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EVALUATING MONETARY BASE TARGETING RULES

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1. INTRODUCTION

In light of recent financial innovations and other instabilities that disrupt the link between the monetary aggregates and economic activity, a renewed interest in the role of the monetary base in the formulation of monetary policy has emerged. For example, both Meltzer (1984, 1987) and McCallum (1987, 1988) have suggested rules for monetary base behavior as a preferable vehicle for implementing monetary policy to that of present discretionary policy procedures currently in place. McCallum goes further, providing evidence to support the notion that his 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 1954-1985 despite the regulatory and financial turmoil that occurred during the latter part of that period"(p. 173). Essentially, McCallum's evidence shows that the use of his monetary base rule would have precluded the emergence of the ever-increasing rates of inflation that characterize the 1960s and 1970s.

The purpose of this paper is twofold. First, we evaluate nominal GNP behavior under three alternative monetary base rules. One version is provided by Meltzer (1984, 1987), another by McCallum (1987, 1988), and a third is the simple X-percent growth rule consistent with the work of Friedman (1959). Our evaluation of these rules is based on statistically comparing the difference between simulated and targeted nominal GNP. We also note that, in his work, McCallum combines both the estimation period and the simulation period in analyzing the capabilities of his base rule. Such an approach casts suspicion on the claim that the policy rule would work well in a true, forward-looking policy setting. We therefore separate the estimation period from the simulation sample.

Our comparison of the rules' abilities is based on levels and growth rate targets for GNP. McCallum's evaluation focuses on summary statistics (e.g., root-mean-squared error) that compare the level of simulated nominal GNP to the targeted level of GNP. The use of levels and not growth rates is curious. Notwithstanding the fact that McCallum's estimated relationships are stated in growth-rate terms, most policy objectives are stated in growth rate terms. To evaluate the robustness of the rules, we compare their ability to hit GNP growth rate objectives as well.

Second, an ostensibly more important issue taken up in our analysis is the role that currency plays in implementing a monetary base rule. Benjamin Friedman (1988) has pointed out that currency currently comprises about 75 percent of the monetary base, and that the Federal Reserve elastically supplies all currency demanded. Based on these two observations, he argues that it is *a priori* suspect to place much credence on simulated results from a monetary base rule. We choose, however, not to reject monetary base rules *a priori* but ask the following question: Given a reasonably well-specified currency demand relationship and the simulated values for GNP generated from a base rule, what would be the levels of currency demanded by the public? Along with the different rules' simulated values for the monetary base and the simulated level of currency held by the public, we are able to infer the behavior of bank reserves under each rule. Ultimately, questions of interest are: What will happen to the provision of reserves to the banking system under the different monetary base rules studied here? Would this provision be consistent with other conditions in the economy? How might it affect interest rate behavior?

The format of the paper is as follows. The following section presents a brief description of the Meltzer and McCallum base rules. In addition, we present the underlying estimates used to derive the GNP simulation results and a comparison of the rules' relative ability to minimize deviations around the level and growth rate targets of nominal GNP. Using an estimation period of

1955 through 1969 to parameterize the models, our simulation results are based on a sample period of 1970 to 1989. The question about the distribution of currency and total reserves obtained by implementing the base rules is addressed in Section 3. Concluding remarks close the paper in Section 4.

SECTION 2: BASE RULES AND SIMULATED NOMINAL GNP BEHAVIOR

All base rules considered here are based on known information, implying that policy actions are dictated by past events and not upon the forecasts of future economic activity. We thus see these rules in sharp contrast to today's discretionary polices which are based on forecasts of future economic performance.[1]

2.1 Meltzer's Rule

Meltzer (1984, 1987) suggests a base rule that recognizes the need for changes in base growth as the economic environment changes. This aspect is especially notable in the event of financial innovations that may alter the time path of velocity. As Meltzer points out, his rule is not one to adjust quickly to transient movements in the relationship between output and base growth, but one that considers only the changes in the longer term drift in base velocity. Moreover, the rule would arguably allow monetary policymakers to achieve price level stability on average.

Meltzer's rule can formally be stated as

$$(1)\ \Delta B_t = 1/12[(\sum_{i=1}^{12} \Delta y_{t-i}) - (\sum_{j=1}^{12} \Delta\, VB_{t-j})]$$

where B is the log of the monetary base, y is the log of real output, and VB is base velocity, defined as the log of the ratio of nominal GNP to base. The Δ is the first-difference operator, such that $\Delta X_t = X_t - X_{t-1}$. In this formulation, we adopt Meltzer's suggestion of a three-year moving average, even though this choice is not based on any formal analysis. As he notes, "The three-year moving-average gives time to learn whether shocks are permanent or transitory. It provides for faster money growth relative to output in a cyclical recession and slower money growth relative to output in a cyclical expansion."(1987, p. 12) Because money per unit of output determines the price level in the long run, the rule thus gives price stability across the business cycle. In the empirical work below, equation (1) is referred to as the "Meltzer Rule."[2]

2.2 McCallum's Rule

McCallum (1987, 1988) stresses that a successful monetary base rule is one that establishes a target path for nominal GNP that equals the economy's long-run average rate of growth for real output.[3] A rule that on average allows GNP to grow only at the same rate as real output will result in inflation being equal to zero on average. McCallum's rule, like Meltzer's, eschews the fixed, X-percent growth rate approach on the grounds that the economic environment changes in ways that would cause fixed rules to have significantly different effects from those anticipated. Unlike Meltzer's rule, however, McCallum allows the policymaker to respond to short-term departures in observed nominal GNP from its target level. He thus combines Meltzer's choice for allowing base growth to vary with cyclical changes in velocity with feedback from the rule's error in hitting the target variable to determine the behavior of base growth. Hence, McCallum's rule allows the policy maker to react, albeit in a very specific manner, to changes in the trend of base velocity and to deviations in the level of GNP from its desired path.

