Monetary Base Rules: The Currency Caveat

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Abstract: Monetary policy rules that rely on the monetary base have been forwarded by Meltzer (1984) and McCallum (1988). They claim that following monetary base rules would minimize fluctuations around the target growth rate for nominal GNP. Critics of such rules contend that currency has not been properly accounted for in their simulations. This paper examines the properties of several monetary base rules, explicitly taking the demand for currency into account. Assuming that currency is supplied elastically, our investigation quantities changes in the composition of the monetary base under these rules and provide an estimate of how these compositional changes might affect the variability around the target nominal GNP growth rate.

*The views expressed in this article are solely those of the authors and should not be attributed to the Federal Reserve Bank of Dallas or to the Federal Reserve System.

I. Introduction

Support for the monetary base as the central bank's chief policy instrument gained momentum in the mid-1980s with the research findings of Meltzer (1984, 1987) and McCallum (1987, 1988). Both Meltzer and McCallum urged that the Fed adopt a rule to guide the movements of monetary base over time. McCallum (1988,1993) provided empirical evidence to support his policy prescription for the United States and Japan. With regard to the U.S., McCallum claimed that his proposed rule "would, if it had been in effect, have kept nominal GNP for the United States close to a smooth target growth path over the period 1954-88 despite the regulatory and financial turmoil that occurred during the latter part of that period" (McCallum (1988), p.173).

Critics such as B. Friedman (1988), are skeptical that simple base rules would substantially smooth fluctuations of nominal income around a target path. Arguments against adopting the base often center on the fact that currency has become an increasingly large component of the monetary base. For example, as of December 1991, currency represented roughly 80 percent of the monetary base.[1] Concerns over the "currency problem" and its effect on the use of a base rule generally falls into two categories. One is that currency is not related to conventional measures of macroeconomic activity. That is, because currency is frequently used in unreported economic transactions--for example, drug trade or exchange in foreign countries--it is suspected that changes in currency are less reliably related to a measure of domestic economic activity, such as GNP. In short, critics of base rules argue that the composition of the change in the monetary base matters, because the effect of changes in the base on nominal GNP will differ depending on the distribution of base money between currency

[1] These figures comes from the February 1994 issue of the *Federal Reserve Bulletin*. Currency data are reported in Table 1.21 and the monetary base (not adjusted for changes in reserve requirements) is reported in line 15 of Table 1.20.

and reserves. The second argument invokes Gresham's Law: The Federal Reserve has always been willing to supply currency to meet whatever quantity is demanded, so that currency will not trade at a premium above its face value. The conjecture is that targeting the base is incongruent with elastic currency supply since the Fed controls only a portion of the base. Moreover, changes in currency may require offsetting movements in reserves.

The contribution of this paper is to quantify the behavior of currency under a base rule regime: To facilitate comparability with earlier work, we use estimation and simulation procedures used by McCallum. We offer two approaches to exploring the role that currency may play if one to adopt one of these monetary base rules. First, we generate an implied path for the monetary base and currency under the base rules studied. This simulation exercise reveals, within the confines of our experimental design, whether the fraction of currency relative to base is relatively constant in a setting in which a base rule dictates the quantity of monetary base supplied. The underlying assumption, consistent with historical Fed behavior, is that the supply of currency is elastic. If the currency-to-base ratio were to rise in a base rule setting, however, then some economic adjustment would be required. For example, interest rates likely would rise, restoring the equilibrium currency-to-base ratio, or financial intermediation would decline. Both scenarios suggest that financial instability may be greater under a base rule than base advocates claim.[2] Either way, a strong version of the criticism would contend that a rising currency-to-base ratio renders the base rule unusable. A weaker version would suggest that adopting a base rule requires careful consideration of the currency issue than presented to date.

Second, we briefly examine total reserves rules, thereby "eliminating" the possible problems associated with currency. Chief among the questions associated with such a rule is,

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[2] Interest rate instability might not be that surprising in a world in which a quantity target is employed. As we discuss later in the paper, however, the fluctuations in interest rates consistent with the base rule may be quite large.

"Could the Fed achieve a target inflation rate only by influencing deposit creation?" Our simulation results suggest that under a "total reserves" rule, total reserves decline when zero-inflation is the explicit policy goal. If the policymaker relaxes the zero-inflation restriction, however, we show that it is possible to generate a total reserves rule that mimics that which actually occurred during the past 30 years.

The format of the paper is as follows. Section 2 specifies the model of nominal GNP behavior. With the simple specification for nominal GNP growth used in this paper, we characterize the behavior of the monetary base in steady state. The simulations generated under alternative base rules are presented in Section 3. Section 4 examines the role of currency is a base rule setting. A total reserves rule is specified and simulated in Section 5 with Section 6 summarizing our results.

II. A Model of Nominal GNP

McCallum (1988, 1993) considered the robustness of his evidence by comparing different empirical models relating base growth and economic activity. Using data for the U.S. and Japan, he found that his simulation results were not very sensitive to the model linking base and income. We adopt the simplest reduced-form specification used in McCallum as our data-generating mechanism for nominal GNP growth. This simple specification allows us to characterize the steady-state growth rate of the monetary base.

2.1 Results

Base growth and nominal GNP growth are linked by the following equation:

(1) $$\Delta Y_t = \alpha_0 + \alpha_1 \Delta Y_{t-1} + \alpha_2 \Delta B_{t-1} + \varepsilon_t,$$

where Y is log nominal GNP, B is the log of the monetary base, ε denotes a stochastic error term, Δ is the difference operator ($\Delta x_t = x_t - x_{t-1}$), and the α's are parameters to be estimated.

