of the derivations from trend of the given series z.

In Chapter 5 we test this nonstationarity of the macro data of Japan, Korea, and the U.S. by adopting the likelihood ratio tests of the unit root hypothesis. The residual sum of square, say URSS, is kept from (4.2C) and a further regression is run on the null model

$$z_t - z_{t-1} = d + \sum_{i=1}^{p} d_i (z_{t-1} - z_{t-2}) + u_t \, , \tag{4.2D}$$

which has residual sum of squares, say RRSS. Then the likelihood ratio statistic

$$LR = [(RRSS - URSS)/2] / [URSS/(T-3-p)]$$

can be constructed and compared with the critical values in Table VI of Dickey and Fuller (1981, p.1063) where T = sample observations, and p is chosen to eliminate autocorrelation in (4.2D).

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[6]Campbell and Mankiw (1987), however, assumed exactly the opposite. The null hypothesis in their study is the series are stationary.

4.3 Mishkin's Model Reconsidered

In this part we raise the issue on nonstationarity in the context of the Mishkin's model. To begin with, we rewrite the output equation of Mishkin (1982, 1983) because we address the issue discussed in the earlier section on Mishkin (1982). That is,

$$y_t = y_{nt} + \sum_{i=0}^{k} d_i (M_{t-1} - M^*_{t-1}) + cM^*_{t-1} + w_t \,, \tag{4.3A}$$

where, by construction, only the current money shock enters the equation (4.3A). Since Mishkin (1982, 1983) assumed the natural rate output follows a deterministic time trend, the disturbance term w_t is purely random and reflects a supply shock. It could possibly be adjusted from short-run economic dynamics, as Mishkin did, if serial correlations exist. According to Nelson and Plosser (1982), however, Mishkin's output equation (4.3A) is not a true reduced form because natural rate output itself follows a stochastic process. In other words, the natural rate output itself is persistent, or serially correlated. An unique level of natural output does not exist.

Under this circumstance, then, how could we conduct Mishkin's test? The model under the current circumstances could be represented as follows. In addition to the equation (4.3A), we have

$$y_{nt} = d + y_{nt-1} + u_t \,, \; d > 0 \tag{4.3B}$$

where d = drift term, and u_t = random component of natural output. The system of equations (4.3A) and (4.3B) is now our model, and we have two distinct shocks to our system of equations. To be more specific, the (4.3A) has a random error which is traditionally regarded as a transitory one. On the other hand, the (4.3B) reveals natural rate output is persistent. This leads one to major controversy as to whether this shock to the natural rate output is permanent. So, the (4.3A) seems not a true reduced form output function.

In contrast, Barro (1977, 1978) and Mishkin (1982) took an approach to the natural rate output as follows. That is,

$$y_{nt} = constant + ct + \sum_{i=1}^{k} \rho_i u_{t-1} \ , \tag{4.3C}$$

where t = time trend, and ρ_i = coefficients of serial autocorrelation of random errors if serial correlation exists. The rationale of this approach is they assume the movements of output or unemployment rate are stationary.

McGee and Stasiak (1986) used growth rates of variables such as real GNP, the GNP deflator, and the money supply because as Nelson and Plosser (1982) indicate, they do not exhibit the nonstationary tendency. The detrended levels of variables as in (4.3C) exhibit nonstationarity if the series is similar to those in (4.3A) and (4.3B). Thus, our conclusion will be misleading when the detrended approach is taken in a nonstationary series.

4.4 Summary Remarks

In this chapter we have examined recent studies of output fluctuations in the literature. We first introduced the important work of Nelson and Plosser (1982) since their original finding leads a major controversy of unit root problem in macroeconomic model building during the eighties. Following Nelson and Plosser's (1982) work, there have been many studies on the output persistence in the literature. Some of them counteracted the original finding of Nelson and Plosser (1982) when the pre-war period of the U.S. data is included. In the literature several test methods other than Dickey-Fuller have appeared (Walton 1987). Among them, we exclusively focus on the Dickey-Fuller tests. To be more specific, we adopt the likelihood ratio tests of the unit root hypothesis which appear in the next chapter.

In addition to this, we discuss three groups of studies on the output fluctuations in the literature. The first group follows the view that movements in aggregate output can be represented as temporary fluctuations about a deterministic time trend such as the studies of Lucas (1972, 1973), Barro (1977, 1978), Gordon (1982), and Mishkin (1982). The second is that these movements are nonstationary, and that the studies of the first group are flawed. Finally, we raise the issue of nonstationarity in the context of the Mishkin model.

In the next chapter we conduct our empirical analysis of Barro (1977, 1978) and Mishkin (1982). Then in the second part we conduct the tests on nonstationarity of the cross-country view by adopting the likelihood ratio tests of the unit root hypothesis. Here, we use a much shorter sample span of the data than that of Nelson and Plosser. In the literature the results of the nonstationary test seem to be sensitive to the sample span in the U.S. case. For this reason, our purpose for nonstationarity tests is primarily expositional.

Chapter 5
THE EMPIRICAL RESULTS

5.1 Introduction

In this chapter we first reexamine the models of Barro (1977a, 1978), Barro-Rush (1980) and Mishkin (1982), utilizing the data of Japan and Korea in addition to the U.S. which this literature has exclusively focused on. We also review the demand for money functions to see why those countries might have different results (see Appendix B). The primary step for the present study is to search for the money growth equations of each country. Then we reexamine MRE hypothesis in the context of Barro-Rush and Mishkin frameworks.

In the second part we conduct the simple likelihood ratio tests of the unit root hypothesis based upon the Dickey-Fuller (1981) work. The sample span used is much shorter than that of Nelson and Plosser (1982). In the literature (Walton 1987, Schwartz 1987), the sample span is sensitive to the results of nonstationarity tests. The original finding of Nelson and Plosser was rejected when the prewar period of the U.S. data is included. For this reason, our results of nonstationarity tests do not give a sound basis as to whether or not the data in the countries examined are stationary. Our purpose of nonstationarity tests is a cross-country comparison, and suggests further studies in this direction. This shorter sample span comes from the fact that we can get consistent data only for the shorter period for Korea.

5.2 Results from the Barro and the Barro-Rush Frameworks

Barro (1977a, 1978) and Barro-Rush (1980) initiated their two-step procedure to test the MRE hypothesis under the maintained hypothesis of RE, as mentioned earlier. In this section we perform the empirical testings of the unanticipated hypothesis, suggested originally by Barro (1977a) whose results implied, only the unanticipated money matters.

The first essential step of the Barro, and Barro-Rush models, is to find the money growth equations in view of the countries examined. These are also utilized in the study of the Mishkin model which appears in the following pages.

3.2.1 Search for Money Growth Equations

A number of search strategies for the money growth equation could be found for the research purposes.[1] In the present study we follow the procedures originally done by Mishkin (1981, 1982) for the U.S., and readopted by Hoffman and Schlagenhauf (1982) for OECD countries. The basic idea behind this approach is 'rationally' formed expectations of money growth for period t should include information available at time t-1 which could be used to predict the policy variable. The actual variables that enter the money growth equation in this section are essentially based upon multivariate Granger tests over a set of macroeconomic variables which had been cited in the literature as being or potential use in explaining monetary policy responses. This set of variables adopted in the present study includes quarterly growth rate of nominal GNP or GDP (GRNGNP, GRNGDP), M1, M2 (D1M, D2M), government expenditure (GE), and government budget deficit (GDF), short-term interest rate (SR), and the unemployment rate (UN).[2] The detailed description for the data and their sources is contained in Appendix A. The present study examines the cases of both seasonally adjusted and unadjusted data of the countries examined.

With these in hand, we perform the multivariate tests by regressing money growth

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[1]As Hoffman and Schlagenhauf (1982) pointed out, a number of potential strategies are available for specifying the money growth forecasting equation. For instance, Barro's money growth forecasting equation is more like a reaction function of central bank. An alternative is to model this equation as a univariate ARIMA process or a transfer function. Perhaps, the ideal approach specifying this forecasting equation is to use the rational expectations solution from a complete macroeconomic model.

[2]This set of macroeconomic variables taken in the present study is similar to those of Mishkin (1982) and Hoffman and Schlangenhauf (1982).

on a constant, four lagged values of money, which insures white-noise residuals,[3] as well as four lagged values of one of the aforementioned macroeconomic variables. An F-test under the null hypothesis that the set of coefficients on the individual macroeconomic variable is zero is conducted. If this F-test[4] is significant at the 5% level, then the variable is included among the set of regressors in the final money growth forecasting equation. In addition, a white-noise property of residuals of the structure of money growth equation must be guaranteed. This is to specify the money growth equations for Japan, Korea, and the United States in this study. Barro originally suggested a cross-country study in this literature, but we could only find the studies of Darby (1980), and Hoffman and Schlagenhauf (1982) for OECD countries, and Noh (1986) for Korea. Noh studied the MRE hypothesis in the context of Frydman and Rappoport (1985) which we examined in an earlier chapter. So, the present study is unique, not only in its data sets used, but also in its cross-country comparison in terms of this literature.

Using this strategy for the search of money growth equation, we obtain the money growth equations of Japan and Korea. The U.S. case appears in the Appendix C; the reader may refer to it to see how the countries examined are different from it. In addition, the demand for money functions of each country are shown in Appendix B. Under the present study we examine the data, seasonally adjusted and unadjusted, to see if they differ. The forecasting money growth equations of Japan and Korea are examined as follows.

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[3]When we regress the output on four lagged money, we find that the resultant forecasting money growth equation has a white-noise property of its residuals.

[4]The F-tests adopted here are more general than a stepwise regression since the latter may miss important explanatory variables. The reason for this is, as Mishkin (1982b) pointed out, the order of listing explanatory variables in the stepwise regressions is crucial.

5.2.1A Setup of Japanese Money Growth Equations

The Japanese money equations,[5] one with seasonal adjustment and the other unadjusted are as follows. That is,

$$D1M_t = .15 + 1.40D1M_{t-1} - .37D1M_{t-2} - .05D1M_{t-3} + .003D1M_{t-4}$$
$$(.04) \quad (.11) \quad (.09) \quad (.01) \quad (.001)$$
$$-.005SR_{t-1} - .002SR_{t-2} + .01SR_{t-3} - .005SR_{T-4}$$
$$(.003) \quad (.008) \quad (.008) \quad (.004)$$
$$R^2 = .9998,\ SEE = .006,\ DW = 1.87,\ Q(24) = 29.75, \qquad (A.1)$$

$$D2M_t = .47 + .32D2M_{t-1} + .58D2M_{t-2} + .05D2M_{t-3} + .001D2M_{t-4}$$
$$(.21) \quad (.11) \quad (.10) \quad (.02) \quad (.007)$$
$$+ .002UN_{t-1} + .003UN_{t-2} + .03UN_{t-3} - .03UN_{t-4}$$
$$(.02) \quad (.02) \quad (.02) \quad (.02)$$
$$- .002CUR_{t-1} + .002CUR_{t-2} + .002CUR_{t-3} - .001CUR_{t-4}$$
$$(.002) \quad (.002) \quad (.002) \quad (.002)$$
$$R^2 = .9969,\ SEE - .03,\ DW = 2.13,\ Q(24) = 14.86, \qquad (A.2)$$

where D1M = growth rate of M1, C=constant, SR = short-term interest rate, D2M = growth rate of M2, UN = unemployment rate, CUR = balance of payments current account position, t's = time indices, R^2 = determinance of coefficient, SEE = standard error of the regression, DW = Durbin - Watson statistic, Q = Box-Pierce, and standard errors of

[5]In the Japanese case, since the quarterly values of government deficits (GDF) are not available from the period, 1980:III-1988:IV, we conduct the aforementioned F-tests for the sample period, 1971:II-1980:II. Then we got the resultant money equation by reestimating the one during the period, 1971:II-1980:II, for the full sample period. In this case the null hypothesis that the residuals were white noise is not rejected at the 5% significance level for each equation. The critical value of Chi-Square distribution of the first 24-lag case at the 5% level is 40.27. This implies, as in the work of Hoffman and Schlagenhauf, the inferences obtained from the F-tests are not biased due to the presence of serial correlation.

coefficients are in parentheses.

The (A.1) is the resultant forecasting money growth equation with seasonally adjusted data, and the (A.2) with seasonally unadjusted one by the aforementioned search strategy. The set of explanatory variables included in each equation is, as above, quite different from each other. That is, the (A.1) includes the set of variables, D1M and SR, while the (A.2) has D2M, UN, and CUR. The chosen variables, such as D1M and S2M are among those which have the desirable property, for example, lower standard error of regression and a white-noise process. As in the above, the lag patterns of each equation are very different. In (A.1) the first-lag component has a bigger effect than any other lag in that equation. On the other hand, in (A.2), the second-lag component is bigger than any other one, and has a triangular structure. In terms of statistical fit of the equation, the (A.1) fits better than the (A.2). This fact is indicated by the standard errors of coefficients and Q-statistics of each equation.

On the one hand, the net effects of D2M from the (A.1) is .99 which has the standard error, .004, its marginal significance level or marginal p-value, 0.7^{-16}. The net effects of SR from the same equation is -.002 which has its standard error and marginal p-value as .0007 and .004, respectively. The net effects of SR is very small. The sign of SR conforms to the traditional relationship between money and rate of interest. In the (A.2), on the other hand, the net effects of D2M is .95 which has its relevant statistics of standard error and marginal p-value as .03 and 0.2^{-15}. The net effects of UN and CUR are .007 and .001, respectively. The relevant standard errors and marginal p-value of UN and CUR are in turn .02, .0007, .77, and .10. From the above, the goodness of fit of equation (A.1) is once again indicated in view of its coefficients and its relevant statistics. The joint tests for significant explanatory power in both money equations of four lags of each variable could be tabulated as in Table (5.2.1A).[6]

Finally, to check the stability of the coefficients of both money equations, we perform Chow-tests which split the sample period in equal halves. The tests indicate that the money growth equations in Japan do have the desirable property that the stability of the coefficients in each equation cannot be rejected at the 5% significance level. In (A.1), on the one hand, it has $F(9,53) = .57$ which has its marginal p-value as .82. The null hypothesis cannot be rejected since the critical values of $F(9,50)$ and $F(9,55)$ lie between 2.02 and 2.00. The marginal p-value show there is a 20% chance to find that value of F or higher under the null hypothesis. In the (A.2), on the other hand, it has $F(13,45)=1.05$ which has its marginal p-value as .42. This case also cannot be rejected at the 5% significance level. In this case its critical value lies approximately between 1.98 and 1.91. The marginal p-value shows there is a 60% chance to find that value of F or higher under the null hypothesis. In each case, therefore, the stability of coefficients during the full sample period cannot be rejected at the 5% significance level.

[6]The F-tests here are not meant to describe what regressions were run in order to achieve the final specification. They only show how much marginal explanatory power each variable has, once the specification was decided upon.

Table 5.2.1A:
Joint Tests For Significant Explanatory Power In Both Forecasting Money Growth Equations of Four Lags of Each Variable During The Sample Period of 1971:II through 1980:II

	Seasonally Adjusted		Seasonally Unadjusted	
Variable	F-Statistic	Marginal Significance Level	F-Statistic	Marginal Significance Level
D1M	11693.98[b]	.00	-	-
D2M	-	-	763.58[b]	.00
GRNGNP	.79	.54	.70	.60
UN	.31	.87	7.70[a]	.0004
GE	.17	.95	.33	.85
SR	3.54[a]	.02	.82	.53
GDF	.43	.78	.67	.61
CUR	.12	.98	1.83	.16

Notes: a=5% significance level, b=1% significance level. The F-statistics test the null hypothesis that the coefficients on the four lagged values of each of these variables equal zero. The marginal significance level is the probability of finding that value of F or higher under the null hypothesis. For the D1M and SR tests in the (A.1), the F-statistic is distributed as F(4,28), while for the tests of the other variables in the same equation, the F-statistic is distributed as F(4,24). For the D2M, UN, and CUR tests in the (A.2), the F-statistic is distributed as F(4,24), while for the tests of the other variables in that equation, the F-statistic is distributed as F(4,20).