McCallum's rule can formally be stated as:

$$(2) \quad \Delta B_t = 0.00739 - (1/16)[Y_{t-1} - Y_{t-17} - B_{t-1} + B_{t-17}] + \lambda(Y^*_{t-1} - Y_{t-1})$$

where ΔB is growth rate of the monetary base, Y is the log of nominal GNP, Y^* is the target path value for GNP, and λ $(0 \leq \lambda \leq 1)$ represents the feedback coefficient. The constant term in equation (2) (0.00739) is simply the quarterly value for a desired 3 percent annual growth rate of nominal GNP. The second term on the right-hand-side of equation (2) accounts for changes in the behavior of base velocity during the past four years, reflecting changes in the public's demand for base money. Given the negative sign, a <u>ceteris paribus</u> increase (decrease) in the trend of base velocity results in a required reduction (expansion) of base growth, similar to the Meltzer Rule. The final term reflects the feedback aspect of the rule: It specifies that the growth of the base will be altered by some λ-percentage points per year for each one percentage point deviation in GNP from its path in the previous quarter. In the empirical work that follows, equation (2) is referred to as the "McCallum Rule."

2.3 The Simulation Procedure

Following McCallum we first evaluate the ability of the rules to achieve a target level of nominal GNP, which is assumed to grow at a 3 percent annual rate. In order to calculate the performance of the McCallum Rule in minimizing deviations around a given target path for income, it is first necessary to specify a link between base growth and income growth. Although McCallum (1988) provides evidence based on a variety of models, there appears to be little gain in moving away from a relatively simple "reduced-form" type of model. In this paper, we choose the following version:[4]

$$(3) \quad \Delta Y_t = \alpha_0 + \alpha_1 \Delta Y_{t-1} + \alpha_2 \Delta B_{t-1} + \epsilon_{1t}$$

where ΔY is the growth rate of nominal GNP, ΔB is defined above, and ϵ_t represents random shocks to the growth of GNP. Although one could estimate equation (3) with contemporaneous base growth on the right hand side, we use this version to capture the fact that the monetary authority must decide their actions before current economic conditions are realized. To compare simulated GNP with target levels in the framework of the McCallum Rule, the parameter estimates from equation (3) are taken as given. Using the rule given by equation (2) and some initial values of GNP growth and base growth, a simulated value for base growth is determined. With simulated base growth one can then use equation (3) to get a new value for nominal GNP, which is then fed through equation (2) and so on.

Because Meltzer's Rule is specified in terms of real output, we use the following modification to the procedure described above. We first specify a linking equation of the form

(4) $\Delta P_t = \gamma_0 + \gamma 1 \Delta P_{t-1} + \gamma 2 \Delta B_{t-1} + \epsilon_{2t}$

where ΔP is the growth rate of the price level. To generate simulations of nominal GNP comparable the McCallum Rule, we use equation (4) to link simulated base growth to changes in the price level. To simulate real GNP within the framework of the Meltzer Rule, the following procedure is used. Using a initial value for base and nominal GNP, equation (3) is used to generate simulated nominal GNP. Similarly, a value of inflation is generated using equation (4), the initialization values for base growth and past inflation. Subtracting simulated inflation from simulated GNP yields simulated real output growth, which is used to construct the three-year moving average in equation (1). Also, the three-year moving average of base velocity is calculated using the simulated nominal GNP from equation (3) combined with simulated values of base growth. From here the process is the same as above.

2.4 Data and Simulation Results

The data for this study consists of quarterly, seasonally adjusted data on nominal GNP, the GNP deflator (1982=100) and the monetary base. Based upon the work of, among others, Haslag and Hein (1990), we use the St. Louis definition of the monetary base adjusted for reserve requirement changes. The data span the period 1955.1 through 1989.4.

Before turning to the actual simulation results, we should reiterate that our approach to examining the usefulness of these monetary base rules differs from that used by McCallum (1988). Whereas McCallum estimates equation (3) across the entire sample available (1954-85) and "simulates" base and GNP for the same sample, we estimate the underlying equations through a given point and then simulate out of the estimation period.

To implement the McCallum and Meltzer Rules, estimates of equation (3) are needed. The equation is estimated over the period 1955.1 through 1969.4 in order to provide the coefficient estimates used in the simulation exercise. These estimates are (standard errors in parentheses):

$$(5) \quad \Delta Y_t = \underset{(0.002)}{0.0090} + \underset{(0.120)}{0.262}\, \Delta Y_{t-1} + \underset{(0.198)}{0.390}\, \Delta B_{t-1}$$

$$\bar{R}^2 = 0.14 \quad S.E. = 0.009 \quad B\text{-}G = 1.25$$

The estimation results indicate that both lagged GNP growth and the growth of the base significantly affect current GNP growth. A Breusch-Godfrey test for serial correlation in the errors was conducted: The calculated F-statistic (B-G) of 1.25 indicates that we cannot reject the null hypothesis of no serial correlation in the residuals. We also should note that our estimates are very similar to those obtained by McCallum for his 1954 - 1985 sample period.[5] Meltzer's Rule is implemented first by obtaining an estimate of equation (4) for the 1955.1-1969.4 sample period. These estimates are (standard errors in parentheses):

$$(6) \quad \Delta P_t = \underset{(0.001)}{0.004} + \underset{(0.121)}{0.321}\, \Delta P_{t-1} + \underset{(0.084)}{0.157}\, \Delta B_{t-1}$$

$$\bar{R}^2 = 0.15 \qquad SEE = 0.004 \qquad BG = 1.45$$

The results are surprisingly similar to those using nominal GNP growth. The results for the inflation equation show that lagged inflation and lagged base growth together explain 15 percent of the variation in inflation. One aspect of this equation is the relatively low estimate of the lagged base coefficient, indicating that our admittedly simple model does not fully capture the dynamic relation between inflation and changes in base growth. Even so, these simple models are used to make our simulation exercise conform as closely as possible with McCallum's work, since his is the best known empirical investigation addressing similar issues along the lines taken here.[6]