Equation (1) is estimated using seasonally adjusted, quarterly observations of nominal GNP and the monetary base, the latter adjusted for changes in reserves requirements using the St. Louis methodology. The data span the period 1954:1 - 1991:3. The estimation results are (standard are reported in parentheses):

$$(2) \qquad \Delta Y_t = \underset{(0.002)}{0.008} + \underset{(0.077)}{0.271}\, \Delta Y_{t-1} + \underset{(0.106)}{0.360}\, \Delta B_{t-1}$$

$$\text{adj } R^2 = 0.19 \qquad \text{SEE} = 0.010 \qquad \text{BG} = 1.24.$$

The estimates are quite close to those reported in McCallum (1988) for the period 1954-85. The coefficients on both logged GNP and the base are statistically significant at the 5-percent level. The Breusch-Godfrey test for serial correlation yields a F-statistic of 1.24, well below the critical value of 2.02. Thus, serial correlation is not a significant problem with this regression. This simple model captures about 20 percent of the variation in GNP growth.

It is important to investigate the temporal stability of the relationship since the estimates in equation (2) are used in subsequent simulations. If the estimates are unstable, the simulation outcomes would be clearly unreliable. We employed a battery of stability tests, always assuming that a break point is unknown a priori. In finite samples, Andrews (1992) suggests imposing boundaries between which the break may have occurred. When the break point is unknown, the asymptotic distribution theory is well specified when one does not search over the entire sample. Following Andrews, we test for break points between 1961:1 and 1985:4, eliminating roughly 15 percent of the sample from consideration as possible break points.

The results from the different tests are reported in Table 1. The results fail to reject the null hypothesis of parameter constancy at conventional significance levels. Although the P-K max test statistic indicates that a break occurred, Ploberger and Kramer (1990) show that the P-K max test is powerful against the alternative in which breaks occur in the intercept term, not slope parameters. Because most of the tests indicate that one cannot reject the null hypothesis and because the one test that rejects the null is has low power against an alternative of changing slope parameters, we proceed under the presumption that there is no structural break in the data.[3]

Equation (2) can also be used to examine the notion that the distribution of the monetary base between currency and reserves is critical in assessing the role of the monetary base as a policy tool. The most direct way to discern if such a problem with the currency-to-reserves ratio exists is simply to test whether the effects on income of changes in currency are systematically different from changes in total reserves.

To investigate this issue, we decomposed base growth into currency and total reserves and estimated the following regression (standard errors are in parentheses):[4]

[3] This evidence contrasts with Feldstein and Stock's (1993) finding of a structural break in nominal GNP growth regressions in which the monetary base is used as the money measure. The explanation may lie in the differences between the two studies. For example, the adjusted R^2 for our regression (0.19) is somewhat higher than what was observed in Feldstein and Stock (see line 1, Table 5 - 0.17). Feldstein and Stock include more lags (three) of a four-quarter growth rate compared with our specification of one lagged value of a one-quarter growth rate. The slightly lower adj R^2 suggests that too many lags are included. In addition, we use 28 more observations in estimating our regression, including the period 1954:2-1960:2.

[4] In order to get a "clean" separation of the base, both currency and total reserves growth are defined relative to the quantity of monetary base. Formally, $\Delta C_t = (C_t - C_{t-1})/[(MB_t + MB_{t-1})/2]$ and $\Delta TR_t = (TR_t - TR_{t-1})/[(MB_t + MB_{t-1})/2]$.

(3) $\Delta Y_t = \underset{(0.002)}{0.008} + \underset{(0.077)}{0.293}\, \Delta Y_{t-1} + \underset{(0.138)}{0.206}\, \Delta C_{t-1} + \underset{(0.204)}{0.592}\, \Delta TR_{t-1}$

adj $R^2 = 0.17$ SEE $= 0.009$ BG $= 0.91$.

Testing the hypothesis that the coefficients on currency and total reserves are equal, the resulting t-statistic is 1.44, less than the 10-percent critical value. Although the coefficient estimates are quantitatively different (0.206 vs. 0.592), one cannot statistically reject the hypothesis that the composition of base money is irrelevant for determining the growth rate of nominal GNP. At least over the range of currency-to-monetary base observed historically, the relationship between currency and nominal income growth is not statistically different from the relationship between total reserves and income growth.

2.2 Implications for steady-state base growth

What does this data-generating mechanism for nominal GNP in equation (2) imply about the steady-state growth rate for the monetary base? Examining the steady-state provides some insight to the issue of how a base rule would be operate. In McCallum's base rule, for example, it is necessary to establish a target growth rate for nominal GNP, denoted ΔY^*.[5] In steady-state, $\Delta Y_t = \Delta Y_{t-1} = \Delta Y^*$. Substituting steady-state nominal GNP growth into equation (1) and solving for the growth rate of the monetary base yields

(4) $$\Delta B = (1 - \alpha_1)/\alpha_2 \ \Delta Y^* - \alpha_0/\alpha_2.$$

According to equation (4), the steady-state growth rate of base money depends on four factors: (i) the persistence of nominal GNP growth, α_1; (ii) the impact multiplier of monetary base

[5] McCallum originally adopted a target for the level of nominal GNP. We adopt a target growth rate for nominal GNP. See Feldstein and Stock (1993) and McCallum (1993) for a discussion of the merits of growth rate vs. level targeting.

growth on nominal GNP growth, α_2; (iii) the average drift in nominal GNP, α_0; and (iv) the targeted value of nominal GNP growth, ΔY^*. Other things being equal, an increase in the persistence of nominal GNP growth (α_1) results in slower monetary base growth in the steady-state; a rise in the average drift of nominal GNP (α_0) also results in slower monetary base growth. Unlike these effects, a change in the impact multiplier has an ambiguous effect on the steady state growth rate of the monetary base.[6] Finally, an increase in the target growth rate of nominal GNP (ΔY^*) results in faster monetary base growth in the steady-state.

The parameter estimates from equation (2) allow us to calculate the (expected) steady-state growth rate for monetary base. Plugging the estimates into equation (4) and setting the target growth rate for nominal GNP growth at a 3-percent annualized rate, the outcome indicates that the monetary base will fall at a 2.8-percent annual rate in the steady state.[7] This means that if nominal GNP growth evolved according this simple reduced-form model, the monetary base would have to decline at 2.8-percent annual rate to hit the desired 3-percent target nominal GNP growth rate.[8]

Declining monetary base does not necessarily present problems for policymakers. More

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[6] Formally, $\text{sgn}(\partial \Delta B/\partial \alpha_2) = \text{sgn}[\alpha_0 - (1 - \alpha_1)\Delta Y^*]$. This equation indicates that if the average drift in nominal GNP is greater than the product of the target growth rate and one minus the persistence of nominal GNP growth then the steady-state growth rate of monetary base is positively related changes in the impact multiplier.