5.2.1B The Korean Case[7]

The forecasting money growth equations in Korea are as follows. That is,

$$
\begin{aligned}
D1Mt = \quad & .04 + 1.44D1M_{t-1} - .31D1M_{t-2} - .14D1M_{t-3} - .003D1M_{t-4} \\
& (.03) \quad (.10) \quad\quad (.10) \quad\quad (.02) \quad\quad (.01) \\
& + .001UN_{t-1} + .02UN_{t-2} + .07UN_{t-3} + .05UN_{t-4} \\
& (.02) \quad\quad (.03) \quad\quad (.03) \quad\quad (.02) \\
& R^2 = .9995,\ SEE = .02,\ DW = 1.95,\ Q(24) = 22.03, \qquad \text{(B.1)}
\end{aligned}
$$

$$
\begin{aligned}
D2M_t = \quad & .16 + .83D2M_{t-1} + .12D2M_{t-2} - .0005D2M_{t-3} - .08D2M_{t-4} \\
& (.03) \quad (.13) \quad\quad (.10) \quad\quad (.03) \quad\quad (.02) \\
& + .03GRNGDP_{t-1} - .07GRNGDP_{t-2} + .04GRNGDP_{t-3} \\
& (.03) \quad\quad\quad (.03) \quad\quad\quad (.03) \\
& + .13GRNGDP_{t-4} + .003UN_{t-1} + .0003UN_{t-2} - .006UN_{t-3} - .003UN_{t-4} \\
& (.03) \quad\quad\quad (.004) \quad\quad (.005) \quad\quad (.004) \quad\quad (.004) \\
& R^2 = .9996,\ SEE = .02,\ DW = 2.09,\ Q(24) = 22.83, \qquad \text{(B.2)}
\end{aligned}
$$

where D1M = growth rate of M1 in log, D2M = growth rate of M2 in log, GRNGDP = growth rate of nominal GDP in log, UN = growth rate of unemployment in log, R^2 = determinance of coefficients, SEE = standard error of the regression, DW = Durbin-Watson statistic, Q = Box-Pierce statistic, t's = time indices, and standard errors of coefficients are in parentheses.

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[7]In the Korean case, since the quarterly values of balance of payments current account position (CUR) are not available from the period, 1970:I through 1974:IV, we conduct the aforementioned F-tests for the sample period, 1976:II through 1988:IV. Then we have the resultant money equations by reestimating the ones during the above period for the full sample period, 1971:II through 1988:IV. In this case the null hypothesis that the residuals were white-noise is not rejected at the 5% significance level as in the Japanese case. The critical value of Chi-Square distribution of the first 24-lag case at the 5% level is 40.27. This implies again, as Hoffman and Schlagenhauf pointed out, that the inferences obtained from the F-test are not biased due to the presence of serial correlation.

Even though the set of explanatory variables of seasonally adjusted and unadjusted cases is different, unlike the Japanese case, both money growth forecasting equations fit equally well. The equation (B.1) is the one with seasonal adjustment, and the (B.2) is the one with seasonal unadjustment. The (B.1) includes the set of variable such as D1M and UN, but the (B.2) has the set of D2M, GRNGDP, and UN. The (B.2) has the variable, GRNGDP, but the (B.1) does not. The lag patterns of D1M and D2M are very similar, even though the set of variables of each equation are different from each other. The values of first-lag of D1M and D2M are very big, and then, the values of the rest die out. This is quite contrary to the case of Japan where there were different lag structures.

On the one hand, the net effect of D1M from the (B.1) is .99 which has its relevant statistics of standard error of coefficients and marginal p-value as .003 and 0.1^{-15}. The net effect of UN from the same equation is .001 which has its standard error and marginal p-value as .004 and .76. So, the variable UN has not only smaller coefficients, but bigger standard errors of coefficients than the variable D1M in that equation. In (B.2), on the other hand, the net effect of D2M is .87 which has its standard error of coefficients as .05. In addition, the values of the net effects of the variables GRNGDP and UN are .12 and -.006, respectively. The value of UN is much smaller than one of GRNGDP. Both values, however, are much smaller than that of D2M. The GRNGDP variable has its standard error and marginal p-value as .05 and .03, and the UN variable as .003 and .10. In comparison to the variables D2M and GRNGDP, the variable UN has less standard error. In the Korean case, like the Japanese case, the above discussion may lead us to justify the superiority of seasonal data to seasonally unadjusted data. However, the overall fit of both equations is about equal, as mentioned earlier. Therefore, the tradition under which researchers in this literature use only seasonalized data could not be justified in the Korea case. The joint tests for significant explanatory power in both money equations of four lags of each variable could, as in the Japanese case, be tabulated as below.[8]

Finally, to check the stability of the coefficients of both money equations, we again perform Chow-test which split the sample period into equal halves. The tests indicate the money growth equations in Korea do have the desirable property of the stability of the coefficients in each equation, and cannot be rejected at the 5% significance level. In the (B.1), on the one hand, it has F(9,53) = .93 which has its marginal p-value as .50. The critical values of F(9,50) and F(9,55) lie between 2.07 and 2.05. So, the hypothesis cannot be rejected at the 5% level. On the other hand, in the (B.2) it has F(13,45) = 1.88 with its marginal p-value of .06. The critical value in this case approximately lies at the value between 1.98 and 1.91. So, the stability test in this case is accepted at the margin. In sum, the stability of Korean forecasting money growth equations is not rejected at the 5% significance level.

[8]The F-tests here are, again, not meant to describe what regressions were run in order to achieve the final specification. They only show how much marginal explanatory power each variable has, once the specification was decided upon.

Table 5.2.1A:
Joint Tests For Significant Explanatory Power In Both Forecasting Money Growth Equations of Four Lags of Each Variable During The Sample Period of 1971:II through 1980:II

	Seasonally Adjusted		Seasonally Unadjusted	
Variable	**F-Statistic**	**Marginal Significance Level**	**F-Statistic**	**Marginal Significance Level**
D1M	7412.01[b]	.00	-	-
D2M	-	-	16.02[b]	$.9^{7}$
GRNGNP	3.27[a]	.02	7.16[b]	.0002
UN	2.88[a]	.03	1.75	.16
GE	3.37[a]	.02	5.35	.002
SR	.29[a]	.88	.73	.58
GDF	1.27	.30	.84	.51
CUR	2.09	.10	.99	.43

Note: a=5% significance level, b=1% significance level. The F-statistics, as in the Japanese case, test the null hypothesis that the coefficients on the four lagged values of each of these variables equal zero. The marginal significance level is the probability of finding that value of F or higher under the null hypothesis. For the D1M and UN tests in the (B.1), the F-statistic is distributed as F(4,42), while for the tests of the other variables in that equation, the F-statistic is distributed as F(4,38). For the D2M, GRNGDP, and UN tests in the (B.2), the F-statistic is distributed as F(4,38), while for the tests of the other variables in the same equation, the F-statistic is distributed as F(4,34).

5.2.2 The Empirical Results for Output

Since we have forecasting money growth equations of Japan and Korea, the unanticipated hypothesis of Barro (1977, 1978) and Barro-Rush (1980) can now be tested. Since MRE hypothesis suggested only "unanticipated" changes in money growth should affect real output, Barro proposed a reduced form output equation which is consistent with this proposition to test this hypothesis. That is,

$$y_t = a_0 + a_1 t + \sum_{i=0}^{N} \beta_i \, (M_{t-i} - E_{t-i-1} M_{t-i}) = e_t \ . \qquad (5.2.2A)$$

where y_t = a measure of the log of real output at time t,

t = a time trend[9],

M_{t-1} = growth rate of the money stock in period t-1,

E_{t-i-1} M_{t-i} = expected M_{t-i} conditioned upon information available in period t

and e_t = an error term.

In addition to (5.2.2A), a money growth rate equation of Japan and Korea which determines the systematic part of money growth has to be specified as earlier. The general form of such an equation may be written as

$$M_t = Z_t r + v_t, \qquad (5.2.2B)$$

where Z_t = a vector of variables presumably linked to money growth rates and known in period t-1, and v_t = a "white-noise" error term.[10]

[9] As Barro and Mishkin did, we approximate a natural rate output by time trend variable where they assumed implicitly the movements of output or unemployment rate are stationery. This is further discussed in later section where we examine a nonstationarity of output series under the present study.

[10] The assumption that e_t and v_t are uncorrelated error terms insures consistent estimates of the coefficients on the unanticipated money growth.

Barro's estimation strategy is to estimate the money growth equation by ordinary least squares (OLS). The residuals from this equation are then used to form the unanticipated money growth series. This series is incorporated into the output equation to obtain

$$y_t = a_0^* + a_1 t + \sum_{i=0}^{N} \beta_i \, (m_{t-i} - Z_{t-1} r*) + e_t \, , \qquad (5.2.2C)$$

where zt-1r represents 'fitted values' from the (5.2.2B). If these 'anticipated' money growth rates are added to equation (5.2.2C), the monetary neutrality proposition can be tested. That is, the equation in this case is written as

$$y_t = a_0 + a_1 t + \sum_{i=0}^{N} \beta_i \, (m_{t-i} - Z_{t-i} r*) + \sum_{i=0}^{N} d_i Z_{t-i} \, r* + e_t \, , \qquad (5.2.2D)$$

The test of neutrality proposition originally proposed by Barro examines whether the β's are jointly different from zero, and whether the d_i's are jointly equal to zero. This approach is exactly readopted under the present study by using the Japanese and Korean data. Under the present study we test the monetary NP in terms of seasonally adjusted and unadjusted data of countries examined.

5.2.2A The Japanese Case

As mentioned earlier, the test of monetary NP is first conducted by a series of joint tests of coefficients of unanticipated component of money in (5.2.2A1). We examine this proposition in both seasonally adjusted and unadjusted data of Japan. The summary results with seasonally adjusted data are shown in Table (5.2.2A1).

Table 5.2.2.A1
Tests of Unanticipated Hypothesis Seasonally Adjusted Case

(1)	(2)	(3)	(4)
Variable	Lags	F-Statistics	F-Statistics
DMR	0	F(1,68) = .02	F(1,64) = .36
DMR	1	F(2,66) = .08	F(2,62) = .23
DMR	2	F(3,64) = .17	F(3,60) = .31
DMR	3	F(4,62) = .32	F(4,58) = .31
DMR	4	F(5,60) = .70	F(5,56) = .50
DMR	5	F(6,58) = .91	F(6,54) = .53
DMR	6	F(7,56) = .91	F(7,52) = .38
DMR	7	F(8,54) = 1.22	F(8,50) = .41
DMR	8	F(9,52) = 1.21	F(9,48) = .51
DMR	9	F(10,50) = 1.15	F(10,46) = .45
DMR	10	F(11,48) = 1.11	F(11,44) = .51
DMR	11	F(12,46) = 1.19	F(12,42) = .59
DMR	12	F(13,44) = 1.27	F(13,40) = .55
DMR	13	F(14,42) = 1.48	F(14,38) = .54
DMR	14	F(15,40) = 1.81	F(15,36) = .59
DMR	15	F(16,38) = 1.91	F(16,34) = .53
DMR	16	F(17,36) = 1.93*	F(17,32) = .49

Notes: DMR = unanticipated component of money. Here we choose 16 lags arbitrarily since Barro's study indicated, in this case, 13 lags in (3), and 7 lags in (4), are significantly different from zero.

Column (3) of the above table indicates the case where the given hypothesis (unanticipated hypothesis) is tested without correcting for serial correlation problems in all equations. Column (4) is the case where serially correlated residuals are corrected by approximating fourth-order autocorrelation in each output equation. This approximation is very successful in this case since Q statistics of all resultant output equations showed a white-noise property of each equation cannot be rejected at the 5% significance level.

The unanticipated hypothesis is not rejected in the sixteenth lag where serial correlation problems are not corrected. Once the problem is solved, the hypothesis is totally rejected as in the table (5.2.2A1). It seems that Barro's unanticipated hypothesis is not supported by the data in Japan, but the values of test statistics of Column (3) increase as the lag length is extended more that the sixteen. This implies that the results obtained are sensitive to the lag length. In Column (4) the results are less sensitive to the lag length that those of Column (3), but it still suggests we need to examine more lags for the test. For this reason, our conclusion is not decisive since the results are sensitive to the lag length taken. To clearly check this point, we run a regression of output on both components of anticipated and unanticipated money with or without correcting for serial correlation problems. This can be summarized as in the table below (5.2.2A2).[11]

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[11]Barro, in his study, regressed the output on unanticipated money and actual money stock. Then, he showed actual money stock is irrelevant to a determination of output.

Table 5.2.2.A2
Tests of Irrelevance for Anticipated Money
Seasonally Adjusted Case

(1) Variable	(2) Lags	(3) F-Statistics	(4) F-Statistics
DMR	0	F(1,67) = .05	F(1,63) = .23
DM	0	F(1,67) = 7.78**	F(1,63) = .32
DMR	1	F(2,64) = 1.23	F(2,60) = 2.00
DM	1	F(2,64) = 4.85*	F(2,60) = 4.44*
DMR	2	F(3,61) = 3.57*	F(3,57) = 3.59*
DM	2	F(3,61) = 8.40**	F(3,57) = 5.48**
DMR	3	F(4,58) = 5.71**	F(4,54) = 4.00**
DM	3	F(4,58) = 8.85**	F(4,54) = 6.00**
DMR	4	F(5,55) = 10.08**	F(5,51) = 6.83**
DM	4	F(5,55) = 13.75**	F(5,51) = 6.38**
DMR	5	F(6,52) = 15.67**	F(6,48) = 7.61**
DM	5	F(8,52) = 20.58**	F(6,48) = 8.90**
DMR	6	F(7,49) = 21.74**	F(7,45) = 7.10**
DM	6	F(7,49) = 21.74**	F(7,45) = 8.27**
DMR	7	F(8,46) = 29.82**	F(8,42) = 6.37**
DM	7	F(8,46) = 35.85**	F(8,42) = 7.39**
DMR	8	F(9,43) = 35.47**	F(9,39) = 5.37**
DM	8	F(9,43) = 41.55**	F(9,39) = 6.25**
DMR	9	F(10,40) = 33.38**	F(10,36) = 4.72**
DM	9	F(10,40) = 38.38**	F(10,36) = 5.52**
DMR	10	F(11,37) = 30.83**	F(11,33) = 4.15**
DM	10	F(11,37) = 34.69**	F(11,33) = 5.10**
DMR	11	F(12,34) = 29.36**	F(12,30) = 3.75**
DM	11	F(12,34) = 31.99**	F(12,30) = 4.43**

(1)	(2)	(3)	(4)
Variable	**Lags**	**F-Statistics**	**F-Statistics**
DMR	12	F(13,31) = 30.56**	F(13,27) = 3.57**
DM	12	F(13,31) = 32.67**	F(13,27) = 4.26**
DMR	13	F(14,28) = 36.21**	F(14,24) = 3.41**
DM	13	F(14,28) = 36.21**	F(14,24) = 4.28**
DMR	14	F(15,25) = 47.88**	F(15,21) = 4.77**
DM	14	F(15,25) = 52.95**	F(15,21) = 5.79**
DMR	15	F(16,22) = 38.87**	F(16,18) = 4.05**
DM	15	F(16,22) = 45.44**	F(16,18) = 4.05**
DMR	16	F(17,19) = 28.30**	F(17,15) = 3.62**
DM	16	F(17,19) = 38.25**	F(17,15) = 4.78**

Notes: *=5% significance level, ** = 1% significance level, DM = anticipated component of money, and DMR = unanticipated part.

Table (5.2.2A2) reveals both components of anticipated and unanticipated money are significantly different from zero. Column (3) is the case where serial correlation problems are not corrected. In this case all coefficients of anticipated money are significantly different from zero. And also, all coefficients of unanticipated money are, except for the coefficients of current and lag one, significantly different from zero. In addition, the coefficients of anticipated and of unanticipated money are still sensitive to the lag length examined. The results obtained, however, is biased toward the autocorrelation of residuals of output equations since Q statistics of residuals of all output equations examined rejected a white noise property of output equations at the 5% significance level. This implies the results drawn here may be not valid. To get rid of autocorrelation problems of residuals of the output function, therefore, we approximated the fourth-order autocorrelation adjustment.[12] The outcome in this case is summarized in Column (4) of Table (5.2.2.A2).