2.5 Empirical Evidence: Levels

Using on the base rules given by equations (1) and (2) and the estimated parameters values in equations (5) and (6), simulated values for the log level of GNP were generated for the sample period 1970.1 through 1989.4. Following McCallum, the target level of nominal GNP is assumed to increase at an annual rate of 3 percent.[7] Figure 1 plots the simulated and target values for log level of nominal GNP across the 1970-89 period. Included are the results for the simple X-percent Rule, where base growth is set equal to 3 percent, the Meltzer Rule and the McCallum Rule. The latter plot is based on a λ value set equal to 0.25. In terms of comparing levels of GNP to the target path, McCallum's Rule appears superior. This observation comes from the fact that simulated values tend to revert back to the target path: Indeed, given the presence of the feedback parameter in the McCallum Rule, one would be surprised to find otherwise.

To better compare the outcome of our different simulations, we calculated the root mean square error (RMSE) and mean error (ME) of the simulated log level of GNP for the Meltzer Rule, the McCallum Rule using several values of λ, and the two X-percent base growth rules (3% and 0 %) relative to the targeted log level of nominal GNP. The results are presented in Table 1. Ranking the different rules by their relative RMSEs, our findings generally concur with McCallum's: The lowest RMSE of 0.0216 is found by setting $\lambda = 0.50$ in out simulation. In addition, the evidence suggests that the McCallum Rule generates a simulated GNP series that is closer to target than either the Meltzer or X-percent Rules.

The comparisons in Table 1 further reveal that a rule that merely allows for base growth to change with long-term swings in base velocity (the Meltzer Rule) is preferable to one that fixes base growth at some predetermined level, in terms of achieving a GNP levels target. For example, fixing base growth at 3 percent, the targeted GNP growth rate that reduces inflation to zero on average, yields a RMSE that is more than four times larger than any found using the McCallum Rule, and over three times larger than that found using the Meltzer Rule. Note also that even a zero percent base growth scenario results in the level of nominal GNP exceeding desired, as indicated by the large mean error (ME). This occurs because base velocity is simulated to grow at a rate greater than 3 percent per annum. Overall, the results in Table 1 support the view that to minimize deviations in the <u>level</u> of nominal GNP from a target path of three-percent growth, the feedback rule advocated by McCallum is superior to one that allows only for velocity swings or sets base growth equal to some predetermined rate.

2.6 Empirical Evidence: Growth Rates

The evidence in Table 1 supports McCallum's contention that the rule embodied in equation (2) is preferable given some predetermined target level of nominal GNP. The use of a levels criterion seems odd, however, in light of the fact that the motivation for the McCallum Rule relies on the notion that long-run nominal GNP growth of 3 percent equals the historical long-run growth of real output, hence setting average inflation to zero.[8] Why is it that this long-term growth relationship motivates the rule, but does not form the objective by which the rule is judged? What is it that suggests that nominal GNP is trend stationary so that there are no permanent shocks to the level of

GNP?[9] Moreover, there is the casual observation that monetary policy discussions are usually couched in terms of target growth rates for GNP.

Another reason for considering a growth rate comparison stems from the fact that the usefulness of the statistical measures of variance, such as the RMSEs in Table 1, may be questioned when the underlying series are not stationary. In other words, different series, some of which are and are not stationary, are not comparable using standard measures of dispersion. Those series that are non-stationary will result in dispersion measures that are functions of time. To assess the validity of this statistical concern, we used the procedures of Dickey and Fuller (1979) to test whether the deviations of simulated levels of GNP from the target path for each of the base rules in Table 1 are stationary. The results of our unit root tests, reported in Table 2, substantiates the concern that a statistical comparison of the RMSEs from the levels results are not comparable across different rules. Note how the deviations for the McCallum Rule in which λ equals 0.50 is the only series for which the hypothesis of stationarity cannot be rejected at the 5 percent level of significance.[10] In every other case, the deviations of simulated GNP from path are not stationary. Thus, comparing the RMSEs in Table 1 is misleading.

Based on the foregoing discussion, we have calculated the respective RMSE's based on deviations of simulated GNP growth rates from the target growth rate of 3 percent per year. As shown in the second column of Table 2, deviations of simulated GNP growth rates from the target growth rate generally are stationary. The results for a growth rate criterion, reported in Table 3, do not corroborate the conclusions drawn from the evidence in Table 1. Based on the RMSEs reported in Table 3, a McCallum Rule that sets λ equal to zero generates a simulated GNP growth path that minimizes the deviation from the 3 percent target rate relative to any other rule tested. This indicates that the feedback mechanism in the McCallum Rule is superfluous in a growth rate setting.[11] More interesting is the finding that there is very little difference among the reported RMSEs under a growth-rate criterion. For instance, setting base growth equal to zero delivers a RMSE that is lower than the outcome using McCallum's Rule with λ set equal to 0.50, the RMSE-minimizing value in Table 1. Moreover, the RMSE values using McCallum's Rule with λ equal to 0.50 or Meltzer's Rule are essentially the same: The largest deviation in RMSEs is only about 20 basis points. The evidence from the mean errors (ME) also indicates that no base rule generates simulated values that tend to drift far from the target growth rate. All rules result in nominal GNP growth that are on average within one percentage point of the target growth.

The evidence based on a GNP growth rate target indicates that the support of a feedback rule to guide base growth must be tempered. With base velocity growth behaving as a simple autoregressive process, a rule that sets the growth of base equal to the target GNP growth and adjusts for previous movements in base velocity growth is superior to a rule with a non-zero λ. Such a rule is similar to that advocated by Meltzer. Moreover, it should also be noted that the simple X-percent Rule, with base growth set equal to zero, also delivers a simulated path for GNP growth that yields departures from the target growth of 3 percent as low or lower than a McCallum Rule with a non-zero λ.