[7] McCallum (1987) reports that in order to achieve 3-percent nominal GNP growth, or zero inflation, his estimate of equation (1) would require base to decline at an even higher 3.8-percent annual rate.

[8] In an earlier version of this paper (Hafer, Haslag, and Hein (1990)), we separated the simulation and estimation period, using data from the 1954-69 period to estimate the nominal GNP growth equation. Judd and Motley (1993) interpret our declining monetary base finding as the product of inconsistency between average output growth in the 1954-69 period, which is much higher than average output growth during the entire 1954-85 period. The fact that steady-state monetary base declines when the nominal GNP equation is estimated over the 1954-91 period would seem to refute the Judd and Motley claim. Indeed, the steady-state characterization in the text makes clear the factors contributing to monetary base decline.

importantly, such a steady-state analysis does not illustrate changes in the distribution of the base between currency and reserves. In the remainder of the paper, we simulate monetary base growth and nominal income growth using several different policy rules. In order to focus on the possible effects of currency growth on this distribution, the demand for currency is simulated using each rule's implied nominal GNP growth path. Determining the path of currency and the monetary base generated under the different rules, the possible evolution of currency in a monetary base rule setting, and to highlight some of the heretofore ignored policy issues associated with such a change.

III. Nominal GNP simulations

The simulated paths for nominal GNP growth generated from equation (2) using different monetary base rules are presented in this section. For comparison, several different monetary base rules are considered.

3.1 The monetary base rules

Monetary base growth is dictated by one of three rules: (i) the McCallum rule; (ii) the Meltzer rule; and (iii) a simple 3-percent rule.

The McCallum rule is written as:

$$\Delta B_t = 0.00739 - (1/16)[Y_{t-1} - Y_{t-17} - B_{t-1} + B_{t-17}] + \lambda(\Delta Y^*_{t-1} - Y\Delta_{t-1}). \quad (5)$$

The term λ is a feedback parameter, where $0 \leq \lambda \leq 1$. This stipulates that monetary base growth respond to a 1-percentage point deviation from last period's growth rate target by λ-percentage points.[9] The first term on the right-hand-side of equation (5) is simply the quarterly value of 3-percent annualized growth. The second term is a four-year moving average of base velocity growth. In this model, a "permanent" increase in base velocity growth results in slower monetary base growth.

The Meltzer rule is written as:

$$(6) \qquad \Delta B_t = (1/12) \left[\left(\sum_{j=1}^{12} \Delta y_{t-j} \right) - \left(\sum_{j=1}^{12} \Delta V_{t-k} \right) \right],$$

where y denotes log output and V is log base velocity. In Meltzer's rule, monetary base growth responds to changes in the twelve-quarter moving average of output growth and twelve-quarter moving average of base velocity growth. The Meltzer rule treats the most recent twelve-quarter moving average of output growth as the "permanent" or target growth rate. If output grows at a 3-percent rate of growth, then the Meltzer rule is simply a special case of the McCallum rule with $\lambda = 0$. The 3-percent rate rule merely sets base growth equal to the target growth rate for nominal GNP. Although the 3-percent rule is a special case of both the Meltzer and McCallum rules, this rule has a much longer history in the discussion of policy.

3.2 Nominal GNP simulations

Equation (2) together with a base rule (either (5), (6), or the 3-percent rule) form a recursive system. The path for base growth is determined for period t, then fed into the nominal GNP growth rate equation (2) in period t+1, which then is fed back into the base rules (equations (5) or (6)) and so on. Two points must be made about the simulation procedure.

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[9] This rule is a modification of the McCallum rule. In its original representation, McCallum (1987) specified a levels target for nominal GNP. The issue of growth rate versus level targeting is discussed in Feldstein and Stock (1993) and McCallum (1993). Hafer, Haslag, and Hein (1990) compare the different rules in both levels and growth rate targeting cases.

First, shocks to the system are generated using the realized error term from equation (2). Formally, let $\hat{\xi}_t = \Delta Y_t - \Delta Y^p_t$, where ΔY^p_t is the predicted value of nominal GNP growth generated by equation (2). The simulated value of nominal GNP growth, ΔY^s_t, is thus the value of GNP growth generated with the parameter estimates in equation (2) plus $\hat{\xi}_t$.[10]

Second, the Meltzer rule requires simulating output growth. To do this, nominal GNP growth is defined as the sum of output growth and inflation. Specifically, we estimate a simple, reduced-form inflation rate equation, subtracting the inflation rate simulated under this base rule to generate a simulated path for output growth.[11] To generate output growth, the path for monetary base growth is used, subtracting the simulated value of the inflation rate from the simulated value of nominal GNP growth. In this case, we implicitly assume that the nominal GNP growth rate shocks are identical to output growth shocks.

Table 2 reports summary statistics comparing each rule's ability to hit the target growth rate for nominal GNP, assumed to be 3-percent. The McCallum and Meltzer rules have roughly the same root mean squared deviation (RMSD) about the targeted GNP growth path, suggesting that each rule is equally adept at hitting a 3-percent target growth rate. Both are superior, in

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[10] This procedure follows McCallum's methodology for including non-monetary shocks.