Column (4) of Table (5.2.2.A2) reveals that the current and the first-lag coefficients of unanticipated component of money are not significantly different from zero, and only the current value of anticipated money is significantly different from zero. The rest of the coefficients of each component of money are significantly different from zero, as in the case without correcting autocorrelation problems. The test statistics associated with anticipated money is even higher than those with unanticipated part in all lags. Thus, it seems the unanticipated hypothesis of the Barro and Barro-Rush frameworks is rejected in the case of Japan with seasonal data. When we correct the autocorrelation problem, a white-noise property of all output equation is guaranteed. This implies the inferences from our F-tests are not biased toward the presence of autocorrelation of residuals of the equations. That is, the presence of autocorrelation may bias the regression statistics. In this case the test statistics are less sensitive to the lag length taken than the case with correcting the serial correlation problem.

In like manner, we examine the case of the output equation with seasonally unadjusted data. This is particularly interesting since Barro (1977, 1978) and Barro-Rush (1980) originally used these seasonally unadjusted data in the U.S. case. As in the case of seasonally adjusted data, we summarize the resultant test statistics as to whether the unanticipated component of money, β's of equation (5.2.2A), are jointly significantly different from zero. This can be shown as in the table (5.2.2.A3).

Column (3) of Table (5.2.2.A3) is the test result where we do not correct serial

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[12]This approach is taken following Sims (1974). Mishkin (1982) also took this approach for his study. In contrast, Barro (1977a, 1978) took a second-order adjustment for his study.

correlation problems. The column indicated after the second lag, the unanticipated hypothesis is not rejected at the 5% significance level. Once we correct serial correlation problems, the unanticipated hypothesis is even more accepted as in Column (4) of the table. This is quite different from the one obtained in case of seasonally adjusted data.

Table 5.2.2.A3
Tests of Unanticipated Hypothesis
Seasonally Unadjusted Case

(1)	(2)	(3)	(4)
Variable	**Lags**	**F-Statistics**	**F-Statistics**
DMR	0	F(1,68) = .39	F(1,64) = .78
DMR	1	F(2,66) = 2.06	F(2,62) = 4.77*
DMR	2	F(3,64) = 5.05**	F(3,60) = 7.89**
DMR	3	F(4,62) = 4.17**	F(4,58) = 27.24**
DMR	4	F(5,60) = 3.87**	F(5,56) = 21.07**
DMR	5	F(6,58) = 3.58**	F(6,54) = 15.23**
DMR	6	F(7,56) = 3.09**	F(7,52) = 17.03**
DMR	7	F(8,54) = 3.22**	F(8,50) = 17.09**
DMR	8	F(9,52) = 3.70**	F(9,48) = 14.96**
DMR	9	F(10,50) = 4.29**	F(10,46) = 13.27**
DMR	10	F(11,48) = 4.65**	F(11,44) = 14,26**
DMR	11	F(12,46) = 4.67**	F(12,42) = 13.04**
DMR	12	F(13,44) = 4.68**	F(13,40) = 11.62**
DMR	13	F(14,42) = 4.73**	F(14,38) = 13.96**
DMR	14	F(15,40) = 4.51**	F(15,36) = 15.04**
DMR	15	F(16,38) = 4.94**	F(16,34) = 17.14**
DMR	16	F(17,36) = 4.87**	F(17,32) = 15.49**

The most significant level of output equation occurs when we include up to the third lag where its marginal p-value is 0.96^{-12}. In this equation its Q statistic at the first 24-lag is 21.20 which does not exceed its critical value of Q(24) = 40.27. Thus, our results drawn here are not biased toward the presence of autocorrelation of residuals of our equation. That is, the equation here has a desirable property which is a white-noise process of residuals of that equation. The marginal p-value of Q statistic is, in this case, .63 which implies there is a 63% chance to reject the null hypothesis of a white-noise process of residuals of the equation. This equation is summarized in Table (5.2.2.A4).

Table 5.2.2.A4
Output Equation With Only Unanticipated Money

Variable	Lags	Coefficient	Standard Error
Constant	0	.58	.26
Trend	0	.0004	.0002
DMR	0	.12	.09
DMR	1	.21	.09
DMR	2	.20	.10
DMR	3	-.84	.44
RHO	1	.89	.09
RHO	2	.28	.10
RHO	3	-.17	.10
RHO	4	-.10	.07

R2 = .98, SEE = .02, DW = 2.13, Q(24) = 21.20

To compare the above equation with the one with the anticipated component of money at the same lag length, we can tabulate the counterpart equation as in Table (5.2.2.A5).

Table 5.2.2.A5
Output Equation With Only Anticipated Money

Variable	Lags	Coefficient	Standard Error
Constant	0	1.43	.57
Trend	0	.003	.002
DM	0	.58	.19
DM	1	-1.06	.20
DM	2	-.43	.21
DM	3	.81	.18
RHO	1	.75	.12
RHO	2	.38	.15
RHO	3	-.11	.13
RHO	4	-.10	.09

The equation with only anticipated component of money also has a white-noise process of residuals. The overall fit of equation is a little better in the case of the one with only unanticipated component of money in terms of standard error of estimates (SEE) and R^2. It seems the unanticipated hypothesis is, again, not rejected. To clearly examine this, we again, as in the case of seasonally adjusted data, run a regression of output on both components of anticipated and unanticipated money. This is summarized in Table (5.2.2.A6).

Table 5.2.2.A6
Tests of Irrelevance for Anticipated Money
Seasonally Unadjusted Case

(1)	(2)	(3)	(4)
Variable	Lags	F-Statistics	F-Statistics
DMR	0	F(1,67) = 4.59*	F(1,63) = 1.06
DM	0	F(1,67) = 58.75**	F(1,63) = .43
DMR	1	F(2,64) = 5.74**	F(2,60) = 2.81
DM	1	F(2,64) = 29.50**	F(2,60) = 4.47*
DMR	2	F(3,61) = 6.50**	F(3,57) = 5.37**
DM	2	F(3,61) = 18.85**	F(3,57) = 2.27
DMR	3	F(4,58) = 6.06**	F(4,54) = 12.95**
DM	3	F(4,58) = 13.36**	F(4,54) = 1.43
DMR	4	F(5,55) = 5.31**	F(5,51) = 10.97**
DM	4	F(5,55) = 9.75**	F(5,51) = 1.80
DMR	5	F(6,52) = 5.00**	F(6,48) = 8.60**
DM	5	F(6,52) = 7.58**	F(6,48) = 1.37
DMR	6	F(7,49) = 4.94**	F(7,45) = 7.95**
DM	6	F(7,49) = 6.84**	F(7,45) = 1.12
DMR	7	F(8,46) = 5.19**	F(8,42) = 7.91**
DM	7	F(8,46) = 5.95**	F(8,42) = 1.05
DMR	8	F(9,43) = 5.13**	F(9,39) = 6.57**
DM	8	F(9,43) = 5.20**	F(9,39) = .91
DMR	9	F(10,40) = 8.48**	F(10,36) = 8.12**
DM	9	F(10,40) = 7.26**	F(10,36) = 2.29**
DMR	10	F(11,37) = 14.26**	F(11,33) = 10.49**
DM	10	F(11,37) = 10.85**	F(11,33) = 3.00**
DMR	11	F(12,34) = 19.87**	F(12,30) = 9.58**

(1)	(2)	(3)	(4)
Variable	**Lags**	**F-Statistics**	**F-Statistics**
DM	11	F(12,34) = 14.13**	F(12,30) = 2.71**
DMR	12	F(13,31) = 22.87**	F(13,27) = 9.33**
DM	12	F(13,31) = 15.40**	F(13,27) = 2.95**
DMR	13	F(14,28) = 29.21**	F(14,24) = 9.81**
DM	13	F(14,28) = 18.35**	F(14,24) = 2.34**
DMR	14	F(15,25) = 24.42**	F(15,21) = 15.54**
DM	14	F(15,25) = 14.72**	F(15,21) = 3.97**
DMR	15	F(16,22) = 23.49**	F(16,18) = 12.41**
DM	15	F(16,22) = 12.21**	F(16,18) = 2.34**
DMR	16	F(17,19) = 19.14**	F(17,15) = 13.11**
DM	16	F(17,19) = 8.91**	F(17,15) = 2.70**

The test statistics associated with irrelevance for anticipated component of money, where serial correlation problems are corrected, are quite difficult to interpret, even though the test statistics associated with unanticipated component of money have higher marginal p-value than the unanticipated part, for the statistics associated with irrelevance of anticipated component of money are not totally negligible. At the first lag, the anticipated component of money are more important that unanticipated one. At the current value of DM and DMR, both components are not important. With this exception, the unanticipated hypothesis is not rejected up to the first eight lags. After that lag, both components of anticipated and unanticipated money turn out to be significant even though marginal p-values of unanticipated are more higher that those of anticipated one. In short, although the unanticipated component of money is significantly different from zero, the test statistics associated with irrelevance of anticipated money are not negligible. The unanticipated hypothesis is not rejected within the limited cases such as lags 2 through 8. In other cases the given hypothesis is not accepted since anticipated component of money is also as much important as unanticipated one. In case serial correlation problems are not adjusted, both components of money are important.

In sum, in the Japanese case the unanticipated hypothesis is rejected even if there are some exceptions within the limited cases. In case of the seasonally adjusted case, the given hypothesis is clearly rejected, indeed, the anticipated component of money seems as important as the unanticipated one. In the case of the seasonally unadjusted case, however, the results are mixed since the unanticipated hypothesis is not rejected in the limited cases, as explained earlier. As for interpretation of the results obtained, the output equation with seasonally adjusted data is far superior to the one with the seasonally unadjusted case. From our empirical results, we infer that the rejection of unanticipated hypothesis might depend upon the seasonality of data in the limited cases. Barro originally used the U.S. data with seasonally unadjustment where he accepted the unanticipated hypothesis. On the other hand, Mishkin used the U.S. data with seasonal adjustment, thus, obtaining his results-rejection of unanticipated hypothesis. The present study suggests that we need to carefully reexamine the seasonality of data at hand in this literature.

5.2.2B The Korean Case

As in the Japanese case, we could now perform a test for the unanticipated hypothesis with the Korean data. In the case of Korea, the results obtained are against the unanticipated hypothesis in either seasonally adjusted or unadjusted data. As in the previous section, we include the variables until joint tests of each coefficient are significantly different from zero. Also, we approximate the natural rate output by time trend variable.

Table 5.2.2.B1
Tests of Unanticipated Hypothesis
Seasonally Adjusted Case

(1)	(2)	(3)	(4)
Variable	**Lags**	**F-Statistics**	**F-Statistics**
DMR	0	F(1,68) = .40	F(1,64) = .01
DMR	1	F(2,66) = .22	F(2,62) = 1.44
DMR	2	F(3,64) = .09	F(3,60) = .98
DMR	3	F(4,62) = .02	F(4,58) = .64
DMR	4	F(5,60) = .09	F(5,56) = .14
DMR	5	F(6,58) = .11	F(6,54) = .89
DMR	6	F(7,56) = .09	F(7,52) = .82
DMR	7	F(8,54) = .11	F(8,50) = .71
DMR	8	F(9,52) = .10	F(9,48) = .54
DMR	9	F(10,50) = .11	F(10,46) = .42
DMR	10	F(11,48) = .14	F(11,44) = .49
DMR	11	F(12,46) = .18	F(12,42) = .41
DMR	12	F(13,44) = .20	F(13,40) = .50
DMR	13	F(14,42) = .25	F(14,38) = .60
DMR	14	F(15,40) = .35	F(15,36) = .66
DMR	15	F(16,38) = .41	F(16,34) = .68
DMR	16	F(17,36) = .55	F(17,32) = .67

The case with seasonally adjusted data reveals that the unanticipated hypothesis cannot be supported by the data. The outcome obtained here, however, show the unanticipated component is not significantly different from zero. Table (5.2.2.B1) shows this aspect where a serial correlation of output equation is either corrected or not. Unlike the Japanese case, the test statistics are not sensitive to the lag length taken.

As in Table (5.2.2.B1), the coefficients of unanticipated money are not significantly different from zero either with Column (3) or without Column (4) correcting the serial correlation problems. However, the autocorrelation problems still exist in some equations examined in the column (4). We used a fourth-order autocorrelation adjustment to correct the problem in all equations as in the Japanese case. Even though the F-statistics associated with all coefficients of unanticipated money do not exceed their critical values, the inferences obtained in the Korean case are biased toward the presence of the autocorrelation problem. This is shown by the Q statistics of each equation examined since some are all rejected at the 5% significance level. This implies a white-noise property of some output equation examined in the Korean case is not accepted. This, again, implied the specification of output equation including only unanticipated component of money is doubtful. Only after the twelve-lag, and on, a white-noise process of residuals of equations is accepted.

Within this limitation we conduct the tests of whether the coefficients of the anticipated component of money are significantly different from zero by regressing the output on both components of anticipated and unanticipated money. That is, we test jointly that the β's and d's of equation (5.2.2D) are significantly different from zero. This is summarized in Table (5.2.2.B2).

As in Table (5.2.2.B2), when the autocorrelation problems are not corrected, the outcome obtained is difficult to interpret for the following reasons. First, up to the first five lags both components of anticipated and unanticipated money are insignificantly different from zero. In other words, neither components of money explain the movement of output. At the sixth lag, the unanticipated hypothesis is rejected, which implies anticipated component of money is more important that the unanticipated one. After the seventh lag, both components of money become to be significant. These results obtained are severely biased toward the presence of autocorrelation problem of each output equation.

Table 5.2.2.B2
Tests of Irrelevant For Unanticipated Money
Seasonally Adjusted Case

(1)	(2)	(3)	(4)
Variable	**Lags**	**F-Statistics**	**F-Statistics**
DMR	0	F(1,67) = .59	F(1,63) = .002
DM	0	F(1,67) = 1.59	F(1,63) = .28
DMR	1	F(2,64) = .32	F(2,60) = .16
DM	1	F(2,64) = .64	F(2,60) = 1.07
DMR	2	F(3,61) = .55	F(3,57) = .54
DM	2	F(3,61) = .84	F(3,57) = 1.11
DMR	3	F(4,58) = .74	F(4,54) = .56
DM	3	F(4,58) = 1.23	F(4,54) = 1.02
DMR	4	F(5,55) = .97	F(5,51) = .22
DM	4	F(5,55) = 1.62	F(5,51) = .78
DMR	5	F(6,52) = 1.46	F(6,48) = 1.03
DM	5	F(6,52) = 2.18	F(6,48) = 1.07
DMR	6	F(7,49) = 1.82	F(7,45) = 1.15
DM	6	F(7,49) = 2.60	F(7,45) = 1.19
DMR	7	F(8,46) = 2.33	F(8,42) = .85
DM	7	F(8,46) = 3.14	F(8,42) = .94
DMR	8	F(9,43) = 2.64	F(9,39) = 1.09
DM	8	F(9,43) = 3.56	F(9,39) = 1.18
DMR	9	F(10,40) = 2.80	F(10,36) = 1.01
DM	9	F(10,40) = 3.77	F(10,36) = 1.11

(1)	(2)	(3)	(4)
Variable	Lags	F-Statistics	F-Statistics
DMR	10	F(11,37) = 3.16	F(11,33) = 1.02
DM	10	F(11,37) = 4.18	F(11,33) = 1.00
DMR	11	F(12,34) = 3.47	F(12,30) = .77
DM	11	F(12,34) = 4.59	F(12,30) = .94
DMR	12	F(13,31) = 3.62	F(13,27) = .52
DM	12	F(13,31) = 5.00	F(13,27) = .77
DMR	13	F(14,28) = 3.82	F(14,24) = .41
DM	13	F(14,28) = 5.40	F(14,24) = .56
DMR	14	F(15,25) = 3.81	F(15,21) = .93
DM	14	F(15,25) = 5.34	F(15,21) = .98
DMR	15	F(16,22) = 4.51	F(16,18) = .79
DM	15	F(16,22) = 6.71	F(16,18) = .74
DMR	16	F(17,19) = 3.76	F(17,15) = .70
DM	16	F(17,19) = 5.99	F(17,15) = .77

Once the serial correlation problem is corrected (even if it is not enough to correct it with a fourth order adjustment of autocorrelation in all equations examined), the results obtained show that not only unanticipated but also anticipated components of money do not explain the movement of output determination. After the twelfth-lag, and on, where a white-noise property of residuals of output equations guaranteed, both components of money become insignificant. This implies, not only is the unanticipated hypothesis rejected, but also the distinction between anticipated and unanticipated components may be irrelevant for a determination of output. Noh (1986) pursued this issue of whether the distinction between them is relevant for a determination of output in Korea in the context of Frydman and Rappoport (1985), as discussed earlier. However, he does not specify whether or not the series used in his study are adjusted. The results obtained from the F-tests are again biased toward the presence of an autocorrelation problem of residuals up to the eleventh lag. After this lag, we can say the unanticipated hypothesis seems to be rejected. Before this lag, the results are biased toward the presence of autocorrelation problems.