Given the notable change in relative rankings of the different rules when one switches from a levels target to a growth rate target for GNP, an interesting question is which of these objectives is preferable? The choice of a level or growth rate criterion to compare different rules hinges on the policymaker's subjective preferences. If a policymaker wishes to minimize deviations from a target level of GNP, then the McCallum Rule is preferred over the Meltzer or X-percent Rules. Indeed, the presence of a feedback mechanism in this rule virtually assures that deviations will asymptotically approach zero. On the other hand, some policymakers may prefer a target growth rate. Casual observation of Federal Reserve statements indicates that policy targets usually are announced in terms of growth rates. Accordingly, our analysis would suggest that the RMSEs reported in Table 3 are more useful for comparing the merits of different policy rules. In short, Tables 1 and 3 will be interpreted according to the policymaker's (and reader's) preferences. The upshot of these results are that different targeting procedures will be preferred depending on which objective function -- levels or growth rates -- that the policymaker wishes to satisfy.

3. THE ROLE OF CURRENCY

Previous discussions of policy rules, such as those presented above, focus on the outcome of simulated GNP relative to some target either in level or growth rate form. An important question that has been ignored in this line of research is how the monetary authority will achieve a given base path under different rules. One of the most compelling reasons given for selecting a monetary base target in lieu of an interest rate or other monetary aggregate target is that the policymaker exercises more direct and timely control over movements in the base. A common argument to the contrary is that the monetary base is comprised largely of currency and thus is not directly controlled by the Fed.[12] To put this point into perspective, in 1955.1 currency comprised about 66 percent of the base while by 1989.4 this figure had risen to 75 percent. Consequently, one question often raised concerns the variability of base growth that stems from the variability of currency growth: Is it possible to achieve a given base objective given fluctuations in currency demand?[13]

The concern is that the monetary authority does not have direct control over the base since it elastically supplies whatever currency is demanded by the public.[14] With a monetary base target changes in currency demanded <u>ceteris paribus</u> will force the monetary authority to alter the supply of reserves to the banking system if the authority is to hit the desired base target. In the absence of GNP evidence uniformly supporting one base rule over another, we examine the role that currency plays in each rule. If one implements any of the base rules discussed here, the logical and heretofore unanswered question is "How must the monetary authority adjust total reserves in the face of autonomous changes in currency demand?"

To address that question, we conduct the following experiment. The supply of currency is assumed to be perfectly elastic. To simulate a level of currency associated with simulated GNP, the following currency demand equation was estimated for the sample period 1955-1969 (standard errors in parentheses):[15]

$$(7) \quad \Delta C_t = \underset{(0.001)}{-0.0001} + \underset{(0.137)}{0.783}\,\Delta C_{t-1} - \underset{(0.178)}{0.160}\,\Delta C_{t-2} + \underset{(0.129)}{0.260}\,\Delta C_{t-3}$$

$$+ \underset{(0.047)}{0.101}\,\Delta Y_{t-1} - \underset{(0.001)}{0.0016}\,\Delta i_{t-1}$$

$$\bar{R}^2 = 0.82 \quad S.E. = 0.003 \quad B\text{-}G = 0.20$$

This relatively simple demand specification indicates that currency growth (ΔC) is determined by its own lagged values along with lagged values of GNP growth (ΔY) and interest rates (Δi), the latter measured as the first difference of the three-month Treasury bill rate. Although the interest rate term does not achieve statistical significance at standard levels ($t=1.6$), it is retained in the model to conform with others found in the literature.

This simple specification of currency demand is used in conjunction with the simulated values of GNP growth to obtain a simulated level of currency implied under the different base rules. That is, each base rules' simulated GNP series is used to construct a simulated currency series based on the parameter estimates found in equation (7). Lagged values of simulated currency are fed through the simulation period as the equation updates. In this experiment, historical values of the interest rate are used in the simulation.[16]

The simulated values for total reserves, which reflect the behavior of the monetary authority imposed by the use of the base rule, are found by subtracting the level of simulated currency from simulated base. Table 4 reports the simulated levels of base, currency and reserves for the terminal period. The table dramatically shows that adhering to any of the base rules analyzed here would require that the monetary authority drain total reserves from the banking system at an incredulous rate. Plots of the time paths for these simulated measures (not reported) also indicate that simulated currency generally exceeds simulated base early in the simulation period. The result using the X-percent Rule setting base growth equal to three percent shows the longest period of positive total reserves, turning negative in 1985.

How sensitive are these results to the form of the currency equation? A simulation based on a currency equation that relates current currency growth only to contemporaneous and lagged GNP growth also delivers the qualitative outcome reported in Table 4. The fact that total reserves turn negative is not a consequence of the specific currency demand specification used, but of the fact that because base velocity rises with simulated GNP, the level of base must fall. This means that if currency demand (and hence supply) is positively related to the income level of the public, total reserves as a proportion of the monetary base must decline over time as long as a non-inflation policy is pursued. Indeed, that is what our experiment forcefully demonstrates across a variety of base rules.[17]

Our experiment indicates that total reserves turn negative if the policymaker follows the constraints of any base rule presented here. An obvious response to this experiment is that key features of the economy are omitted that would have reduced currency demand as a proportion of the monetary base so that total reserves falling below zero would not occur. For example, strictly following any of the base rules examined would require contracting reserves but, as reserves fell below some critical level, interest rates would begin to rise in order to attract deposits. Such an adjustment, not captured in our model, would quell the rise in currency demand and total reserves would (may) remain positive.[18] Recognizing this concern, we attempted several permutations of the estimated currency model, such as including lagged values of total reserves in an attempt to capture the pressure on depository institutions to keep total reserves positive. This, too, failed to keep total reserves from going negative.