[11] In equation (8), the constant term is not estimated as a free parameter. Rather, the constant term is derived from the steady-state expression for the inflation rate. We plugged in the steady-state value of base growth generated from the steady-state nominal GNP growth expression, assuming that the target growth rate for nominal GNP is 3 percent. If potential output grows at a 3-percent rate, consistency requires that the steady-state inflation rate is zero. However, in the unrestricted inflation rate equation, the steady-state inflation rate was positive. To achieve consistency, we treated the coefficients on lagged inflation and lagged base growth as parameters in the steady-state expression and solved for the value of the constant term which would yield steady-state inflation equal to zero. The inflation rate equation estimated for the 1954-91 sample is (standard errors in parentheses):

$$\Delta P_t = \underset{}{0.0014} + \underset{(0.0685)}{0.5499\,\Delta P_{t-1}} + \underset{(0.1062)}{0.1625\,\Delta B_{t-1}}$$

where ΔP_t is the inflation rate (measured by the implicit price deflator) in period t.

terms of minimizing RMSD, to the simple 3-percent rule. Equally suggestive is the near zero average errors for the McCallum and Meltzer rules compared with the average 3-percentage point miss from the fixed-rate rule. So one would expect a priori, the success of the rule is determined largely by their ability to adapt to changes base velocity movements across the sample. Indeed, this results suggests that the feedback aspect of McCallum's rule is not required to accurately hit a predetermined GNP growth target.[12]

IV. Currency demand simulations

We now focus on the issue of how the base paths generated by each rule could be distributed between currency and reserves. This not a trivial matter if one considers the controllability of currency. We estimate three different currency demand functions. In Model I we specify the growth rate of currency demand as a function of nominal income growth and (a first difference of) a short-term nominal interest rate. This version is a relatively normal specification of currency demand. Model II estimates currency demand growth as a function of output growth, the inflation rate, and the (ex post) lagged value of the real interest rate. Both Models I and II include three lagged values of currency growth in the regression. Finally, Model III is a Goldfeld-type specification (see Goldfeld (1973)) in which the log value of real currency is the dependent variable and the independent variables are contemporaneous log values of real GNP the nominal interest rate and one lagged value of log real currency.[13] Though not attempting to capture all possible specifications, these three are sufficiently general to demonstrate the evolution of currency under a base rule.

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[12] All results reported here set $\lambda = 0.25$. This value was found by McCallum (1988, 1993) to minimize deviations from the target path.

[13] Our currency demand specifications are linked to the existing literature. See, for example, see Goldfeld (1973) and Cagan (1982).

The estimation results, using data spanning the period 1954:1-91:3, are reported in Table 3. The estimates there suggest that there is a nontrivial amount of persistence in currency and currency growth (the sum of the coefficients on lagged currency growth equal roughly 0.85). Thus innovations, such as slowing income growth, are likely to have to long-lived effects in our simulations. Model I shows that lagged income and nominal interest rates exert a statistically significant effect on currency demand, once lagged currency is accounted for. This result is consistent with earlier results suggesting that changes in income probably influence currency demand decisions. Model II shows inflation playing a significant role in explaining currency demand. Model III shows that both real income and the nominal interest rate play significant roles in helping to explain currency demand.[14] For our purposes, however, determining which model is "the" correct specification is not necessary. Since each has theoretical and (some) empirical support, all three can be used to assess the robustness of out conclusions about the role currency in setting base rules.

Using the currency demand equations, we generate simulated values of currency using simulated nominal GNP growth in Model I, and both simulated output growth and inflation in Model II.[15] We make two simplifying assumptions. First, shocks to currency demand are omitted. Second, since the model is not rich enough to determine the nominal or real interest

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[14] As Model III is specified with log levels, we checked the residuals from this regression for a unit root. The first-order autocorrelation coefficient on the residuals is 0.32, the Stock-Watson q-statistic is -97.04, and the Dickey-Fuller test statistic is -3.38. Both formal tests indicate that one would reject the null hypothesis of a unit root at the 5-percent significance level (or higher).

[15] Our earlier finding (see Section 2.1) simplifies the simulation exercise. Specifically, changes in monetary base growth due to currency are statistically equal to changes due to total reserves. Consequently, the path of currency relative to base does not affect the nominal GNP simulation.

rates, we use their actual histories.[16]

The result of this simulation exercise is revealed in the path of the monetary base and simulated currency demand from each of the three models in Figure 1. Panel (a) plots the monetary base path generated by the McCallum rule along with the simulated currency from the three different currency demand models. Panels (b) and (c) repeat the exercise for the Meltzer and 3-percent rules, respectively. Note that across the different rules, a particular model of currency demand demonstrates qualitatively similar behavior. What is more interesting for our purposes is to focus on how the different models of currency demand relate to the monetary base. In particular, in any panel of Figure 1, one sees that if currency demand is generated by any of the currency models, currency exceeds the quantity of monetary base dictated by the rule around the mid 1970s, implying that total reserves would be negative.

Finding negative total reserves is clearly not an equilibrium outcome. While a result in which the demand for total reserves is less than zero may be theoretically possible, in a simulation exercise such an outcome probably would not occur. For a given reserve requirement ratio, falling reserves means that the quantity of deposits supported is also falling. This means that the banking sector would be contracting. There are changes that would probably be at work to mitigate the banking sector's contraction under a base rule. In particular, banks would likely raise interest rates on deposits, shifting the composition of the existing monetary base toward reserves in an attempt to mitigate the hemorrhaging bank sector. Obviously, with a shrinking banking sector possibly rising interest rates, it is quite likely that the reduced-form parameters would be very different from those in the historical data generating mechanism estimated above.

[16] As an anonymous referee pointed out on an earlier draft, the nominal interest rate is likely to look very different in the simulations. A more reasonable assumption, without solving for the nominal interest rate path, is to assume that the real interest rate is unchanged. Thus, our Models I and II use real interest rates as explanatory variables.

It is this potential instability in the reduced-form model that raises suspicion about the reliability of the simulation results from previous studies of base rules. But, our concern is motivated by more than conjecture about the possible uses of currency. Indeed, the simulation results for currency suggest that some startlingly different behavior would unfold, and that this behavior is generated using the same methodology as rule advocates. Our results demonstrate that, at least within the historical context of our (and others') simulation exercise, the distribution of base between currency and reserves should not be lightly dismissed in discussing the usefulness of adopting base rules.

Because the distribution of the monetary base might differ quite dramatically, as the results in Models I, II, and III would indicate, one way to investigate the adoption effect of the rule is let the coefficients on currency and total reserves differ. As a first pass, we use the parameter estimates in equation (3) as point estimates of the differential effects on income associated with changes in currency and total reserves. These point estimates are historical base and thus are only suggestive of what might actually occur. Since this exercise attempts to provide a first-pass notion of changes in the composition of monetary base on variability around the target income growth rate, the simulation simply allows the coefficients on currency and total reserves to differ.