In sum, the unanticipated hypothesis seems to be rejected in the Korean case, irrespective of whether we conduct the tests including only the unanticipated component, and of whether we include both components of money for the tests. This result, however, is biased toward the presence of autocorrelation of residuals of some output equation examined even if we approximate a fourth-order correlation problem. That is, some output equations with seasonally adjusted data do not have a white-noise process of residuals after adjusting for serial correlation problems of error term of the equation. This implies, again, we may have misspecified the specification of output equations in the Korean case. This suggests we need to carefully reexamine the specification of output equation for the Korean case.

In the case of seasonally unadjusted data, we test the unanticipated hypothesis in like manner. This is, again, particularly interesting since Barro and Barro-Rush used these unadjusted series in their study. As in the case of seasonally adjusted data, we summarize the resultant statistics relevant for the unanticipated hypothesis as in Table (5.2.2.B3).

Table 5.2.2.B3
Tests of Unanticipated Hypothesis
Seasonally Unadjusted Case

(1)	(2)	(3)	(4)
Variable	**Lags**	**F-Statistics**	**F-Statistics**
DMR	0	F(1,68) = .01	F(1,64) = .01
DMR	1	F(2,66) = .17	F(2,62) = .22
DMR	2	F(3,64) = .08	F(3,60) = 1.19
DMR	3	F(4,62) = .13	F(4,58) = 1.85
DMR	4	F(5,60) = .05	F(5,56) = .87
DMR	5	F(6,58) = .04	F(6,54) = 1.04
DMR	6	F(7,56) = .03	F(7,52) = .87
DMR	7	F(8,54) = .11	F(8,50) = .85
DMR	8	F(9,52) = .23	F(9,48) = .83
DMR	9	F(10,50) = .24	F(10,46) = .77
DMR	10	F(11,48) = .26	F(11,44) = .55
DMR	11	F(12,46) = .30	F(12,42) = .62
DMR	12	F(13,44) = .38	F(13,40) = .71
DMR	13	F(14,42) = .36	F(14,38) = .75
DMR	14	F(15,40) = .41	F(15,36) = .89
DMR	15	F(16,38) = .43	F(16,34) = .95
DMR	16	F(17,36) = .57	F(17,32) = .65

Unlike the Japanese case, the unanticipated hypothesis continues to be rejected in this case. Column (3) of the table (5.2.2.B3) indicated the test statistics where the autocorrelation problem of each equation has not seen corrected. The column (4) is the case correcting the problem in each equation. In both cases the test statistics do not exceed their critical values for them, which implies the anticipated hypothesis in joint tests can be rejected in each equation. All these output equations with only unanticipated component of money, however, do no possess a white-noise property of residuals even if those are tried to be corrected by using a fourth-order adjustment of autocorrelation. This implies, as in the Japanese case, the inferences from the F-test are biased toward the presence of autocorrelation of residuals in each equation. So, the rejection of unanticipated hypothesis is subject to change in the presence of serial correlation problem. This, again, leads us to doubt the specification of output equation in Korea.

To check the irrelevance of the anticipated component of money to the movement of output, we regress the output on both components of money to see the relevance of the anticipated part of money in a determination of output. This can be tabulated as in Table (5.2.2.B4). Column (3) of Table (5.2.2.B4) is associated with the test statistics without a fourth-order adjustment for autocorrelation. In this case, first, the current values of anticipated and unanticipated money are insignificantly different from zero. Secondly, up to the first three lags the unanticipated hypothesis is rejected in each case. Finally, after the fourth-lag, both components turn out to be significant. This case, however, reveals each equation examined suffers from severe correlation problems of residuals. This fact, therefore, twists the results obtained from the F-tests.

Table 5.2.2.B4
Tests of Irrelevance for Anticipated Money
Seasonally Unadjusted Case

(1)	(2)	(3)	(4)
Variable	Lags	F-Statistics	F-Statistics
DMR	0	F(1,67) = .02	F(1,63) = .03
DM	0	F(1,67) = .15	F(1,63) = .26
DMR	1	F(2,64) = 2.11	F(2,60) = 32.55**
DM	1	F(2,64) = 7.55**	F(2,60) = 62.26**
DMR	2	F(3,61) = 2.19	F(3,57) = 5.73**
DM	2	F(3,61) = 7.90**	F(3,57) = 13.61**
DMR	3	F(4,58) = 2.07	F(4,54) = 3.23*
DM	3	F(4,58) = 6.59**	F(4,54) = 5.80**
DMR	4	F(5,55) = 8.96**	F(5,51) = 3.10*
DM	4	F(5,55) = 13.71**	F(5,51) = 5.70**
DMR	5	F(6,52) = 6.31**	F(6,48) = 5.47**
DM	5	F(6,52) = 11.29**	F(6,48) = 8.04**
DMR	6	F(7,49) = 7.47**	F(7,45) = 4.46**
DM	6	F(7,49) = 13.47**	F(7,45) = 6.76**
DMR	7	F(8,46) = 7.93**	F(8,42) = 4.01**
DM	7	F(8,46) = 13.00**	F(8,42) = 6.10**
DMR	8	F(9,43) = 11.46**	F(9,39) = 3.34**
DM	8	F(9,43) = 16.28**	F(9,39) = 5.14**
DMR	9	F(10,40) = 10.87**	F(10.36) = 2.54*
DM	9	F(10,40) = 17.57**	F(10,36) = 4.43**
DMR	10	F(11,37) = 11.26**	F(11,33) = 2.57*
DM	10	F(11,37) = 18.34**	F(11,33) = 4.58**
DMR	11	F(12,34) = 19.08**	F(12,30) = 3.33**
DM	11	F(12,34) = 28.34**	F(12,30) = 5.87**

(1)	(2)	(3)	(4)
Variable	Lags	F-Statistics	F-Statistics
DMR	12	F(13,31) = 17.16**	F(13,27) = 3.76**
DM	12	F(13,31) = 24.04**	F(13,27) = 5.97
DMR	13	F(14,28) = 18.47**	F(14,24) = 3.18**
DM	13	F(14,28) = 26.19**	F(14,24) = 5.46**
DMR	14	F(15,25) = 15.87**	F(15,21) = 3.67**
DM	14	F(15,25) = 24.61**	F(15,21) = 6.97**
DMR	15	F(16,22) = 33.74**	F(16,18) = 6.46**
DM	15	F(16,22) = 49.50**	F(16,18) = 12.78**
DMR	16	F(17,19) = 25.8**	F(17,15) = 3.90**
DM	16	F(17,19) = 37.52**	F(17,15) = 10.11**

The results with the fourth-order adjustment for autocorrelation are shown in Column (4) of the same table. In this case, the results obtained show (a) the current values of coefficients of each component are not significantly different from zero as in the case without correcting for the autocorrelation problem, (b) both components of money turn out to be very important when they are regressed simultaneously, and (c) the autocorrelation problem is much improved in this case. The fact (a) is the same as in the case without a fourth-order autocorrelation adjustment. In the fact (b) we found the anticipated money is as important as the unanticipated one. The output functions with seventh lag and on do show a white-noise property of residuals so that the test statistics in this case are not biased toward the presence of the autocorrelation problem. In each equation with seven lag, and on, both components are very significant which implies anticipated component is at least as important as the unanticipated one. Among them, the most significant output function occurs at the fifteenth lag F-statistic of which significantly exceeds its critical value. This output equation has its R^2 = .998, SEE = .03, DW = 1.92, Q(21) = 30.51 where the critical value of Q-statistic for the first 24-lag case is 36.41 at the 5% significance level. The marginal p-value of Q-statistic is .08. This output equation is far superior to the one with either anticipated, or unanticipated, component alone. This, again, suggests the distinction between the two components is not necessary as in the case of seasonally adjusted data.

In sum, the test results obtained in the Korean case are biased toward the presence of the autocorrelation problem. In the case of seasonally adjusted case, the output function after the seventh-lag and on reveal a white-noise property of residuals where both components of anticipated and unanticipated money turn out to be insignificantly different from zero. Within the first six lags the test statistics are biased toward the presence of autocorrelation of residuals in each equation. In like manner, the output functions with seasonal unadjustment do not have a white-noise process of their residuals in all lags. Only after the twelfth lag, and on, the residuals of each equation have a white-noise property. This, again, implies that the specification of output equation in Korea is suspected. We draw the following suggestions: (a) we need to carefully reexamine the specification of Korean output equation in a further study, and (b) the distinction between the two components of money may be irrelevant for a determination of output function in Korea. Within this limitation, in both cases of seasonally adjusted and unadjusted data, the unanticipated hypothesis seems to be rejected.

5.3 Results from the Mishkin Model

5.3.1 Introduction

In the previous section we tested the unanticipated hypothesis of Barro (1977, 1978) and Barro-Rush (1980) with the data of Japan and Korea. Their studies, however, tested the monetary NP under the maintained hypothesis of RE. In contrast, the Mishkin (1982, 1983) framework allows more general framework to test the MRE hypothesis via a series of likelihood ratio tests drawn from the joint, nonlinear estimation of the money growth equation and a form of output equation which reflects either the maintained or a relevant alternative hypothesis. As we discussed in the introductory chapter, the MRE hypothesis requires both the NP and REH.

For convenience, we rewrite the equations (5.2.2A) through (5.2.2D) again. That is,

$$y_t = a_0 + a_1 t + \sum_{i=0}^{N} \beta_i (M_{t-i} - \mathrm{E}_{t-i-1} M_{t-i}) + e_t , \tag{5.3A}$$

$$M_t = Z_t r + v_t , \tag{5.3B}$$

$$y_t = a_0 + a_1 t + \sum_{i=0}^{N} \beta_i (M_{t-i} - Z_{t-i} \hat{r}) + e_t , \tag{5.3C}$$

$$y_t = a_0 + a_1 t + \sum_{i=0}^{N} \beta_i (M_{t-i} - Z_{t-i} \hat{r}) + \sum_{i=0}^{N} d_i Z_{t-i} \hat{r} + e_t , \tag{5.3D}$$

As mentioned in an earlier section, the test of monetary neutrality originally proposed by Barro examines whether the beta's are jointly different from zero, and whether the d_i's are jointly equal to zero. This test is, however, not to test the MRE hypothesis but only monetary NP, as we saw earlier, since the rationality hypothesis is maintained the anticipated money growth rates in the output equation coincide with the least square projection of money growth on Z_t.

Several econometrics issues are raised by the above methodology. The two-step procedure of parameter estimates may be invalid, since this procedure implicitly assumes that the covariances of the β and r estimates are zero. When there are off-diagonal elements in the information matrix of the joint estimates, ignoring them, as is done in the two-step procedure will lead to test statistics which do not have the correct asymptotic distribution, and this can lead to inappropriate inferences.

Joint estimation allows for off-diagonal elements in the information matrix. Furthermore, it will result in more efficient estimates of the β and r parameters because both (5.3B) and (5.3C) make use of information from each other in the estimation process. In addition, the Mishkin framework allows full testing of the MRE hypothesis via a series of likelihood ratio tests drawn from the joint, nonlinear estimation of the money growth equation and a form of the output function which reflects wither the maintained or a relevant alternative hypothesis while the two-step procedure cannot test for rationality and is only capable of testing for neutrality.

To conduct this joint, nonlinear test, Mishkin assumed that the covariances of residuals of money growth and output equation, e_t and v_t in the above equations, are zero. That is, both equations are assumed to be true reduced form equations. This assumption insures consistent estimates of the coefficients on the unanticipated money growth. One advantage of this approach is that it allows to correct the degree of freedom problem that we face in the full information maximum likelihood method. What is more, this approach allows us to easily impose the necessary covariance restrictions. Finally, it can make use of a computer package like SAS that can estimate systems with large number of parameters. In this section we conduct this joint, nonlinear test of the MRE hypothesis with Japanese and Korean data. As in the previous section, we examine the test and MRE hypothesis in the context of both seasonally adjusted and unadjusted data.

To construct the relevant likelihood statistics, in addition to the above equation system, we need to introduce one more equation. That is,

$$y_t = a_0 + a_1 t + \sum_{i=0}^{N} \beta_i (M_{t-1} - Z_{t-1} r^*) + \sum_{i=0}^{N} d_i Z_{t-1} r^* + e_t, \tag{5.3E}$$

where r* is not equal to r. Efficient estimates of the parameters in the output and money growth equation under the MRE hypothesis, then, can be obtained by estimating equations (5.3B) and (5.3C) jointly where r = r*. A test of the MRE hypothesis may be obtained by comparing the maximum likelihood value from the system formed by (5.3B) and (5.3C) with that obtained from jointly estimating (5.3B) and (5.3E).[12] The maximum likelihood test statistic is asymptomatically distributed as Chi-Square (q) where q is the number of restrictions.

Besides being able to test the joint assumptions of neutrality and rationality, as mentioned earlier, the Mishkin framework allows testing of individual hypotheses. A test of monetary neutrality may be obtained by jointly estimating equations (5.3B) and (5.3D) where neutrality is not maintained and, then, comparing the resulting likelihood value with the likelihood value from the system of equations formed by equation (5.3B) and (5.3C).

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[12] A likelihood ratio statistic can be calculated from the sum of squared residuals from each two equations system. The appropriate test statistic is

$$2T[\ln(SSR^c) - \ln(SSR^u)]$$

where SSR^c is the total sum of square residuals from the constrained system, SSR^u is the total sum of squared residuals from the unconstrained system, and T is the number of observations in each equation.

In addition, a test of the rationality assumption can be tested by forming relevant systems of equations (5.3B) and (5.3D) which includes the cross-equation restrictions from the REH and equations (5.3B) and (5.3E) where these restrictions are not imposed.[13]

Before proceeding with our estimation procedure, we should make two important decisions. The first concerns the problem of potential serial correlation in the reduced form output function. The presence of serial correlation would seriously tainted our test statistic if it is left uncorrected. To avoid this problem, we take Mishkin's position that the error terms follows a fourth order autoregressive process.

The second decision is related to the specification of the lag length on unanticipated money growth - the size of N in equations (5.3C), (5.3D), and (5.3E). Since the MRE theoretical framework offers little direction on this point, some basis for choosing the lag length is needed.[14] Among them, we follow Leamer's (1978) suggestion for experimenting with plausible, less restrictive models to obtain insight of the rubustness of the results. As Hoffman and Schlagenhauf (1982) pointed out, the cost of choosing lag length is a potential decrease in the power of the likelihood ratio test, rendering it less

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[13] The nonlinear estimation of the various systems of equation is, as mentioned above, conducted under the assumption that the covariance of the error terms from the two equations is zero. If heteroscedasticity exists within or across equations, the test statistics are not appropriate. In this section we only had to adjust for across equation heteroscedasticity. the actual correction involved an iterative nonlinear GLS procedure with equated the variances across the money growth and output equations. The weighing procedure continues in an iterative fashion until the changes of log determinants of each covariance matrix are not different from the iterative criterion value of estimating pairs of constrained and unconstrained models in out analysis. The SSRs from the constrained money and output equations will be used to weight the relevant unconstrained system as well. This approach , as in Mishkin (1982, 1983), avoids the problem of using SSRs which were determined with vastly different degrees of freedom in estimating the constrained and unconstrained models.

[14] A number of potential criteria exist. A statistical criterion as suggested by Akiake (1969) is one possibility. Another possibility for specifying the lag length is to choose the lag length on the basis of excluding lagged unanticipated money variable if their coefficients are not significantly different from zero as Barro did.

likely to reject the null hypothesis if it were untrue. The addition of irrelevant variables will not result in incorrect test statistics. Given the decision to err on the side of longer lags, we specified the longest lag scheme possible with our data sample.[15] This is a lag length of thirteen quarters. In addition, we conducted our analysis for a lag length of seven quarters which was the lag specification employed by Barro and Barro-Rush in their studies.

[15] Actually, it is the data sample and the number of parameters that must be estimated in the totally unconstrained model - the system formed by (5.3B) and (5.3E) - which limit our lag length to thirteen quarters.