One interpretation of these simulations is to recognize that the base rules imply results so far outside our historical experience that sufficient changes in currency demand are not attainable based on actual data. As such, the so-called Lucas critique should be invoked when looking at our simulation results. Indeed, total reserves near zero would represent a dramatic regime change by the policy maker. Such changes in the rules of conducting monetary policy would surely be evidenced by changes in the parameter estimates used to simulate currency demand and hence total reserves. Unfortunately, we simply do not have an historical experiment to draw on that tells how much these parameter estimates would be affected.

4. CONCLUSIONS

Recent financial innovations and their attendant impacts on monetary control procedures have sparked renewed interest in monetary base rules to guide policy. Suggested rules have gone beyond Friedman's simple X-percent approach of Friedman. For example, Meltzer argues for adjusting base growth to reflect swings in base velocity in an attempt to offset the effects of financial innovations. McCallum recommends appending a dynamic feedback mechanism onto a Meltzer-type rule, so that base growth adjusts to observed departures in GNP from its target objective. Based on statistical criteria and the casual observation that GNP policy discussions by the Federal Open Market Committee is couched in terms of growth rates, we prefer the use of a growth rate target as the basis of comparison over a levels target. Comparing the different rules performance on this criterion, we find very little difference between the three rules evaluated here. This is interesting for the very fact that, on the basis of a growth rate criterion, the simple X-percent rule does about as well in *minimizing deviations* of GNP from the target as the more sophisticated rules.

We also find that adopting any of the base rules discussed here would force the monetary authority to restrict the supply of reserves to the banking system to such an extent that by the end of the simulation period, base would consist solely of currency. Is such an outcome feasible? No: Adopting any of these rules represents a dramatic break in the behavior of the monetary base relative to that observed historically. Consequently, imposing any of the monetary base rules examined here would mark such a drastic change in policy that behavioral parameter estimates would change. We thus interpret our evidence as confirming the empirical validity and relevance of the Lucas critique.

The message one should take away from our results is not of model failure, even though some of the evidence tends to support the concerns raised by opponents of monetary base rules. The role of currency requires greater understanding, indeed must be accounted for is some way, that the monetary base rules evaluated here do not accomplish. Thus, while any of the rules evaluated here show that they are quite able to achieve desired GNP growth rate objectives, the issue left for further research is a more detailed investigation on just how the rules would be implemented and the economic consequences of such actions.

FOOTNOTES

1. Meltzer (1987) argues that forecast accuracy of future economic performance is so poor that policy is likely to be destabilizing. Alternatively, the data-generating process may be an ARMA. thus supporting the use of past observations in constructing these rules.

2. Meltzer also suggested gains to be realized if the rule was adopted by a number of other countries at the same time, resulting in coordinated long-run policies. We do not consider this potentially important aspect of Meltzer's suggested rule.

3. For a recent exposition of nominal GNP targeting, see Bradley and Jansen (1989). Earlier discussions of GNP targeting are found in Gordon (1985) and Taylor (1985).

4. Haslag and Hein (1989) consider modifications to equation (2), such as longer lags or the inclusion of fiscal policy measures. These efforts, however, do not yield significant improvement on the results reported for equation (2) in its current form.

5. For purposes of comparison, McCallum's (1988) estimation results for the period 1954 - 1985 are:

$$\Delta Y_t = \underset{(.002)}{0.0074} + \underset{(.079)}{0.262}\, \Delta Y_{t-1} + \underset{(.120)}{0.488}\, \Delta B_t$$

$$\bar{R}^2 = 0.23 \qquad S.E. = 0.010$$

6. The simulation procedure used below employs estimates of inflation together with nominal GNP growth to get output growth, a component in Meltzer's Rule as given by equation (1). As an alternative, we also approached the simulation by estimating both an inflation equation and an output equation, using the sum of the two predicted values to get an estimate for nominal GNP growth, which then would be used to generate a base velocity measure. The results discussed below are little changed when this alternative approach is used. These results are

available upon request.

7. We generate a series of shocks during the simulation period using equation (3). The procedure works as follows for the McCallum Rule: After estimating the GNP growth equation using 1955-69 data, a series of one-step ahead forecasts are generated using the actual values for both lagged monetary base growth and GNP growth. Consequently, the forecast errors represent the portion of GNP growth not accounted for by equation (3) and are defined as shocks. The "observed" shocks are then added back into equation (3) in the simulation of 1970-89.

In the Meltzer framework, the inflation equation is estimated using the 1955-69 data. To obtain the simulated value of inflation we plug the simulated values of lagged inflation and lagged monetary base growth. The simulated value of GNP growth is constructed exactly the same way as in the McCallum framework. To obtain simulated values of output growth, we simply subtract simulated inflation from simulated GNP growth. Note that shocks are included in the construction of GNP growth, but not in the construction of the inflation equation. Implicitly we are assuming that shocks to GNP growth are all due to shocks to real output growth, a view not unlike that taken in McCallum's tests.

8. Loef (1989) also questions the use of a level criterion. He provides evidence that the volatility of nominal GNP growth generated using McCallum's Rule is not less than the actual volatility of nominal GNP growth observed for the United States between 1955 and 1985.

9. If as Nelson and Plosser (1982) argue nominal GNP is difference stationary, then shocks to the level are permanent. Forcing GNP to revert back to a trend level makes little sense in a difference stationary setting.

10. This is a small sample property. Any $\lambda > 0$ will give rise to errors reverting back toward zero over time. McCallum has noted, however, that some dynamic instability may arise as the value of λ rises close to unity. Arguably,

McCallum's Rule should be modified in a growth rate context so that the feedback term responds to deviations from the desired growth rate. We tried this modification without substantially affecting the results reported in Table 3.

11. Why should a rule that sets λ equal to zero yield the superior performance? The answer lies in the fact that base velocity growth during the sample period fluctuates around a mean value of about 5 percent for the sample period. In a simple quantity theory framework, this would mean that GNP growth would be simulated to be, on average, about 5 percent above base growth. But, since the simulated base growth is determined by equation (2), base growth is adjusted for changes in its velocity over the previous four years. This adjustment allows simulated base growth to adjust for the changes in velocity growth. Note that even though the characteristic of base velocity growth changes following 1980, the construction of the Meltzer and McCallum Rules specifically allows for such a change.