The experiment is conducted as follows: The McCallum rule is used to generate the path for the monetary base growth. Given the monetary base growth rate, the growth rate for currency demand is generated using each of the three models. Since equation (3) is calculated in percentage-change form (see footnote 4), we derive the levels of monetary base and currency, taking the difference as total reserves. Lagged values of the percentage-change of both currency and total reserves relative to the base are then plugged into the equation (3) to generate the percentage change of nominal GNP.[17] For currency demand generated by the alternative currency demand models, the deviation of income from its target is substantially higher than those generated for the case in which the composition of base money is ignored. The RMSD using currency demand Model I is 11.8 percent, for Model II it is 23.1 percent, and for Model III it is 29.3 percent. These results further hint at the possible loss of stabilization improvement when one actually considers how currency and total reserves behave under these rules.

V. Total reserve rules

We eliminate the problems associated with currency in a monetary base targeting regime by assuming that the Federal Reserve supplies currency elastically to accommodate demand and focuses instead on hitting a total reserves target. This alternative to the base rule requires that we estimate a nominal GNP growth equation identical to equation (1), except that the one lagged value of total reserve growth has been substituted for monetary base growth. The relevant full-sample regression results after this substitution are:

$$(7) \qquad \Delta Y_t = \underset{(0.002)}{0.01} + \underset{(0.075)}{0.328}\,\Delta Y_{t-1} + \underset{(0.062)}{0.206}\,\Delta TR_{t-1}$$

$$\text{adj } R^2 = 0.17 \qquad \text{SEE} = 0.010 \qquad \text{BG} = 1.24.$$

Compared with the monetary base version, we see that the adjusted R^2 is only slightly lower when total reserves are used instead of the base. Even though total reserves have a smaller point impact than base (0.026 vs. 0.360), the coefficient is highly significant ($t = 3.3$). The results from the battery of stability tests indicate one cannot reject the hypothesis that the

[17] As with our previous nominal GNP simulations, the errors from equation (3) are added to the "expected" value to account for nonmonetary shocks to the economy.

parameters are constant over time.[18]

Setting the target nominal GNP growth rate at 3-percent, total reserves would decline at a 9.3-percent annual rate in the steady state according to the estimates from equation (7). This again means that the Federal Reserve would have to contract the quantity of total reserves by this rate in order to achieve a presumed zero average inflation target. Assuming a constant reserve requirement ratio, this contraction again would force the banking system to contract as fewer reserves support fewer deposits. Thus, using total reserves as the policy instrument, a non-inflationary path for GNP dictates that total reserves would decline, an outcome similar to that found in the monetary base simulation with currency explicitly accounted for.

We substitute total reserves for the monetary base in the rules and simulate nominal GNP growth and the path for total reserves. Table 4 reports the summary statistics for the deviations from target nominal GNP growth under each rule. In each case, the mean deviations (MD) and RMSD are higher for the same rule using the monetary base as the instrument. The differences, however, are small, less than 5-percent for either the McCallum or Meltzer rules when comparing the RMSD statistics. In contrast, the 3-percent rule for total reserves generates a RMSD that is 15 percent greater than when the monetary base is used.

Figure 2 plots the path for total reserves generated under each of the rules. Both the Meltzer and McCallum rules show declining total reserves during the simulation period while total reserves rise in the 3-percent case. In addition, we simulate currency demand under each rule to examine the ratio of currency to base. These results, which are available upon request, show that the currency-to-base ratios approach one under the McCallum and Meltzer total

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[18] The test statistics from the alterative stability tests are as follows: QLR = 2.647; Mean Chow = 0.980; A-P exp W = 0.561; P-K max = 0.937; P-K mean sq = 0.321. The test statistics do not reject the null of parameter constancy.

reserves rules.

VI. Summary

We explicitly consider the role that currency could play in carrying out suggested monetary base policy rules. Since currency is often cited as the key factor keeping policymakers from adopting such base rules, our contribution is to illustrate how currency might have behaved within the context of the alternative base rules under consideration. Our key finding is that the demand for currency simulated under the monetary base rules would likely be incompatible with adhering to the rule. We produce the result that under standard currency demand specifications, total reserves would go negative if the Federal Reserve let individuals acquire whatever quantities of currency demanded and fixed the supply of base using a policy rule developed by Meltzer, McCallum, or even the 3-percent rule.

What is interesting is the implication that such paths for currency and total reserves might have for the economy. The banking system would have to shrink as deposits and reserves decline, potentially accompanied by higher interest rates as bankers seek to curtail the deposit outflow. Under these conditions, the reduced-form models which we have used to characterize nominal GNP growth would likely change with the underlying economic structure. If one accepts the Lucas-critique kind of criticism, claims by base rule advocates that such rules would dampen fluctuations around a target growth rate for nominal GNP become less credible. As a first-pass, we estimate the effects of that sharp changes in distribution of monetary base between currency and reserves. The results suggest that the economy would be much more volatile around a 3-percent target path than claimed by McCallum.

We also investigated the usefulness of such rules when the Fed is assumed to focus policy on the behavior of total reserves. Simulated total reserves again declined during the sample period, mimicking the problems similar to those encountered with base rules. Whereas the 3-percent rule did not suffer these problems, the evidence indicates that one would fail to achieve the zero-inflation goal by adopting the policy of a 3-percent growth rate policy for reserves.

There remains much work to be done on this subject. Our results suggest that the role of currency cannot be dismissed in future analyses of base rule for policy. The challenge for future research is to construct some form of rule that circumvents these problems.