5.3.2 The Empirical Results

In this section we present the results from the complete set of the MRE hypothesis with Japanese and Korean samples (the U.S. case is in Appendix D). We first examine the results derived from testing the joint hypothesis of RE and anticipated monetary neutrality. Then, we consider the results from individual tests of the rationality assumption and neutrality hypothesis. This order of study is logical in that, if the joint hypothesis of rationality and neutrality is rejected, it is only logical to complete the analysis and determine which of two hypotheses was responsible for the result. As in the previous section, Barro and others in this literature tested only neutrality under the maintained hypothesis of RE. Thus, the present section highlights the limitations of the previous test procedure like Barro's.

We now present two tables (5.3.2.A1) and (5.3.2.A2) where the first shows the results from nonlinear estimates of the totally constrained output equation with the seven-lag case. Then, in the second we present the results of likelihood ratio tests for various hypotheses with seven and thirteen lags. For brevity, we present separately the U.S. case in Appendix D. and put one of the programs with the SAS NLIN procedure for the reference in Appendix F.

Table 5.3.2.A1: Nonlinear Estimates of Output Equations (Lag=7)

	Country						
		Japan				Korea	
Parameter	S.A		S.U		S.A		S.U
Constant	10.68		0.07		20.65		0.006
Time	0.006		0.006		0.003		0.0003
β1	-0.40		-0.002		0.57		0.002
β2	0.39		0.016		-0.86		-0.027
β3	0.51		0.007		0.66		0.049
β4	-0.96		0.008		0.98		-0.040
β5	0.79		-0.005		-0.56		-0.008
β6	0.60		-0.009		0.45		0.035
β7	0.69		0.002		0.22		-0.046
ρ1	-0.93		1.446		0.22		0.173
ρ2	0.65		-0.778		0.34		0.144
ρ3	0.44		0.345		0.80		0.145
ρ4	0.27		0.444		1.44		1.102
R^2	0.95		0.87		0.91		0.85
Root MSE	0.028		0.086		0.025		0.098
Q(24)*	29.2		32.7		33.5		40.9
	(0.21)		(.13)		(0.09)		(0.01)

Notes: S.A. = Seasonally adjusted, S.U. = Seasonally Unadjusted data, ρ's = coefficients of autocorrelations, MSE = mean square error, and β's = coefficients of unanticipated money. The marginal significance level appears in parentheses below the Q-statistic.

As in Table (5.2.3.A1), the output equation with seasonal data fits better than the one with nonseasonal data. For simplicity, the asymptotic errors of coefficients and their confidence intervals are not shown here. For interpretative purpose, the equations with seasonally adjusted data are much more convenient than the ones of the seasonally unadjusted case. These statistics revealed that unanticipated money of Japan and Korea is not important. To check the validity of the MRE hypothesis, we present the results as in Table (5.3.2.A2). Unlike the previous section, output equation in both countries do not reveal the autocorrelation problem.

In Table (5.3.2.A2), the MRE hypothesis is not rejected in the Japanese Case, but can be rejected in the Korean case when lag length is seven.

Table 5.3.2.A2: Likelihood Ratio Tests for Various Hypotheses Seasonal Adjustment Case

	Lag Length of Seven with Seasonal Data		
Country	Joint Hypothesis	Neutrality Hypothesis	Rationality Hypothesis
Japan	Q(22)=29.9 (0.140)	Q(8)=19.6 (0.011)	Q(13)=12.5 (0.492)
Korea	Q(22)=51.5 (0.011)	Q(8)=14.8 (0.079)	Q(13)=12.5 (0.024)
	Lag Length of Thirteen with Seasonal Data		
Country	Joint Hypothesis	Neutrality Hypothesis	Rationality Hypothesis
Japan	Q(27)=52.9 (0.003)	Q(14)=29.5 (0.004)	Q(13)=32.4 (0.002)
Korea	Q(27)=63.2 (0.0008)	Q(14)=32.0 (0.004)	Q(13)=27.6 (0.002)

* Marginal P-value is in parenthesis at the 5% significance level.

To be more specific, the NP is rejected in Japan, but not in Korea. However, the RE hypothesis is not rejected in the Japan case, but not in the Korean case. From these results, we may infer that the acceptance of the MRE hypothesis in Japan is due to the presence of RE hypothesis, and that the rejection of the MRE hypothesis in Korea is due to the failing of RE hypothesis. On the other hand, when the lag length is extended to the thirteen, the MRE hypothesis is rejected in both countries. In this case neutrality and rationality are all rejected in both countries.

In the case of seasonally unadjusted data, the results are similar to those from the case with seasonally adjusted data. In the former the marginal p-values of some test statistics, for example, those of the joint hypothesis and the RE hypothesis are zeros since their test statistics are relatively high.[18] Because of their similarity to the results with seasonally adjusted data, we do not report them in the case of seasonal unadjusted data. Mishkin (1982) and others who used the method adopted here utilized seasonal rather than nonseasonal data.

In sum, the present section summarized the results when we adopted the methodology suggested by Mishkin (1982). In every area of tests the MRE hypothesis is not rejected in only one case when we examined the Japanese data with the lag length of seven. In this case the acception of the MRE hypothesis is due to the REH. In contrast, the MRE hypothesis is rejected in the Korean case. This rejection is also due to the REH. From these, we infer that the REH seems to be important whether or not the MRE hypothesis is accepted. In the lag length of thirteen, however, the MRE hypothesis is rejected in both countries. These rejections come from the results that both the

[18] The Goldfeld-Quandt tests do not reveal the heterosckesdacity within money and output equations. From these, we infer that the seasonality play an important role to test for the MRE hypothesis.

monetary NP and the REH are rejected in each country. Thus the results obtained are sensitive to the lag length taken. The present section also suggests that to test the MRE hypothesis, the seasonal data is more expressive than the nonseasonal ones.

5.4 Testings for Nonstationarity

5.4.1 Introduction

As McCallum (1982) points out, the studies of Barro (1977, 1978), Barro-Rush (1980), Gordon (1982), and Mishkin (1982, 1983) presumed the movements of output or unemployment rate are stationary (McCallum 1982). Nelson and Plosser (1982), however, argued most macro time series in the U.S. are nonstationary. To test for nonstationarity of the U.S. macro data, they assumed two alternative classes of statistical univarite time series models. These statistical classes are important to understand the recent studies on nonstationarity of macro time series.

One of these, they called a trend stationary (TS) process. Consider the time series variable z_t, which we assume is measured in logarithms. According to the TS model, z_t is covariance stationary about a deterministic trend. If the growth rate of z_t is a stationary stochastic process, the deterministic trend component must be linear. The following univariate time series representation for z_t reflects these assumptions:

$$z_t = a + bt + a(L)u_t, \qquad (5.4.1A)$$

or

$$z_t = bt + a(L)u_t \qquad (5.4.1A')$$

where z = series examined, t = trend variable, u = random error with zero mean, serially uncorrelated time t innovation to z_t, $a(1) = 1 + a_1L + a_2L^2 + \ldots$ is a polynomial in the lag operator L, a = drift, and b = fixed parameter. The (5.4.1A) includes the drift term, but the (5.4.1A') does not. We denote the variance of u_t by σ^2. Since z_t is covariance stationary, a^2_j and σ^2_u are both finite. This kind of model is consistent with the ones mentioned in the previous sections since the TS specification is fundamentally stationary.

On the other hand, the other class of process is they called a difference stationary

(DS). According to the DS model, the first difference of z_t, z'_t, is a covariance stationary process which we write

$$z'_t = b + c(L)e_t, \quad (5.4.1B)$$

where z' = the first difference of z series, $b(L) = 1 + c_1L + c_2L + ...$ is a polynomial in the lag operator, $\Sigma\, b_j^2 < \infty$, b = constant, and e = random error with zero mean and serially uncorrelated innovation to z_t. We denote the variance of e_t by σ^2_e. As Christiano and Eichenbaum (1989) point out, to distinguish TS and Ds processes, we need a requirement imposing that b(1) is not zero.[17]

To test nonstationarity in the U.S. macro time series, Nelson-Plosser adopted the augmented version of Dickey-Fuller (1979) tests as explained in Chapter 4. We, however, adopt the likelihood ratio test of null hypothesis of unit root (Dickey-Fuller 1981). To understand the rationale for Dickey-Fuller tests, we write a simple version of time series model as follows.

$$z_t = a + bz_{t-1} + u_t, \quad (5.4.1C)$$

Under the DS specification b is equal to unity, and under the TS class b is less than unity. In other words, under the TS process stability and ivertibility conditions of time series model are held, thus, the variance of u_t of the model is finite. If b is equal to unity, these conditions do not hold, and the variance of u_t is increasing over time. When we assume TS class is appropriate, therefore, we are implicitly bounding uncertainty and greatly restricting the relevance of the past to the future.

Nelson and Plosser (1982, p. 143) state, "It would appear then, if a series is generated by a member of the linear TS subclass, we should fail to reject the hypothesis of a unit MA root in the ARMA model for its first difference, and if it is generated by a

[17] See, Christiano and Eichenbaum (1989 p. 7).

member of the first order DS subclass, we should fail to reject the hypothesis of a unit AR root in the ARMA model for its level."[18] They also point out the standard asymptotic theory developed for stationary and invertible ARMA models is not valid for testing the hypotheses that either polynomial contains a unit root. Under the null hypothesis of DS specification the (5.4.1C) can be written

$$z_t - z_{t-1} = a + u_t, \qquad (5.4.1D)$$

since b = 1 under this hypothesis. The standard expression for the large sample variance of the least-square estimator $\hat{b}$ is $[(1-b^2)/T]$ which would be zero under the null hypothesis. The true variance, of course, is not zero; the problem is the conventional asymptotic theory is not proper in this case. For this reason, Dickey and Fuller developed the limiting distribution of $\hat{b}$ and the conventionally calculated least-square t-statistic In addition, they provide a set of results which allow us to test the DS hypothesis against the TS hypothesis as long as we are willing to assume only AR terms are required to obtain satisfactory representations.[19] The idea of Dickey-Fuller[20] tests is then, to embed both hypotheses into a common model which can be written

$$z_t = a + bz_{t-1} + ct + u_t, \qquad (5.4.1E)$$

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[18] The fundamental difference between the two classes of process can be expressed in terms of the roots of the AR and MR polynomials. If the linear TS model is first-differenced, it indicates a unit root will be present in the MA part of the ARMA process describing the first differences of the series. Correspondingly, when the DS is written in terms of levels, there exists a unit root in the AR polynomial.

[19] There are, however, many reasons to believe economic times series contain MA component. See, Schwert (1987 pp. 77-78).

[20] Their study allows us, as Nelson and Plosser (1982) point out, to examine the distribution of $\hat{b}$ in higher AR order cases. They employed this augmented version of Dickey-Fuller tests to examine the U.S. data. See, Walton (1987, pp. 219-220).

$$z_t = a + bz_{t-1} + ct + u_t, \qquad (5.4.1E)$$

where under the DS specification b=1 and c=0. Dickey and Fuller (1979) developed an augmented version of (5.4.1E) in higher AR order cases, and they (1981) further extended their study to the likelihood ratio tests of the unit root hypothesis, as we saw earlier. In this section we examine macro time series of Japan, Korea and the U.S. (Appendix E) by adopting the likelihood ratio tests of Dickey and Fuller (1981).

5.4.2 Analysis of Output Series in Japan and Korea

We now turn to the analysis of Japanese and Korean (including the U.S.) yearly data in macro time series ranging from 1970 to 1988 which include measures of real output, nominal output, the unemployment rate, the money stock, and the GNP deflator. All series used are transformed to natural logarithm.

Table 5.4.2A1: Sample Autocorrelations[a] of the Natural Logarithm of Annual Data in Japan

		Sample Autocorrelation						
Series	Period	T	r1	r2	r3	r4	r5	r6
Real GNP	70-88	19	.81	.64	.47	.33	.20	.07
Nominal GNP	70-88	19	.85	.70	.54	.39	.24	.10
Unemployment Rate	70-88	19	.55	.05	-.23	-.37	-.36	-.38
M1	70-88	19	.84	.68	.52	.38	.24	.10
M2	70-88	19	.85	.70	.55	.40	.26	.11
GNP Deflator	70-88	19	.87	.72	.55	.38	.23	.10

a. T = sample size, r_i = the ith order correlation coefficient. The large sample standard error under the null hypothesis of no autocorrelation is $T^{-1/2}$ or roughly 0.23 for series of the length considered here (Barlett test).

Even though the sample span is much shorter than that of Nelson and Plosser, it is still interesting in that the present section gives us a cross-country comparison of Japan, Korea, and the U.S. To specify the lag length of extended version of (5.4.1E) in its AR part, we need to consider the sample autocorrelation functions of the series.

The results of sample autocorrelations of the levels in Korean macro time series are shown in Table (5.4.2A1). The sample autocorrelations of the levels in Korea start at around 0.85 at lag one and decay rapidly as the lag increases. Among the series, the

Table 5.4.2A2: Sample Autocorrelations of the First[a] Difference of the Natural Logs of Annual Data

			Sample Autocorrelations						
Series	Period	T	r1	r2	r3	r4	r5	r6	s(r)
Time Aggregated[b]									
Random Walk			.25	.00	.00	.00	.00	.00	
Real GNP	70-88	18	.22	-.20	-.33	-.35	.13	.11	.08
Nominal GNP	70-88	18	.75	.65	.45	.23	.08	-.18	.07
Unemployment Rate	70-88	18	17	-.22	-.14	-.24	.05	.01	.20
M1	70-88	18	.52	.10	.18	.30	.22	.01	.09
M2	70-88	18	.70	.42	.31	.29	.09	-.22	.06
GNP Deflator	70-88	18	.52	.15	-.05	-.02	.10	.13	.10

a. T. is again a sample size, r_i is the estimated ith order autocorrelation coefficient, and s(r) is the large sample standard error for r under the null hypothesis of no autocorrelation.

b. Theoretical autocorrelations as the number of aggregate observations becomes large; result due to Working (1960).

unemployment rate has lower starting values of sample autocorrelations than other series examined, and shows a stability. Even though the sample span is much smaller than that of Nelson-Plosser, the series have very similar patterns to those of the United States.

On the other hand, when we first difference the series examined, the results can be summarized as in Table (5.4.2A2). This shows the sample autocorrelation structure of real GNP, and the unemployment rate display positive autocorrelation at lag one only which is characteristic of first-order moving average (MA) process. The sample autocorrelation structure of nominal GNP, M1, M2, and GNP deflator exhibit more persistent autocorrelation in first difference. This can be, as Nelson and Plosser (1982) pointed out, explained by the sample autocorrelations of the deviations from the trend which is not shown here. These are very similar in all of series. The partial autocorrelations of the deviations from the trend (not shown here) are also very similar across all of the series. The values of first differenced series and partial autocorrelations of deviations from the trend suggest the specification of type of model (5.4.1D) in all series[21] as

$$z_t = a + ct + b_1 z_{t-1} + b_2 (z_{t-1} - z_{t-2}) + u_t \, . \tag{5.4.2A}$$

To conduct the likelihood ratio tests of the unit root hypothesis, we need to estimate the models

$$z_t - z_{t-1} = a + ct + b_1 z_{t-1} + b_2 (z_{t-1} - z_{t-2}) + u_t \, . \tag{5.4.2B}$$

$$z_t - z_{t-1} = a + b_2 (z_{t-1} - z_{t-2}) + e_t \, ,$$

[21]This is very different from the U.S. cases where the series examined have all different specifications (see Nelson and Plosser, Table 5 at p.151). This is due to the fact that the partial autocorrelations of deviations from trend are a sharp cut-off after lag one which suggests the lag length of k=1 in all series. Recall that Nelson and Plosser (1982) presumed that time series can be represented by the AR only. So, they fit AR approximation where MA models for first difference seem appropriate.