12. Alan Greenspan, Chairman of the Board of Governors of the Federal Reserve System, noted in testimony before the House Subcommittee on Domestic Monetary Policy, February 22, 1989, that ". . . the reason we have a problem in utilizing the monetary base is that a very substantial part, perhaps more than half, of U.S. currency is outside the United States and does not have any of the characteristics, therefore, to affect the specific activity within the United States. We in recent months have examined the monetary base very extensively for purposes of trying to see how it relates to inflation, how it relates to the economy, and have found that it is not a useful tool for us [policy makers]." For a somewhat different conclusion, see Haslag and Hein (1989).

13. Because the monetary base is the summation of currency and total reserves, we can calculate the proportion of the variance of base growth due to the variances of currency and reserve growth. Calculation of the relative variances

is properly done by measuring the growth of currency and reserves as percentage changes relative to the base. That is, currency growth is calculated as $(C_t - C_{t-1})/[(B_t + B_{t-1})/2]$. For the full-period, the variance of currency growth accounts for about 50 percent of the variance in monetary base growth. It is important to note that this percentage varies widely over time. For example, the variance in currency growth explains about 60 percent of the variance in base growth in the 1960s, about 75 percent for the 1970s and only 22 percent during the 1980s.

14. Cagan (1982) argues that "The advance information provided by the base is questionable because of its major component, currency."(p. 676) Cagan bases this statement on the finding that when he regresses nominal GNP growth on contemporaneous and lagged values of checkable deposits and currency, "The currency contribution is significant when the concurrent values of the two components are included but quite insignificant when they are excluded. This is consistent with the findings of a strong feedback from GNP to currency."(p. 673) B. Friedman (1988) also notes that "the Federal Reserve System has never pretended to limit the amount of currency in circulation, but instead has explicitly acted to accommodate fluctuations in the public's demand for currency."(p.206)

15. The form of our equation is similar to that used in Cagan (1982) and Pierce (1977).

16. Given the small estimate of the interest elasticity, omitting the interest rate in the currency equation does not qualitatively alter the results presented.

17. We also experimented with simulating total reserves and deriving currency as the residual component. Using a simulation equation that relates total reserve growth to current GNP along with lagged values of GNP growth and total reserves, the simulated currency values turn negative by the end of the sample

period.

18. We also attempted to determine what interest rate behavior would be like under a base rule regime. For heuristic purposes we assume that our goal is just to keep total reserves at the level observed in 1970.1. Back-of-the-envelope calculations indicate that under the three percent growth rate rule, the three-month Treasury bill rate would have to rise to over 300 percent by 1989.4 to maintain the level of total reserves. For a base rule of $\lambda = 0.50$, the simulated interest rate increases to about 750 percent.

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Table 1
Summary Statistics for Simulation Errors: Levels
Sample Period: 1970 - 1989

Rule	RMSE[1]	ME[2]
Meltzer Rule	0.1239	0.0276
McCallum Rule:		
λ = 0.0	0.0941	-0.0800
0.10	0.0469	-0.0010
0.25	0.0278	0.0080
0.50	0.0216	-0.0010
X-Percent Rule:		
B = 0%	0.2542	-0.2242
B = 3%	0.4301	-0.3792

1. RMSE represents the root-means squared error, defined as

$$RMSE = \{[\sum_{i}^{n} (X_i - X_i^*)^2]/n\}^{1/2}$$

where X is simulated GNP and X^* is the target value.

2. ME represents the mean error, defined as

$$ME = [\sum_{i}^{n} (X_i - X_i^*)]/n$$

Table 2
Test Statistics for Unit Roots in
Deviations of Simulated GNP from Target[1]

	t-ratios[2]	
Rule	Levels	Changes
Meltzer Rule	-0.32	-2.27
McCallum Rule:		
$\lambda = 0.0$	-1.45	-3.38*
0.10	-1.48	-3.61*
0.25	-2.18	-4.42*
0.50	-3.32*	-5.21*
X-Percent Rule:		
B = 0.0%	-1.75	-3.29*
3.0	-1.81	-3.32*

----

1. Estimated equations include constant term and lagged value of dependent variable.
2. Critical value at 5 percent level is about -2.89. See Fuller (1979). An (*) denotes significance at 5 percent level.

Table 3
Summary Statistics for Simulation Errors: Growth Rates
Sample Period: 1970 - 1989

Rule	RMSE	ME
Meltzer Rule	0.0115	-0.0038
McCallum Rule:		
λ = 0.00	0.0101	-0.0005
0.10	0.0103	-0.0001
0.25	0.0103	-0.0004
0.50	0.0111	-0.0003
X-Percent Rule:		
B = 0.0%	0.0106	-0.0042
B = 3.0%	0.0126	-0.0080

See footnotes to Table 1.

Table 4
Levels of Base, Currency and Total Reserves: 1989.4

Rule	Base	Simulated Values Currency	Total Reserves
Meltzer Rule	\$19.82	\$67.71	\$-47.89
McCallum Rule:			
$\lambda = 0.0$	20.53	96.30	-75.77
0.1	20.11	93.63	-73.52
0.25	20.63	94.78	-74.15
0.50	20.31	94.87	-74.56
X-Percent Rule:			
B = 0.0%	40.97	118.74	-77.77
3.0	117.86	158.84	-40.98
Actual	294.20	220.80	73.50