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Table 1

Results from Tests for Structural Breaks
Nominal GNP Growth with Monetary Base

Test Procedure	Statistic
QLR	6.322
Mean Chow	1.745
A-P exp W	1.421
P-K max	1.416**
P-K mean sq	0.514

** denotes significance at the five-percent level

Notes: QLR - Quandt Likelihood Ratio (maximum of likelihood ratio statistics)

Mean Chow - average of likelihood ratio statistics

A-P exp W - Andrews and Ploberger exponential weighted average of likelihood ratio statistics

P-K max - Ploberger and Kramer maximum of squared scaled residuals

P-K mean sq - Ploberger and Kramer average of squared scaled residuals

Table 2

Summary Statistics for Nominal GNP Growth Rate Target
Simulation period 1959:1 - 91:3, Estimation period 1954:1 - 91:3
Monetary Base as the Policy Instrument

Rule	MD	MAD	RMSD
McCallum	0.12	3.00	3.87
Meltzer	-0.00	3.05	3.91
3-percent	-3.15	4.00	5.00

Note: All deviations are reported at annualized rates

Table 3

Results from Currency Demand Specifications

Model Specification

Independent Variable	I	II	III[a]
$\Delta \ln Y_{t-1}$	0.0703** (0.0353)	-	-
Δi_{t-1}	-0.0016** (0.0004)	-	-
$\Delta \ln y_{t-1}$	-	0.0399 (0.0375)	-
$\Delta \ln P_{t-1}$	-	-0.0014** (0.0004)	-
Δr_{t-1}	-	0.0174 (0.0604	-
$\Delta \ln C_{t-1}$	0.5797** (0.0810)	0.5880** (0.0851)	-
$\Delta \ln C_{t-2}$	0.2415** (0.1048)	0.2380** (0.1075)	-
$\Delta \ln C_{t-3}$	0.0376 (0.0939)	0.0551 (0.0968)	-
$\ln y_t$	-	-	0.039** (0.005)
r_t	-	-	-0.0017** (0.0002)
$\ln(C/P)_{t-1}$	-	-	0.972** (0.008)

Legend: standard errors are in parentheses
a Note that Model III has the log value of real currency as the dependent variable.

Table 4

Summary Statistics for Nominal GNP Growth Rate Target
Simulation period 1959:1 - 91:3, Estimation period 1954:1 - 91:3
Total Reserves as the Policy Instrument

Rule	MD	MAD	RMSD
McCallum	-0.28	3.17	4.00
Meltzer	-0.92	3.21	4.12
3-percent	-4.04	4.67	5.72

Note: All deviations are reported at annualized rates

Figure 1 (a)

McCallum Rule--simulated monetary base and currency paths

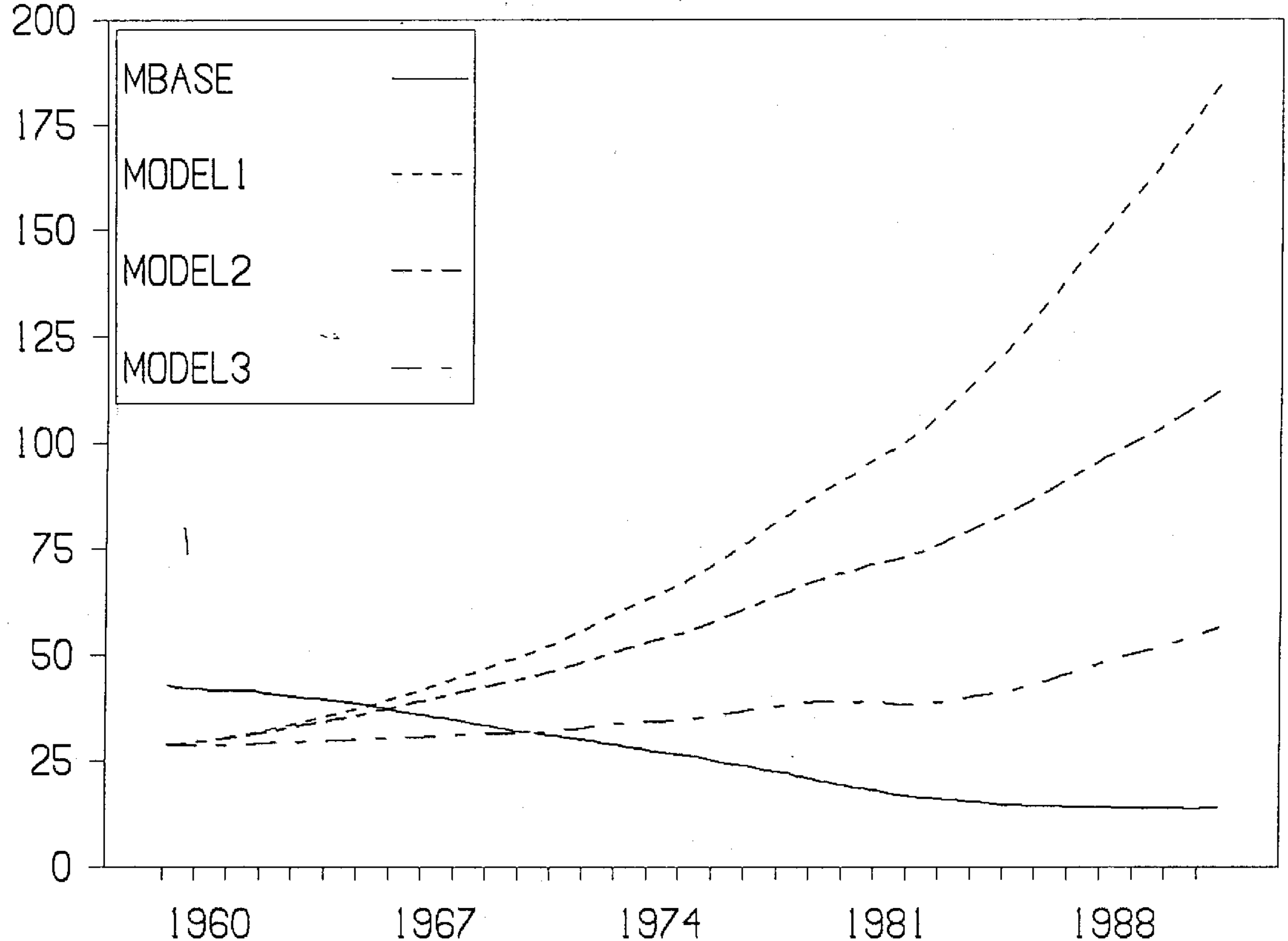


Figure 1 (b)