(5.4.2C)

Table 5.4.2A3: The Resultant Estimates of Eq. (5.4.2B)

Series	$\hat{a}$	$\hat{c}$	b1	b2	SSR1	SSE	R2	DW	Q(8)
Real GNP	2.30	.06	- .61	.53	.065	.07	.399	2.14	8.45 (.39)
Nominal GNP	.65	.008	- .06	.53	.025	.04	.723	2.64	13.97 (.08)
Unemployment Rate	8.92	.21	-1.33	.40	.447	.19	.978	.329	21.45 (.006)
M1	1.15	.01	- .13	.21	.060	.07	.605	1.97	14.77 (.06)
M2	.77	.01	- .08	.52	.026	.04	.639	1.97	7.76 (.46)
GNP Deflator	.66	.009	- .13	.47	.110	.09	.462	1.97	7.17 (.52)

Notes: SSR1 = residual sum of squares, SSE = standard error of regression, R^2 = determinance of coefficients, DW = Durbin-Watson Statistic, and Q(8) = Ljung-Box Q-Statistic with 8 degrees of freedom. Q-statistic is calculated from the formula as follows:

$$Q = N(N+2)\ [\sum_{j=1}^{M} \frac{1}{N-j} r_j^2]$$

where N = number of observations, M = degrees of freedom, and r_j = jth lag autocorrelation of residuals. Significance of Q statistic is in the parentheses underneath the Q-statistic.

where the (5.4.2B) is one version of the stationary model, and the (5.4.2C) is one version of the nonstationary model. To test the unit root hypothesis, we construct the F-ratio by (5.4.2B) and (5.4.2C) where our constrained equation is (5.4.2C). Then, we refer it to the Dickey-Fuller (1981, pp.1070-1071) limiting distribution. The resultant estimated equations of (5.4.2B) can be summarized as in Table (5.4.2A3). From this table, we infer that AR representation of the unemployment rate is doubtful since its Q-statistic exceeds its critical value of 22.0 at the 5% significance level. In contrast, Nelson and Plosser (1982) found the U.S. unemployment rate series are represented by AR term only which enables them to test their unit root hypothesis. In the present study, however, the unemployment rate is not successfully represented by the pure AR terms only. This is one of the reasons that the results of nonstationarity tests using Dickey-Fuller method is open to question (Walton 1987, Schwert 1978). In the present study the other series except the unemployment rate are successfully represented by AR terms only.

Table 5.4.2A4: The Resultant Estimates of Eq. (5.4.2C)

Series	$\hat{a}$	b3	SSR2	SSE	R2	DW	Q(8)	
Real GNP	.08	.22	.10	.08	.05	1.86	7.33	(.50)
Nominal GNP	.04	.78	.04	.04	.59	2.41	9.68	(.29)
Unemployment Rate	7.60	-.35	20.22	1.16	.005	.071	24.61	(.002)
M1	.09	.55	.11	.08	.29	1.61	11.29	(.19)
M2	.06	.72	.04	.05	.50	1.87	10.29	(.24)
GNP Deflator	.05	.54	.15	.10	.28	1.82	5.27	(.73)

To construct the F-ratio, we also summarize the resultant estimated equations of (5.4.2C) in Table (5.4.2A4). To check whether the given series are DS or TS class, we present the F-statistic in terms of both traditional and Dickey-Fuller limiting F-table to understand the controversial issue of a unit root in recent macroeconomic literature. This statistic can be constructed as usual, but we can no longer refer this to the traditional F-table since the traditional one is written under the assumption that the least squares estimates of b_1 is less than unity, that is, the series under the study are stationary. The F-ratios constructed here are as follows. That is,

$$\frac{(SSR2-SSR1)/k1}{SSR1/(T-k2)}$$

where k1 and k2 are number of parameters in the corresponding equations, and T = a number of observations.

Table 5.4.2A5: F-Statistic from Conventional and Limiting Case

		Critical Values	
Series	F-Stat	Conventional Case	Limiting Case
Real GNP	3.21	3.98 (7.21)	7.24 (10.61)
Nominal GNP	2.74	3.98 (7.21)	7.24 (10.61)
Unemployment Rate	243.57*	3.98 (7.21)	7.24 (10.61)
Interest Rate	2.67	3.98 (7.21)	7.24 (10.61)
M1	4.43	3.98 (7.21)	7.24 (10.61)
M2	2.07	3.98 (7.21)	7.24 (10.61)
GNP Deflator	1.83	3.98 (7.21)	7.24 (10.61)

Notes: 1% significance levels are in parentheses.

As in Table (5.4.2A5), the unemployment rate seems to be of the TS class, but its AR representation is doubtful. For this reason, the resultant statistic is not valid. The other series seem all nonstationary, that is, those seem to belong to the DS specification. Referring to the traditional F-table, we notice that the M1 series belongs to the TS process at the 5% significance level. When we refer to the Dickey-Fuller table, however, M1 belongs to the DS class even though it still does DS at the 1% significance level under the traditional table. In general, our findings in the Korean case seem, except for the unemployment rate, not inconsistent with those of Nelson and Plosser (1982) even though the spans of two studies are quite different from each other.

In contrast, we now examine the Japanese macro time series. As in the Korean case, we first present the results of sample autocorrelations of the levels of series examined in Table (5.4.2B1). The resultant sample autocorrelations of the levels in Japan start approximately at .80 at lag one and decay rapidly as the lag increases. Unlike the Korean case, the starting value of real GNP is the lowest among the series examined, and these series decay more rapidly than other series.

Table 5.4.2B1: Sample Autocorrelations of the First[a] Difference of the Natural Logarithm of Annual Data in Japan

			Sample Autocorrelations					
Series	Period	T	r1	r2	r3	r4	r5	r6
Real GNP	70-88	19	.73	.50	.34	.23	.10	.01
Nominal GNP	70-88	19	.83	.66	.49	.34	.21	.09
Unemployment Rate	70-88	19	.82	.63	.50	.29	.10	.03
M1	70-88	19	.78	.59	.43	.31	.20	.09
M2	70-88	19	.82	.64	.49	.36	.23	.11
GNP Deflator	70-88	19	.85	.69	.51	.34	.21	.09

a: T is also a sample size, r_i = the ith order autocorrelation coefficient. The large sample standard error under the null hypothesis of no autocorrelation is $T^{-1/2}$ or roughly 0.23, as in the Korean case, for series of the length considered here (Bartlett test).

The sample autocorrelations of first difference of given series is shown in Table (5.4.2B2). Unlike the Korean case, the above table reveals the sample autocorrelations structure of real GNP, unemployment rate, and GNP deflator display positive autocorrelation at lag one only which is again characteristic of first-order MA process. On the other hand, the sample autocorrelation structure of nominal GNP, M1, and M2 shows more persistent autocorrelation in first difference. For the series of nominal GNP, M1, and M2, we need to consider the sample autocorrelations of the deviations from the trend which is not shown here.

Table 5.4.2B2: Sample Autocorrelations of the first[a] Difference of the Natural Logs of Annual Data

			Sample Autocorrelations						
Series	Period	T	r1	r2	r3	r4	r5	r6	s(r)
Time Aggregate[b]		.25	.00	.00	.00	.00	.00	.00	
Random Walk									
Real GNP	70/88	18	.01	-.14	-.01	.05	-.03	-.23	.06
Nominal GNP	70/88	18	.75	.54	.42	.26	.10	-.06	.04
Unemployment Rate	70/88	18	.002	-.36	.21	-.12	-.21	.18	.10
M1	70/88	18	.66	.46	.26	.08	.12	-.02	.06
M2	70/88	18	.60	.37	.23	.14	.13	-.03	.04
GNP Deflator	70/88	18	.06	-.07	-.06	-.05	-.12	-.16	.06

a. s(r) indicates the large sample standard error for r under the null hypothesis of no autocorrelation.

b. Theoretical autocorrelations as the number of aggregate observations becomes large, result due to Working (1960).

The structure of sample autocorrelation of deviations from the trend is very similar across the series at hand. In addition, the partial autocorrelations of the deviations from the trend (not shown here) are also very similar across all of series examined. The values of first difference series and partial autocorrelations of deviations from trends suggest the specification of the type of model (5.4.1D) is the same in the Japanese case of (5.4.2A) in all series examined. For this reason, the analysis is quite similar to the Korean case.

We present the resultant estimates of equations (5.4.2B) and (5.4.2C), and tabulate the conventional and Dickey-Fuller limiting F-table to see whether the series examined are stationary or not.

Table 5.4.2B3: The Resultant Estimates of Eq. (5.4.2B)

Series	$\hat{a}$	$\hat{c}$	b1	b2	SSR1	SSE	R2	DW	Q(8)
Real GNP	4.40	.01	-.48	.13	.05	.06	.318	2.02	7.03(.53)
Nominal GNP	1.87	.006	-.14	.22	.006	.02	.823	2.50	9.48(.30)
Unemployment Rate	.17	.02	-.54	.21	.14	.10	.270	1.72	6.21(.62)
M1	3.54	.02	-.30	.10	.01	.03	.808	2.12	11.7(.16)
M2	4.13	.03	-.32	-.55	.006	.02	.781	2.11	9.66(.30)
GNP Deflator	1.36	.02	-.35	.15	.06	.07	.266	2.07	5.72(.68)

As in the above table, we recognize that the AR(1) specification is, unlike the Korean case, quite successful in all series examined since, as the Q-statistics show, the residuals of all series under the study have a white noise property. The significance level of Q-statistic is in the parentheses next to it. The unemployment rate is also represented as AR(1) term only even though its fit is poorer than the other series.

To construct the F-ratio, we need another constrained equation (5.2.4C) as in the Korean case. This is summarized in Table (5.4.2B2). As in Table (5.4.2B2), the overall fit of unemployment equation is much poorer than those of the others.

Table 5.4.2B4: The Resultant Estimates of Eq. (5.4.2C)

Series	$\hat{a}$	b3	SSR2	SSE	R2	DW	Q(8)
Real GNP	.03	.01	.07	.07	.0002	2.00	4.06(.85)
Nominal GNP	.02	.78	.01	.03	.5985	2.06	3.55(.90)
Unemployment Rate	.04	.004	.19	.11	.00001	1.84	7.21(.51)
M1	.02	.665	.02	.04	.6154	2.52	15.68(.05)
M2	.04	.608	.02	.03	.4531	2.41	8.04(.43)
GNP Deflator	.05	.060	.08	.07	.0034	1.96	6.06(.64)

The white-property of residuals of each equation is all accepted at the 1% significance level (critical value is 15.5 in that case). So, the AR specification of each equation is quite successful.

Finally, we are ready to construct the F-ratio to check whether the given series are DS or TS class as in the previous case.

Table 5.4.2B5: F-Statistic from Conventional and Limiting Case

		Critical Value	
Series	F-Stat	Conventional Case	Limiting Case
Real GNP	2.56	3.98 (7.21)	7.24 (10.61)
Nominal GNP	6.98	3.98 (7.21)	7.24 (10.61)
Unemployment Rate	20.39*	3.98 (7.21)	7.24 (10.61)
M1	5.50	3.98 (7.21)	7.24 (10.61)
M2	8.22	3.98 (7.21)	7.24 (10.61)
GNP Deflator	1.97	3.98 (7.21)	7.24 (10.61)

As in Table (5.4.2B5) above, the unemployment rate seems TS class, and the series of real GNP, nominal GNP, M1, and GNP deflator belong to the DS class referring to the limiting table (where sample size is 25) suggested by Dickey-Fuller (1981, p. 1063). In the case of M2, however, it is rejected at the 5% level, but not rejected at the 1% level so that its specification is not clearly set up in out context. As in the Korean case, we could see here how the traditional F-table misleads one in conducting the test. For example, nominal GNP and M1 is rejected at the 5% level in view of traditional F-test, but accepted the null hypothesis of DS specification in view of Dickey and Fuller table.

In sum, the findings of Nelson and Plosser (1982) not, overall, inconsistent with the ones of the present study. That is, the real GNP series of each country seem to be nonstationary. Our conclusion of nonstationarity of Japanese and Korean data is, however, not decisive for the following reasons: (a) as Schwert (1987) points out, many economic time series are not pure AR process. That is, there are many reasons to believe economic time series contain MA component (Schwert 1987, pp. 77-78). As evidence, the AR representation of the Korean unemployment rate is not firmly established. (b) More importantly, our sample span is much shorter than Nelson and Plosser (1982). In the literature the results of studies in this line seem to be sensitive to the sample span. The present study has only examined 19 yearly data for the tests. Even though our conclusion is not decisive, we focus on the issue in a cross-country aspect that suggests a further study in this direction.

Chapter 6
CONCLUSION

In the present study we have surveyed the MRE models, and conducted the empirical analysis with the Japanese and Korean data which are rarely considered in the literature. In the Barro's framework we found the MRE hypothesis is rejected except the limiting case. Furthermore, the present study suggests the specification of output equation in the Korean case should be carefully reconsidered since its residuals reveal that they are serially correlated. In contrast, the Japanese output equation is rather firmly established so that the results obtained are not biased towards the presence of the autocorrelation.

In the Mishkin's framework, the results obtained are similar to the findings of Hoffman and Schlagenhauf (1982). Generally, in the Japanese case the MRE hypothesis is not rejected due to the presence of the RE when the shorter lags of seven are considered. Examining the longer lags indicated the hypotheses of NP and RE are rejected, respectively. In the Korean case both examining shorter and longer lags reveal the MRE hypothesis is rejected. Where a shorter lag of seven is considered in the Korean case, the rejection of the MRE hypothesis seems due to the rejection of the RE. In contrast, in the Japanese case the acceptance of the MRE hypothesis in shorter lag of seven is due to the presence of the REH. For this reason, the MRE hypothesis tests hinge on the REH when the lag length of seven is considered. In the lag length of thirteen, all individual hypotheses are rejected in both countries. In every area of tests, the MRE hypothesis is accepted in only one case where the lag length of seven is considered with the Japanese data.

We have not been able to reject the possibility real macroeconomic variables for

Japan and Korea are nonstationary. Thus, this case some doubt on our results regarding the NP (as well, of course, as Barro's and Mishkin's). However, neither is the evidence conclusive that these data are better described by DS or more general classes of nonstationarity process than by some temporary process that would render the testing procedures we have used appropriate.

Appendix A
SOURCES AND DESCRIPTIONS OF DATA

1. The Japanese Case

Nominal GNP (NGNP), Government Expenditure (GE), Unemployment Rate (UN), Short-term Interest Rates (SR), M1 (JM1), M2 (JM2), GNP Deflator (P), Current Accounts Balance (CUR):

> These series are available from OECD Main Economic Indicator 1984, Historical Summary and Various Issues.

Government Deficits (GDF):

> Government Financial Statistics (GFS) from International Monetary Fund (IMF)

Notes: Quarterly values of GDF are available only up to 1980:II where the starting value is 1970:I. All series are seasonally unadjusted.

2. The Korean Case

Gross Domestic Product (GDP):

> National Accounts 1989, The Bank of Korea

Government Expenditure (GE):

> National Accounts 1989, The Bank of Korea

Unemployment Rate (UN):

> Economic Statistics Yearbook, The Bank of Korea, Various Issue

Short-term Interest Rate (SR):

> Money and Banking Statistics 1984, The Bank of Korea

M1 (KM1)

> Money and Banking Statistics 1984, The Bank of Korea

M2 (KM2)

Money and Banking Statistics 1984, The Bank of Korea

Government Deficits (GDF):

International Financial Statistics (IFS) from International Monetary Fund (IMF), Various Issues

Wholesale Price Index (WPI):

Price Statistics 1989, The Bank of Korea
Price Statistics Summary 1987, The Bank of Korea

Current Accounts Balance (CUR):

Balance of Payments Statistics (BPS) from International Monetary Fund (IMF), Various Issues
International Financial Statistics (IFS) from International Monetary Fund (IMF), Various Issues

Notes: All series are seasonally unadjusted. WPI is used as GDP deflator. CUR is only available from 1975:I to 1988:IV, as mentioned in the text.

3. The U.S. Case

Since the main study is focused on the Japan and the Korea es, cases, we consider smaller numbers of variables in the U.S. case, and sources of the data is OECD Main Economic Indicators, 1984, Historical Summary and Various Issues. The variables used are as follows:

Nominal GNP (NGNP), Government Expenditure (GE), Unemployment Rate (UN), Short-term Interest Rates (SI), M1 (UM1), M2 (UM2), GNP Deflator (P)

Notes: All series are seasonally unadjusted where we exclude current account balance and government deficit variables.

4. Seasonal Adjustment Method

We seasonally adjusted the data at hand under the present study by adopting the Holt-Winters approach. Refer more to the paper by Everette S. Gardner, Jr. (1985). We imposed multiplicative seasonality of series examined except for Government Deficits and Current Accounts Balance. These two are imposed by additive seasonal pattern.