FIGURE 1

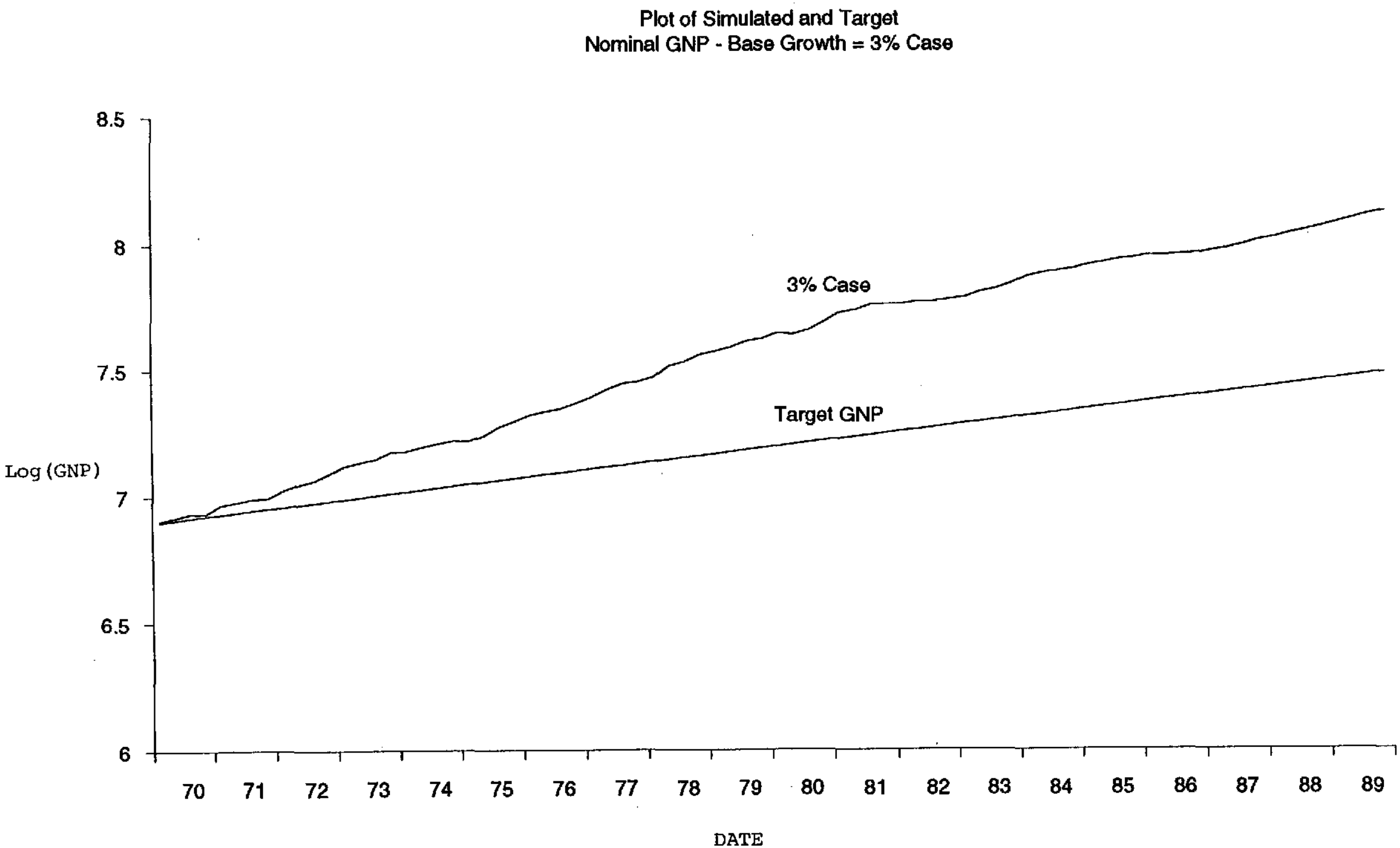

Plot of Simulated and Target
Nominal GNP - Base Growth = 3% Case
8.5
8
7.5
7
6.5
6
Log (GNP)
3% Case
Target GNP
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
DATE

FIGURE 1, cont.