Meltzer Rule--simulated monetary base and currency paths

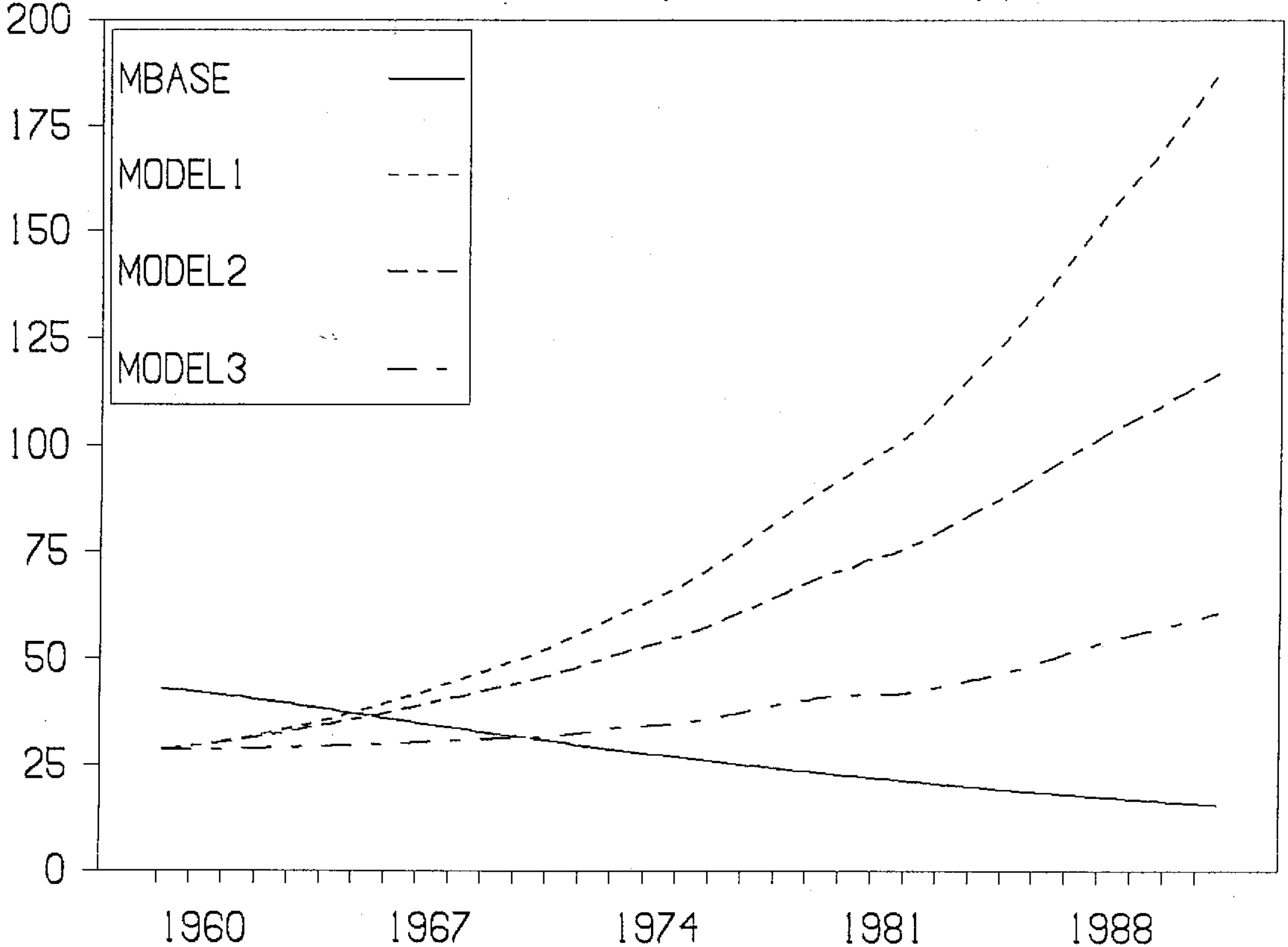


Figure 1 (c)