Appendix B
DEMAND FOR MONEY FUNCTIONS OF COUNTRIES EXAMINED

This appendix examines the demand for money function of each country reviewed in the present study to closely see the reason of different policy results of Barro and Mishkin tests performed in the main text. To select the demand for money equations of countries examined, we allow up to five lags of the ones with the highest R^2 and lowest standard error of estimate (SSE). Also, the white-noise property of each equation is checked out, and we found the demand for money equations of each country examined have this property. the variables examined are traditionally considered as the arguments of the demand for money equation. Barro (1978) suggested a time trend variable in the demand for money function. We do, however, not include this variable since we simply run regressions on the levels considered rather than the differences in variables.

1. **The Japanese Demand for Money Functions**

$$(M2/P)_t = \underset{(.09)}{.09} - \underset{(.06)}{.021EX_t} - \underset{(.12)}{.002EX_{t-1}} + \underset{(.07)}{.02EX_{t-2}}$$

$$-\underset{(.008)}{.008SR_t} + \underset{(.09)}{1.66(M2/P)} - \underset{(.09)}{.67(M2/P)_{t-2}}, \qquad (A.1)$$

$$R^2 = .996,\ SEE = .02,\ DW = 1.94,\ Q(24) = 22.15\ (.57)$$

$$(M2/P) = \underset{(.24)}{.47} - \underset{(.03)}{.03EX_t} - \underset{(.06)}{.05SR_t} - \underset{(.09)}{.001SR_{t-1}} + \underset{(.06)}{.01SR_{t-2}}$$

$$+ \underset{(.10)}{.65(M2/P)_{t-1}} + \underset{(.09)}{.30(M2/P)_{t-2}} \qquad (A.2)$$

$$R^2 = .996,\ SEE = .05,\ DW = 1.78,\ Q(24) = 26.26\ (.34)$$

where M2/P = real money balance, EX = expenditure excluding government expenditure where M2/P = real money balance, EX = expenditure excluding government expenditure (see Barro 1978), SR = short-term interest rate and p-value of Q-statistic is in parenthesis. The (A.1) and (A.2) is the equations with seasonally adjusted and unadjusted data. In general, the fit of equation is much better in the seasonally adjusted than in the unadjusted data. More specifically, the net effect of the EX variables in (A.1) is negative, -0.0003 which implies, as Japanese government increases its expenditure, its money supply is rather falls. Even though its value is small, it is tainted the traditional monetary theory like Barro's (1978). In (A.1) the net effect of short-term interest rate is negative, -0.003, which conforms to the traditional money-interest relationship. Finally, the net effect of M2/P is almost random walks which has its value of .99.

On the other hand, (A.2) implies the following points; (i) the net effect of the EX variables which has its value of .03 are conformed to the traditional monetary theory. This is different from the (A.1), (ii) the net effects of short-term interest is also negative, -0.041, which also conform to the traditional relationship between these variables, and finally, (iii) net effect of M2/P has a value of .95 which is also approaching to unity, but the value is smaller than the one in (A.1).

2. The Korean Demand for Money Function

$$
\begin{aligned}
(M2/P)_t = \; & .37 - .02EX_t + .007EX_{t-1} - .13EX_{t-2} + .04EX_{t-3} \\
& (.37)\;(.05) \qquad (.08) \qquad (.08) \qquad (.05) \\
& -.20SR_t + .29SR_{t-1} - .13SR_{t-2} + .01SR_{t-3} \\
& (.06) \qquad (.14) \qquad (.14) \qquad (.07) \\
& + 1.87(M2/P)_{t-1} - 1.06(M2/P)_{t-2} + .17(M2/P)_{t-3}, \\
& (.12) \qquad (.19) \qquad (.07)
\end{aligned}
\qquad (B.1)
$$

$$(M2/P) = .82 + .06EX_t - .11EX_{t-1} - .11EX_{t-2} - .01EX_{t-3}$$
$$(.27)\ (.06) \quad (.03) \quad (.03) \quad (.04)$$
$$- .03EX_{t-4} - .19SR_t + .13SR_{t-1} - .08SR_{t-2}$$
$$(.06) \quad (.07) \quad (.10) \quad (.10)$$
$$+ .05SR_{t-3} - .003SR_{t-4} + 1.25(M2/P)_{t-1}$$
$$(.10) \quad (.07) \quad (.13)$$
$$- .55(M2/P)_{t-2} + .47(M2/P)_{t-3} - .19(M2/P)_{t-4},$$
$$(.20) \quad (.07) \quad (.13)$$

(B.2)

R^2 = .9969, SEE = .04, DW = 2.09, Q(24) = 15.10 (.92)

where (B.1) = seasonally adjusted case, and (B.2) = seasonally unadjusted case. In the Korea case the fitness of equation is also much better in seasonally adjusted than unadjusted case. To be more specific, the (B.1) implies: (i) the net effect of the EX variables is, unlike the Korean case, positive, 0.103 which conforms to the traditional monetary theory, (ii) the net effect of short-term interest rate is negative, -0.03, which fits the money-interest rate relationship, and finally, (iii) the net effect of M2/P is .98 which, as in the Japanese case, close to unity.

On the other hand, (B.2) complies: (i) the net effect of the EX variables is ill-signed, -0.2, (ii) the net effect of short-term interest rate is -0.093 which accord to the traditionally believed relationship, and (iii) the net effect of the M2/P variables is .98, which is the same as in (B.1).

Finally, in comparison to the Japanese case, the lag length of the Korean money demand functions are relatively longer, which implies that economic agents in Korea adjust their real balances slower than the Japanese agents. In other words, government demand functions are relatively longer, which implies that economic agents in Korea adjust their real balances slower than the Japanese agents. In other words, government monetary policy lingers more in the Korean than in the Japanese case.

3. The U.S. Demand for Money Function

$$
\begin{array}{llllllllll}
M2/P_t & = & -.03 + .04EX_t & - & .03EX_{t-1} & + & .05EX_{t-2} & - & .10EX_{t-3} \\
 & & (.03)\quad(.04) & & (.07) & & (.08) & & (.07) \\
 & + & .06EX_{t-4} & + & .01EX_{t-5} & + & .003SR_t & - & .02SR \\
 & & (.07) & (.04) & & & (.05) & & (.07) \\
 & + & .01SR_{t-2} & + & .01SR_{t-3} & - & .06SR_{t-4} & + & .05SR_{t-5} \\
 & & (.08) & (.07) & & & (.07) & & (.04) \\
 & + & 1.83(M2/P)_{t-1} & - & .89(M2/P)_{t-2} & - & .01(M2/P)_{t-3} & & \\
 & & (.11) & & (.24) & & (.27) & & \\
 & + & .008(M2/P)_{t-4} & + & .06(M2/P)_{t-5}, & & & & \\
 & & (.25) & & (.13) & & & & (C.1)
\end{array}
$$

$$R^2 = .999,\ SEE = .01,\ DW = 2.05,\ Q(24) = 9.28\ (.997)$$

$$
\begin{array}{llllll}
(M2/P)_t & = & .02 & + & .04EX_t + .97(M2/P)_{t-1}, & (C.2) \\
 & & (.08) & (.03) & (.97) &
\end{array}
$$

$$R^2 = .985,\ SEE = .05,\ DW = 2.04,\ Q(24) = 8.64\ (.998)$$

In the U.S. case we also know that the overall fit of equation is better in the seasonally adjusted than in the unadjusted data. More specifically, (C.1) implies: (i) the net effect of the EX variables is .02, (ii) the net effect of the S variables is -0.107, and finally, (iii) the net effect of the M2/P variables is 0.998.

On the other hand, (C.2) shows an immediate response to the monetary policy which does not have interest rate in the equation. The net effect of the EX is .04 which has its current value only. The net effect of the M2/P is .97 which is a little smaller than that of (C.2). In comparison to the previous two countries, the U.S. shows a very different lag structure in each equation.

Appendix C
THE EMPIRICAL RESULTS FROM THE BARRO-RUSH FRAMEWORK IN THE U.S. CASE

1. Forecasting Money Growth Equations

$$D2M_t = \underset{(.02)}{.03} + \underset{(.13)}{1.22D2M_{t-1}} - \underset{(.18)}{.13D2M_{t-2}} - \underset{(.14)}{.21D2M_{t-3}}$$

$$+ \underset{(.07)}{.14D2M_{t-4}} - \underset{(.08)}{.01NGNP_{t-1}} - \underset{(.15)}{.009NGNP_{t-2}}$$

$$+ \underset{(.13)}{.15NGNP_{t-3}} - \underset{(.06)}{.13NGNP_{t-4}} + \underset{(.01)}{.008GE_{t-1}} + \underset{(.02)}{.004GE_{t-2}}$$

$$- \underset{(.02)}{.01GE_{t-3}} + \underset{(.01)}{.001GE_{t-4}},$$

R^2 = .9999, SEE = .004, DW = 1.65, 1(24) = 30.37 (.17)

$$D1M_t = \underset{(9.35)}{-1.17} - \underset{(.11)}{.13D1M_{t-1}} + \underset{(.11)}{.34D1M_{t-2}} + \underset{(.11)}{.12D1M_{t-3}}$$

$$+ \underset{(.11)}{.64D2M_{t-4}} - \underset{(.57)}{.50UN_{t-1}} + \underset{(.98)}{1.27UN_{t-2}} + \underset{(.95)}{.76UN_{t-3}}$$

$$- \underset{(.52)}{.35UN_{t-4}}, \qquad (A.2)$$

R^2 = .9996, SEE = 1.99, DW = 2.05, 1(24) = 37.88 (.04)

As above, the overall fit of forecasting money growth equation is better in (A.1) than in (A.2). These equations are obtained by the same methodology used in the main text.

2. The Empirical Results from the Barro-Rush Framework

In this part we present the results from the Barro-Rush framework using the U.S.

data. Since Barro utilized seasonally unadjusted data, for simplicity we present the same case with the sample period of 1970-1988. Before doing this, we simply discuss the results from the case using seasonally adjusted data. Without correcting for the serial correlation of problems, the unanticipated hypothesis seems to be rejected, and the associated test statistics are not sensitive to the lag length taken. When the anticipated and unanticipated components are regressed simultaneously, we found the anticipated components are at least as much important as the unanticipated ones. With a fourth-order approximation of the autocorrelation of residuals of output equation the unanticipated hypothesis is, again, rejected. When we regress the anticipated and unanticipated components simultaneously, we also found the anticipated part is at least as much important as the unanticipated component. For this reason, the unanticipated hypothesis of the Barro-Rush framework seems not supported by the U.S. data.

We first present the results with seasonally unadjusted data by regressing only the unanticipated part on the real GNP as in the Table (AC.1). As in Table (AC.1), the unanticipated hypothesis is accepted at the limiting cases. When we do not correct the autocorrelation problem [see Column (3)], the unanticipated hypothesis is rejected up to the thirteen lag. From lag fourteen, and on, the hypothesis begins to be not rejected. When we test more lags of seventeen, and on, we found the hypothesis is not rejected. In contrast, once we correct an autocorrelation problem of each output equation [see Column (4)], the hypothesis is not rejected at the very limiting cases, lag eight to twelve. As the lag increases to the twenty, the hypothesis are still rejected. In comparison to the Japanese and the Korean cases, the results from the U.S. seem difficult to be interpreted.

As joint test, we regress the output on both the unanticipated and the anticipated components simultaneously. This is summarized as in Table (AC.2). Table AC.2 shows

Table AC.1: Tests of Unanticipated Hypothesis
Seasonally Unadjusted Case

(1)	(2)	(3)	(4)
Variable	Lags	F-Statistic	F-Statistic
DMR	0	F(1,68) = .07	F(1,64) = .66
DMR	1	F(2,66) = .36	F(2,62) = 1.32
DMR	2	F(3,64) = 1.35	F(3,60) = 7.74
DMR	3	F(4,62) = 1.48	F(4,58) = 1.43
DMR	4	F(5,60) = 1.21	F(5,56) = 1.21
DMR	5	F(6,58) = 1.03	F(6,54) = 1.00
DMR	6	F(7,56) = .99	F(7,52) = .91
DMR	7	F(8,54) = 1.33	F(8,50) = 1.75
DMR	8	F(9,52) = 1.41	F(9,48) = 2.42*
DMR	9	F(10,50) = 1.47	F(10,46) = 2.36*
DMR	10	F(11,48) = 1.28	F(11,44) = 2.15*
DMR	11	F(12,46) = 1.42	F(12,42) = 2.21*
DMR	12	F(13,44) = 1.52	F(13,40) = 2.15*
DMR	13	F(14,42) = 1.60	F(14,38) = 1.93
DMR	14	F(15,40) = 1.96*	F(15,36) = 1.94
DMR	15	F(16,38) = 2.20*	F(16,34) = 1.73
DMR	16	F(17,36) = 2.23*	F(17,32) = 1.49

both the anticipated and the unanticipated components are not important except for only one case in each test. Where serial correlation of error terms is not corrected, we found the evidence that the unanticipated hypothesis is not rejected in only eight and nine lags at the 5% significance level. Barro and Rush (1980) found the evidence that the unanticipated hypothesis is not rejected up to the thirteen lag case without correcting serial correlation problem. This is quite different from the present case. When we allow

Table AC.2: Tests of Irrelevance for Anticipated Money Seasonally Unadjusted Case

(1)	(2)	(3)	(4)
Variable	Lags	F-Statistic	F-Statistic
DMR	0	F(1,67) = .05	F(1,63) = .75
DM	0	F(1,67) = .03	F(1,63) = .13
DMR	1	F(2,64) = .59	F(2,60) = 1.57
DM	1	F(2,64) = .50	F(2,60) = .63
DMR	2	F(3,61) = 2.17	F(3,57) = 1.80
DM	2	F(3,61) = .91	F(3,57) = .86
DMR	3	F(4,58) = 1.24	F(4,54) = .91
DM	3	F(4,58) = .24	F(4,54) = .65
DMR	4	F(5,55) = 1.19	F(5,51) = .91
DM	4	F(5,55) = .71	F(5,51) = .90
DMR	5	F(6,52) = .79	F(6,48) = .86
DM	5	F(6,52) = .42	F(6,48) = .75
DMR	6	F(7,49) = 1.26	F(7,45) = 1.29
DM	6	F(7,49) = .95	F(7,45) = 1.29
DMR	7	F(8,46) = 2.27	F(8,42) = 3.99**
DM	7	F(8,46) = 1.53	F(8,42) = 3.41**
DMR	8	F(9,43) = 2.46*	F(9,39) = 1.72
DM	8	F(9,43) = 1.49	F(9,39) = .71
DMR	9	F(10,40) = 2.52*	F(10,36) = 1.80
DM	9	F(10,40) = 1.39	F(10,36) = .91
DMR	10	F(11,37) = 1.76	F(11,33) = 2.19
DM	10	F(11,37) = 1.05	F(11,33) = 1.34
DMR	11	F(12,34) = 1.52	F(12,30) = 2.14
DM	11	F(12,34) = .73	F(12,30) = 1.22
DMR	12	F(13,31) = 1.27	F(13,27) = 1.79

(1)	(2)	(3)	(4)
Variable	Lags	F-Statistic	F-Statistic
DM	12	F(13,31) = .55	F(13,27) = .96
DMR	13	F(14,28) = 1.15	F(14,24) = 1.68
DM	13	F(14,28) = .55	F(14,24) = .98
DMR	14	F(15,25) = .91	F(15,21) = 1.27
DM	14	F(15,25) = .43	F(15,21) = .70
DMR	15	F(16,22) = .90	F(16,18) = 1.26
DM	15	F(16,22) = .55	F(16,18) = .81
DMR	16	F(17,19) = .95	F(17,15) = 1.26
DM	16	F(17,19) = .62	F(17,15) = .86

Notes: DMR = unanticipated component, DM = anticipated component, (3) = the case where autocorrelation of the error term is not corrected, (4) = the case where it is corrected, * = 5% significance level, and ** = 1% significance level.

more lags up to twenty lag, the hypothesis is still rejected.

On the other hand, when we correct the serial correlation problem with a fourth-order autocorrelation adjustment, we found the evidence that the unanticipated hypothesis is not rejected in only lag seven with 1% significance level. Interestingly, this lag length is accorded with that of the Barro and Rush (1980) study. Except for this case, the unanticipated hypothesis is rejected in all cases examined. When we extend lags up to the twentieth, the hypothesis is still rejected.