Plot of Simulated and
Tarter GNP - Meltzer-Rule Case

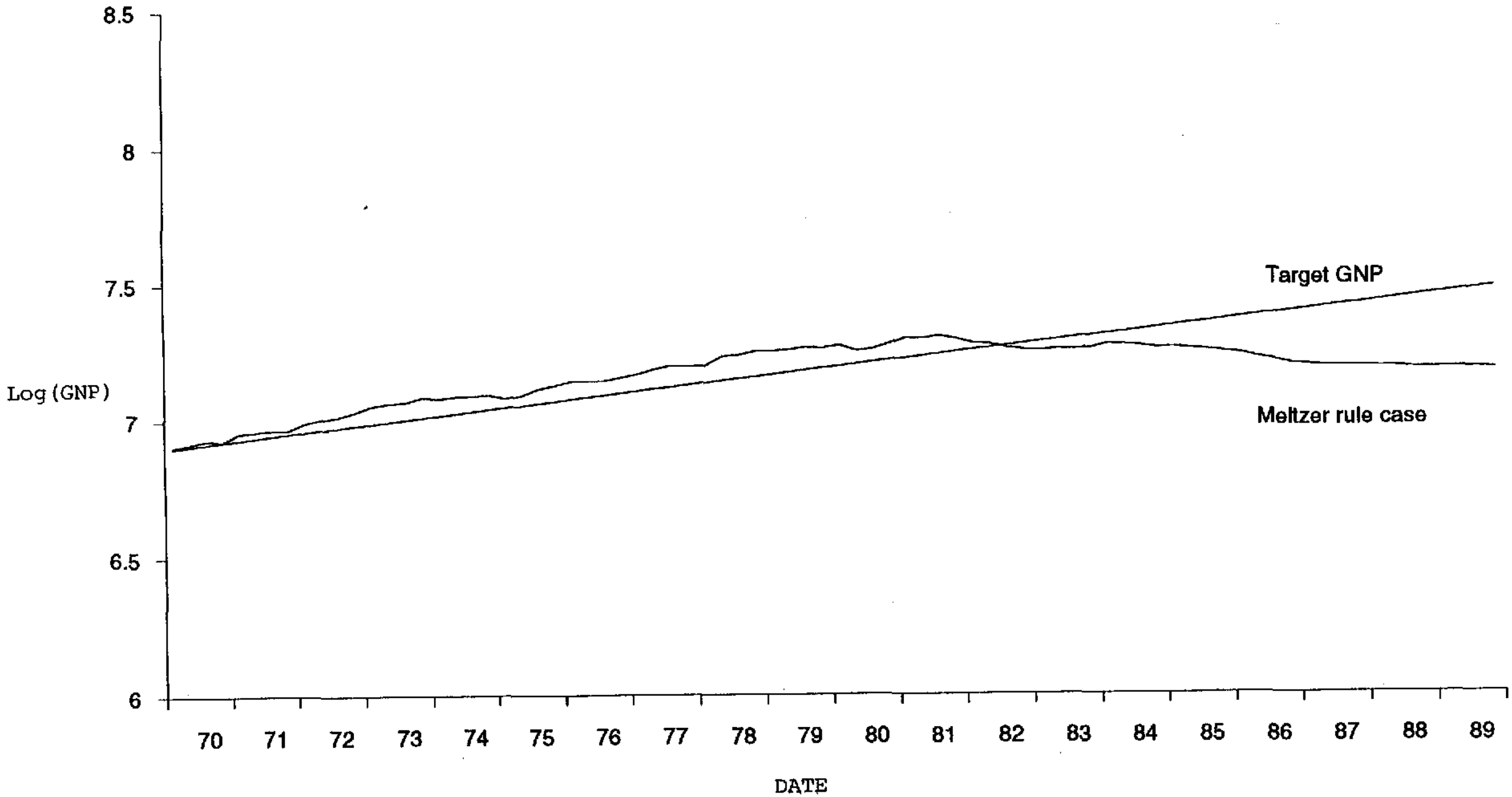
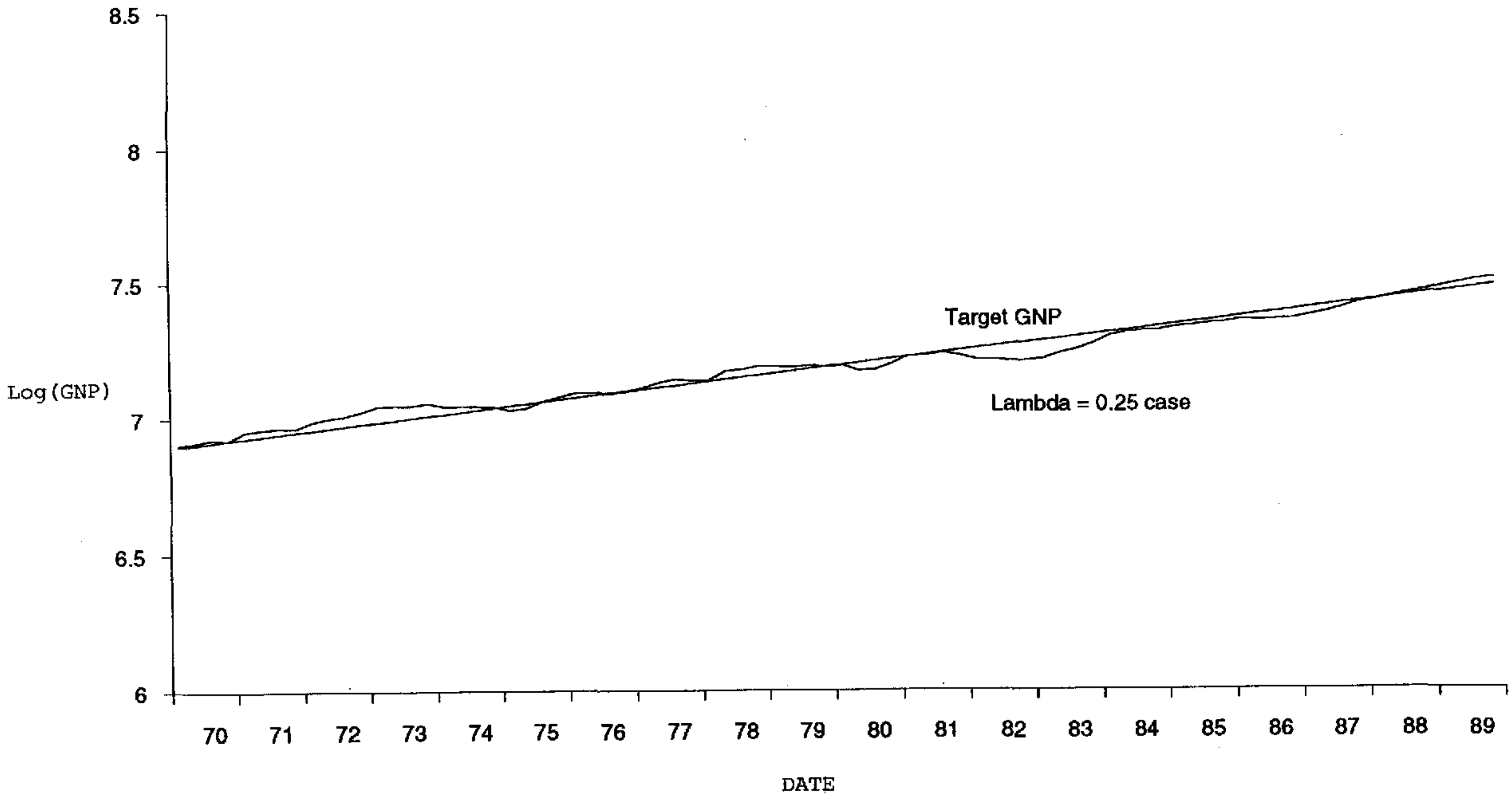


FIGURE 1, cont.

Plot of Simulated and
Target GNP - Lambda = 0.25 Case



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