3 Pct Rule--simulated monetary base and currency paths

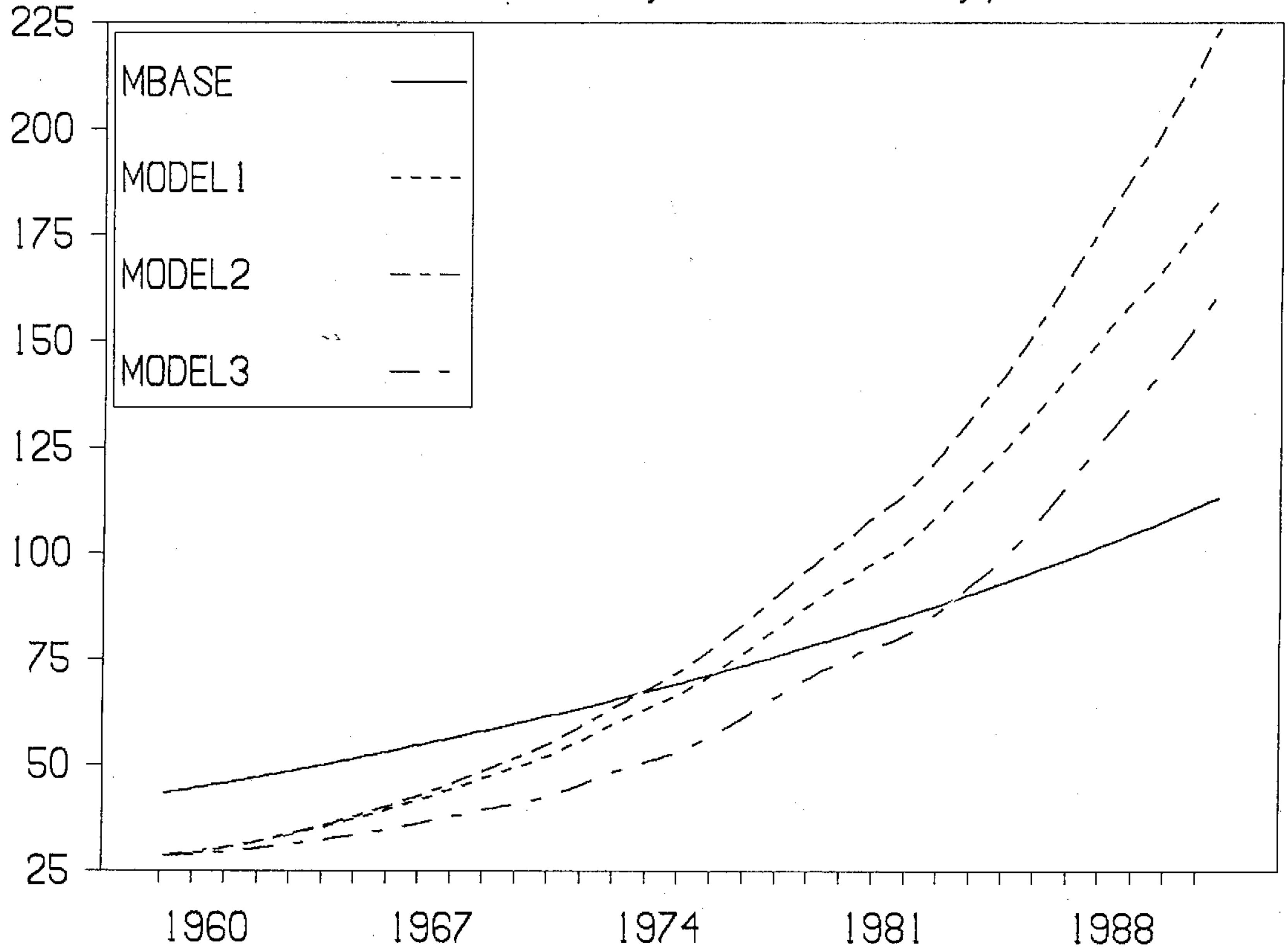
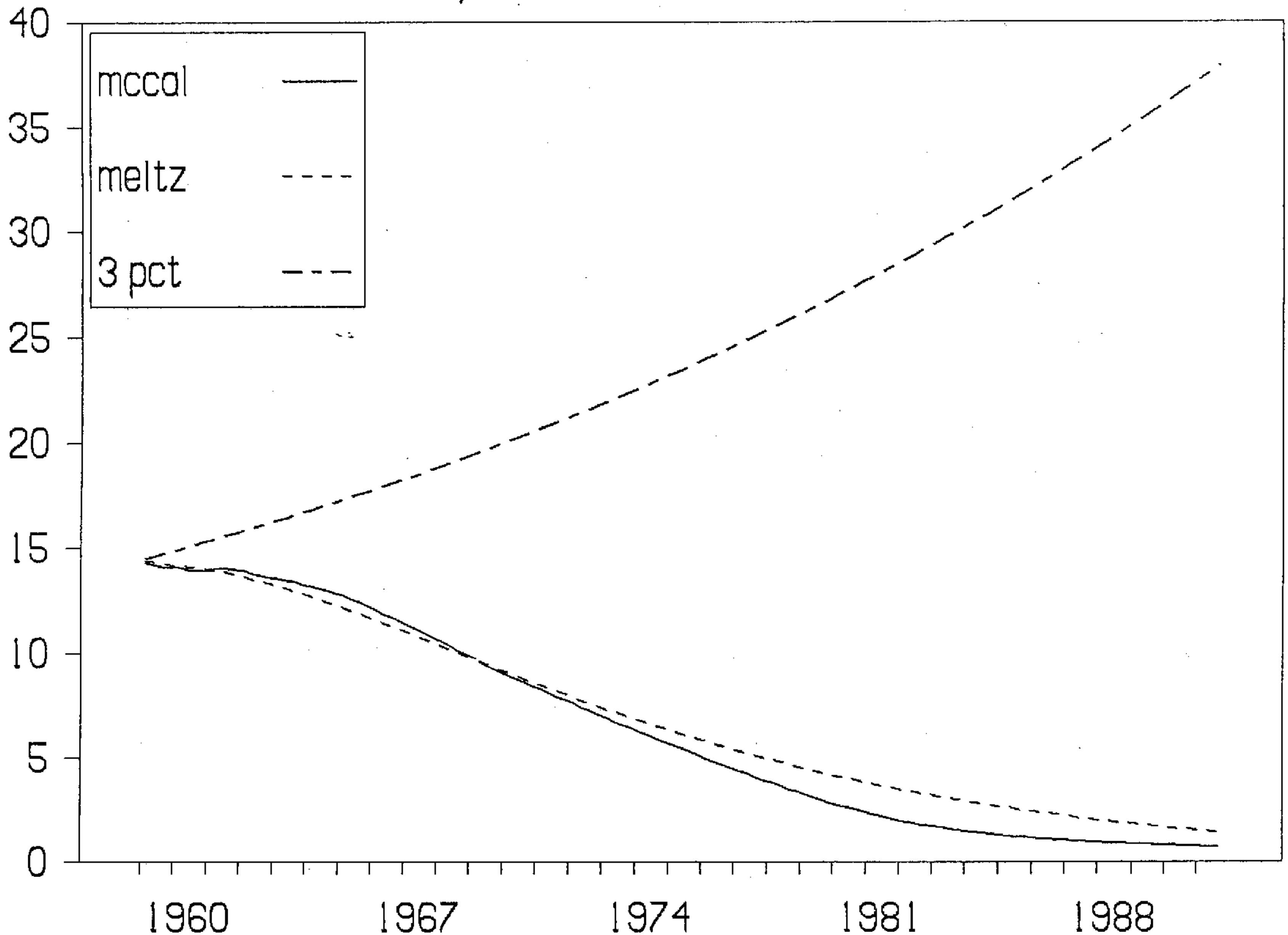


Table 2

Total reserve paths under the alternative rules



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