In sum, the unanticipated hypothesis is rejected in the U.S. when we consider it with seasonally adjusted data. When we left the serial correlation problem uncorrected, the test statistics show the unanticipated hypothesis sensitive to the lag length taken. This is because after the seventeenth lag we found the evidence that the unanticipated hypothesis is not rejected. Once we correct serial correlation problem, the unanticipated hypothesis is not rejected in very limiting cases, lags eight to twelve.

In contrast, when we regressed the output on both the unanticipated and the anticipated components simultaneously, the unanticipated hypothesis is not rejected in only one case whether or not serial correlation problem is corrected. When we left the serial correlation problem uncorrected, the unanticipated hypothesis is not rejected in lag eight and nine. When we correct serial correlation problem, however, the unanticipated hypothesis is not rejected in only one case, the seventh lag, which is accorded with the one of the original Barro-Rush (1980) study. From the results of the U.S. case, we found: (i) the unanticipated hypothesis is rejected in all lags considered when we examine the seasonal data, and (ii) when we consider the nonseasonal data, the unanticipated is not rejected in very limiting cases. From this evidence, we can infer that the tests for the unanticipated hypothesis depend upon the seasonality of data and the lag length considered.

Appendix D
THE RESULTS FROM THE MISHKIN MODEL IN THE U.S.

In Chapter 5 we applied the Mishkin study to the Japanese and the Korean data. We now present the results from the Mishkin model with the U.S. data. For brevity, we present the results from likelihood ratio tests for various hypotheses. This is summarized in the table (DA.1) below.

Table DA.1: Likelihood Ratio Tests for Various Hypotheses

United States	Lag Length of Seven		
	Joint Hypothesis	Neutrality Hypothesis	Rationality Hypothesis
	Q(22) = 30.2 (0.106)	Q(8) = 15.1 (0.052)	Q(13) = 17.6 (0.278)

* Marginal P-values are in the parentheses.

As in Table (DA.1), the joint hypothesis and individual hypothesis of neutrality and rationality are not rejected at the 5% significance level. Therefore, the acception of the MRE hypothesis is due to both the presence of neutrality and rationality in the U.S. case.

Table DB.2: Likelihood Ratio Tests for Various Hypotheses

United States	Lag Length of Thirteen		
	Joint Hypothesis	Neutrality Hypothesis	Rationality Hypothesis
	Q(27) = 49.5 (0.005)	Q(14) = 29.9 (0.008)	Q(13) = 24.9 (0.025)

* Marginal P-values are in the parentheses.

When we allow the lag up to thirteen, the MRE hypothesis is rejected, which is due to the rejection of neutrality and rationality hypotheses. This is shown as in Table (DB.2). From the results obtained, we infer that the MRE hypothesis tests are very sensitive to the lag length considered.

Appendix E
TESTS FOR NONSTATIONARITY IN THE UNITED STATES

Here we present the results of tests for nonstationarity in the U.S. by adopting a likelihood ratio test of Dickey and Fuller (1981). The sample autocorrelations of the variables in levels are shown in the table (EA.1). The sample autocorrelations of the levels in the U.S. macro time series start at around 0.85 approximately at lag one and decay rapidly as the lag increases. In contrast with the original study of Nelson and Plosser

Table EA.1: Sample Autocorrelations of the Natural Logarithm of Annual Data in the U.S.

Series	Period	Sample Autocorrelation						
		T	r1	r2	43	r4	r5	r6
Real GNP	70-88	19	.86	.60	.42	.33	.22	.09
Nominal GNP	70-88	19	.86	.71	.55	.40	.25	.11
Unemployment Rate	70-88	19	.65	.27	.05	-.09	-.11	-.03
M1	70-88	19	.84	.68	.52	.38	.24	.11
M2	70-88	19	.84	.69	.54	.39	.25	.11
GNP Deflator	70-88	19	.86	.67	.48	.30	.14	.01

a. T = sample size, r_i the ith order autocorrelation coefficient. The large sample standard error under the null hypothesis of no autocorrelation is $T^{1/2}$ or roughly 0.23 for series of the length considered here (Bartlett test).

(1982), the series here decay more rapidly, and their starting values are lower. Among them, unemployment rate seems stationary. In general, the patterns of the series are similar to those of the Nelson and Plosser (1982, p. 147) study with more sample points.

On the other hand, the first difference of the above series show a little different from those in the Nelson and Plosser (1982, p. 148) study. This is summarized as in Table (EA.2). The difference comes from the series of real GNP and GNP deflator which show negative values at lag one. The series with positive values at lag one are the unemployment rate and the M1. The rest of the series exhibit more persistent autocorrelation in their first difference. As Nelson and Plosser (1982) indicates, we need to consider the sample autocorrelations of the deviations from the trend (not shown here) to explain more persistent series including real GNP and GNP deflator. These, as in the Japanese and Korean cases, suggest the AR(1) specifications for all series examined.

Table EA.2: Sample Autocorrelations of the First Difference of the Natural Logs of Annual Data

Series	Period	Sample Autocorrelation							
		T	r1	r2	43	r4	r5	r6	s(r)
Time Aggregated Random Walk	70-88	19	.25	.00	.00	.00	.00	.00	
Real GNP	70-88	19	-.10	.19	-.13	-.14	.00	.06	.09
Nominal GNP	70-88	19	.20	.12	.20	.08	.10	.12	.03
Unemployment Rate	70-88	19	.25	-.30	-.24	-.10	.11	.16	.14
M1	70-88	19	.31	-.02	.06	.07	-.14	.02	.02
M2	70-88	19	.32	.21	-.14	-.09	-.19	.07	.02
GNP Deflator	70-88	19	-.09	.17	-.12	-.30	.06	-.11	.09

For simplicity, we discuss the resultant F-statistic in the U.S. case. This can be summarized in Table (EA.3). As in Table (EA.3), real GNP and M2 seem stationary. In contrast, the other series seem nonstationary. This result is quite contradictory with Nelson and Plosser's. The AR specifications of these series seem successful because the Q-statistics of residuals of each equation shows no serial correlation problem. From this result, we argue, once again, our conclusion that macro time series are nonstationary seems not decisive (see Chapter 5).

Table EA.3: F-Statistics from the Liming Case

Series	F-Stat	Critical Values
Real GNP	15.45*	7.24 (10.61)
Nominal GNP	2.81	7.24 (10.61)
Unemployment Rate	1.13	7.24 (10.61)
M1	2.47	7.24 (10.61)
M2	12.64*	7.24 (10.61)
GNP Deflator	2.32	7.24 (10.61)

Appendix F
PROGRAM LISTING AND OUTPUT

```
DATA ONER ;
SET ONE ;
C = 1 ;
IF _N_<=28 THEN LGNP=. ;
PROC NLIN CONVERGENCE=.0001 ;
OUTPUT OUT=DRESID PREDICTED=PRED RESIDUAL=RESID ;
          CO      =     4.0
           T      =     0.002
          MO      =     0.7
          M1      =     0.7
          M2      =     0.7
          M3      =     1.3
          M4      =     1.3
          M5      =     1.3
          M6      =     1.3
          M7      =     1.3
          E0      =     0.7
          E1      =     0.7
          E2      =     0.7
          E3      =     1.3
          E4      =     1.3
          E5      =     1.3
          E6      =     1.3
          E7      =     1.3
          A0      =     0.7
          A1      =     0.7
          A2      =     0.7
          A3      =     0.7
          A4      =     0.5
          A5      =     0.5
          A6      =     0.5
          A7      =     0.5
          A8      =     0.5
          A9      =     0.5
         A10      =     0.5
         A11      =     0.5
         A12      =     0.5
        RH01      =     1.0
        RH02      =     0.5
        RH03      =     0.5
        RH04      =     0.5
 ;
ZC = C*(1-RH01-RH02-RH03-RH04) ;
MZC = ZC*(-M0-M1-M2-M3-M4-M5-M6-M7) ;
EZC = ZC*(E0+E1+E2+E3+E4+E5+E6+E7) ;
```

```
ZM = M2G1 - RH01*M2G2 - RH02*M2G3 - RH03*M2G4
        - RH04*M2G5 ;
MZM = - M0*ZM - M1*LAG1(ZM) - M2*LAG2(ZM) - M3*LAG3(ZM)
- M4*LAG4(ZM) - M5*LAG5(ZM) - M6*LAG6(ZM) - M7*LAG7(ZM) ;
ZG = NGNP1-RH0*NGNP2-RH02*NGNP3 -RH03*NGNP4-RH04*NGNP5 ;
MZG = -M0*ZG-M1*LAG1(ZG)-M2*LAG2(ZG)-M3*LAG3(ZG)
 -M4*LAG4(ZG)-M5*LAG5(ZG)-M6*LAG6(ZG)-M7*LAG7(ZG) ;
ZU = U1 - RH01*U2 - RH02*U3 - RH03*U4 - RH04*U5 ;
MZU = -M0*ZU-M1*LAG1(ZU)-M2*LAG2(ZU)-M3*LAG3(ZU)
-M4*LAG4(ZU)-M5*LAG5(ZU)-M6*LAG6(ZU)-M7*LAG7(ZU) ;
EZM = E0*ZM+E1*LAG1(ZM)+E2*LAG2(ZM)+E3*LAG3(ZM)
+E4*LAG4(ZM)+E5*LAG5(ZM)+E6*LAG6(ZM)+E7*LAG7(ZM) ;
EZG = E0*ZG+E1*LAG1(ZG)+E2*LAG2(ZG)+E3*LAG3(ZG)
+E4*LAG4(ZG)+E5*LAG5(ZG)+E6*LAG6(ZG)+E7*LAG7(ZG) ;
EZU = E0*ZU+E1*LAG1(ZU)+E2*LAG2(ZU)+E3*LAG3(ZU)
+E4*LAG4(ZU)+E5*LAG5(ZU)+E6*LAG6(ZU)+E7*LAG7(ZU) ;
EM = A0*C+A1*M2G1*A2*M2G2+A3*M2G3+A4*M2G4+A5*NGNP1
+A6*NGNP2+A7*NGNP3+A8*NGNP4+A9*U1+A10*U2+A11*U3+A12*U4 ;
UM = M2G - EM ;
UM1 = LAG1(UM) ;
UM2 = LAG2(UM) ;
UM3 = LAG3(UM) ;
UM4 = LAG4(UM) ;
UM5 = LAG5(UM) ;
UM6 = LAG6(UM) ;
UM7 = LAG7(UM) ;
UM8 = LAG8(UM) ;
UM9 = LAG9(UM) ;
UM10 = LAG10(UM) ;
UM11 = LAG11(UM) ;
EM1 = LAG1(EM) ;
EM2 = LAG2(EM) ;
EM3 = LAG3(EM) ;
EM4 = LAG4(EM) ;
EM5 = LAG5(EM) ;
EM6 = LAG6(EM) ;
EM7 = LAG7(EM) ;
EM8 = LAG8(EM) ;
EM9 = LAG9(EM) ;
EM10 = LAG10(EM) ;
EM11 = LAG11(EM) ;
RUM = UM - RH01*UM1 - RH02*UM2 -RH03*UM3 - RH04*UM4 ;
RUM1 = LAG1(RUM) ;
RUM2 = LAG2(RUM) ;
RUM3 = LAG3(RUM) ;
RUM4 = LAG4(RUM) ;
RUM5 = LAG5(RUM) ;
RUM6 = LAG6(RUM) ;
```

```
RUM7 = LAG7(RUM) ;
REM = EM - RH01*EM1 - RH02*EM2 - RH03*EM3 - RH04*EM4 ;
REM1 = LAG1(REM) ;
REM2 = LAG2(REM) ;
REM3 = LAG3(REM) ;
REM4 = LAG4(REM) ;
REM5 = LAG5(REM) ;
REM6 = LAG6(REM) ;
REM7 = LAG7(REM) ;
MODEL LGNP =
RH01*LGNP1 +RH02*LGNP2 + RH03*LGNP3 + RH04*LGNP4 +
C0*C*(1-RH01-RH02-RH03-RH04) +
T*(TIME-RH01*(TIME1)-RH02*(TIME2)-RH03*(TIME3)-RH04*(TIME4)
+E0*REM+E1*REM1+E2*REM2+E3*REM3+E4*REM4+E5*REM5+E6*REM6+
E7*REM7+M0*RUM+M1*RUM1+M2*RUM2+M3*RUM3+M3*RUM3+M4*RUM4+
M5*RUM5+M6*RUM6+M7*RUM7 ;
DER.CO = C*(1-RH01-RH02-RH03-RH04) ;
DER.T = (TIME-RH01*TIME1-RH02*TIME2-RH03*TIME3
-RH04*TIME4) ;
DER.M0 = RUM ;
DER.M1 = RUM1 ;
DER.M2 = RUM2 ;
DER.M3 = RUM3 ;
DER.M4 = RUM4 ;
DER.M5 = RUM5 ;
DER.M6 = RUM6 ;
DER.M7 = RUM7 ;
DER.E0 = REM ;
DER.E1 = REM1 ;
DER.E2 = REM2 ;
DER.E3 = REM3 ;
DER.E4 = REM4 ;
DER.E5 = REM5 ;
DER.E6 = REM6 ;
DER.E7 = REM7 ;
DER.RH01 = LGNP1 - C0*C - T*(TIME1)
-E0*EM1 -E1*EM2 -E2*EM3 - E4*EM5 -E5*EM6
-E6*EM7 -E7*EM8 ;
-M0*UM1 -M1*UM2 -M2*UM3 -M3*UM4 -M4*UM5
-M5*UM6 -M6*UM7 -M7*UM8 ;
DER.RH02 = LGNP2 - C0*C - T(TIME2)
-E0*EM2 -E1*EM3 -E2*EM4 -E3*EM5 -E4*EM6
-E5*EM7  -E6*EM8 -E7*EM9
-M0*UM2 -M1*UM3 -M2*UM4 -M3*UM5 -M4*UM6
-M5*UM7 -M6*UM8 -M7*UM9 ;
DER.RH03 = LGNP3 - C0*C - T*(TIME3)
-E0*EM3 -E1*EM4 -E2*EM5 -E3*EM6 -E4*EM7
-E5*EM8 -E6*EM9 -E7*EM10
```

```
-M0*UM3 -M1*UM4 -M2*UM5 -M4*UM6 -M4*UM6 -M5*UM7
-M5*UM8 -M6*UM9 -M7*UM10 ;
DER.RH04 = LGNP4 - C0*C - T*(TIME4)
-E0*EM4 - E1*EM5 - E2*EM6 - E3*EM7 - E4*EM8
-E5*EM9 - E6*EM10 - E7*EM11
-M0*UM4 -M1*UM5 -M2*UM6 -M3*UM7 -M4*UM8
-M5*UM9 -M6*UM10 -M7*UM11 ;
DATA DRESID ;
SET DRESID ;
KEEP RES RESID ;
PROC MEANS ;
```

This program estimates the following equations:

$$M2G = \gamma_0 + \sum_{i=1}^{N} \gamma_i \; M1G_{t-i} + \sum_{i=1}^{N} \gamma_{i+4} \; NGNP_{t-i} + \sum_{i=1}^{N} \gamma_{i+p} \; N_{t-i} \; , \qquad \text{(AF.1)}$$

$$Log\;(GNPt) = c + t\;TIME + \sum_{i=1}^{N} \beta_i \,(M2G_{t-i} - M2G^{*}_{t-i}) + \sum_{i=1}^{N} S_i \; M2G^{*}_{t-i} + e_t \; , \qquad \text{(AF.2)}$$

$$Where \quad e_t = \varrho_1 e_{t-1} + \varrho_2 e_{t-2} + \varrho_3 e_{t-3} + \varrho_4 e_{t-4} + U_t \; ,$$
$$M2G_t = \gamma_0 + \gamma_i M2G_{t-i} + \gamma_{i+4} \; NGNP_{t-i} + \gamma_{i+8} \; U_t$$

This program shows the most uncontrained system where the forecasting money growth and output equations are separately estimated. The forecasting money growth equation is estimated at the DATA ONE where the data is contained. The above program estimates the output equation (Mishkin 1983). The RES is the residual from the forecasting money growth equation, and the RESID is the ones from the output function. These RES and RESID give a initial estimate for the variance-covariance matrix of the residuals.

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