OPTIMAL CONTROL STUDIES OF INTERACTIONS

BETWEEN THE MONETARY AND FISCAL AUTHORITIES

IN THE U.S. ECONOMY

by

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ABSTRACT

This thesis analyzes U.S. economic stabilization policy-formation as a decentralized, linear quadratic, deterministic control problem in which the monetary and fiscal authorities are independent controllers. A series of experiments is performed on a small macroeconometric model to demonstrate how varying assumptions governing policy-maker interactions change the character and effectiveness of optimal stabilization strategies. The assumptions lead to non-game treatments:

- A) Joint (centralized) strategy optimization,
- B&C) One authority optimizes while the other holds to either an ad hoc exogenous policy sequence or an empirically-based, endogenous policy "reaction" function (a feedback relation),
- D) Both authorities follow policy "reaction" functions,

and to dynamic game treatments:

- E) Open-loop Nash non-cooperation,
- F) Closed-loop Nash non-cooperation, and
- G) Nash bargaining.

Insights gained from game and non-game approaches are compared and characteristics of the monetary-fiscal balance of power are identified.

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INTRODUCTION

Economic stabilization policy in the United States is the product of a fiscal-monetary balance of power. Policy-makers in the government's Executive and Congressional Branches on the one hand and in the Federal Reserve on the other are empowered to pursue the country's well-being as best they see fit, whether it be working in close cooperation or outright conflict. This division of power raises several questions about stabilization. How even is the power balance? Does either authority have enough power to fully counter balance or to manipulate the other's policies? Assuming that an ideal strategy mix can be determined from "society's" point of view, how close can the decentralized policies come to this ideal? What are the costs attributable to the two authorities competing instead of negotiating an agreement when their objectives clash? Given that objectives and views of the world always differ, is cooperation ever likely?

One way to approach these questions is to embed decentralized stabilization in a differential game framework and consider how alternate sets of rules governing "player-interactions" affect optimal "player-strategies." Nash non-cooperative games shed light on stabilization under pure conflict, Nash bargaining on enforced or elected cooperation, Stackelberg concepts on leader-follower behaviors.

The idea of applying game concepts to economics was the main motivation behind von Neumann and Morgenstern's seminal treatise on game theory (Vnl). Nash (N1), (N2), (N3) and von Stackelberg (Vsl) gave their own interpretations to nondynamic games soon thereafter which have more recently been extended to dynamic differential games (I1). It has been argued that these notions deal directly with the decentralization which characterizes much economic behavior (Sh1).

Until very recently, however, optimal control studies of stabilization have considered a simplified problem by restricting the monetary and fiscal authorities to act as a centralized unit. Kendrick's 1975 survey reports sixty such applications to thirty-nine different macroeconomic models (K1). The control problems addressed range in complexity from linear, deterministic models with quadratic objective functions to nonlinear, stochastic models with general objective functions. They uniformly indicate a potential for substantial benefit to optimal rather than ad hoc policies and a greatly enhanced insight into the model which is studied. While these studies have certainly improved understanding of stabilization, it is clearly desirable to take into explicit account the decentralized nature of policy formation in the United States.

Pindyck was the first to analyze the monetary-fiscal balance of power empirically in a differential game setting (P3). His 1977 study compares policies derived under Nash competition with the cooperative strategies of a centralized solution to indicate the costs of conflict. A comparatively longer lag in monetary policy-effectiveness inherent to his model enables the fiscal authority to realize short-term gains at monetary expense when the conflict is between unemployment and inflation. Beyond four or six quarters, however, monetary effectiveness picks up enough to force a compromise which leaves neither authority as close to its objectives as it would have been in a cooperative situation. Thus, conflict akin to Nash competition can lead to equilibrium strategies which differ significantly from those accompanying centralization.

Fair (F1) subsequently suggested another way to account for the balance of power in a paper which derives optimal fiscal stabilization policies when the monetary authority is assumed to follow either a fixed ad hoc strategy or an empirically-based policy "reaction" function (a feedback relation) (F1). Fiscal policy is found to be least effective when the monetary authority holds the money supply constant; it is found most effective when the monetary authority holds the short-term bill rate constant; and intermediately effective when a "reaction" function is followed. The conclusion is that "fiscal-policy effects are quite sensitive to alternative assumptions about the behavior of the Fed," (F1, p. 2).

This thesis is partially motivated by several questions arising out of the Pindyck and Fair studies:

1) While both studies demonstrate the importance of decentralization in studying stabilization, their approaches are fundamentally different in that Fair's does not allow the authorities to optimize their behaviors simultaneously. Do the two treatments nonetheless give similar insights?

2) In keeping with the decentralized spirit of Pindyck's study, an appropriate benchmark against which to measure the costs of conflict in the form of Nash competition might be cooperation in Nash bargaining rather than in centralization. How does Nash bargaining compare to competition or centralization?

3) Pindyck presents equations for the Nash closed-loop competitive equilibrium which are not evaluated. How do the open- and closed-loop solutions compare?

4) Fair takes only the fiscal viewpoint. Are optimal monetary policies also sensitive to assumptions about the behavior of the fiscal authority?

To study these as well as the more general questions posed earlier, this thesis evaluates:

1) Pindyck's open- and closed-loop Nash competitive solutions;

2) Fair's "one-sided" optimal fiscal solutions with ad hoc and "reaction" monetary short-term bill rate policies;

3) One-sided optimal monetary solutions with ad hoc and "reaction" fiscal policies;

4) A Nash bargaining solution; and

5) A centralized solution;

all in the context of a small macroeconomic model.

In order to render the games mathematically tractable, modeling assumptions equivalent to those in Pindyck's and Fair's studies are made:

1) the monetary and fiscal authorities share the same deterministic view of how the economy works; this view is embodied in the econometric model;

2) the authorities share perfect knowledge of this model and their individual objectives;

3) their independently determined objectives can be adequately expressed in terms of economic variables contained in the model.

Chapter 1 conveys familiarity with the model through discussion of its estimation statistics and its static and dynamic properties.

Chapter 2 outlines the experiments with a brief motivation for the mathematics and how they relate to the general questions posed above. "Reaction" functions are proposed and estimated for both authorities.

Chapter 3 presents the results, and discusses tentative conclusions.

The relevance of optimal control analyses is enhanced by the stabilizing and robustness properties of the strategies they yield. These properties often enable a strategy derived on the basis of a highly simplified mathematical model to produce desired behavior when applied to an actual system; that is, even though the model is too simple, the strategies compensate for inaccuracies. When it comes to macroeconomic systems, in particular the small model in this study, one suspects that more often than not inaccuracies will overpower the compensating ability of optimal strategies. However, it is conceivable that they will not. One way to test this conjecture is to compare optimal strategies derived under a number of widely varying models in order to identify whether generic characteristics arise. Consequently this thesis may take on greater relevance in the light of future studies.

CHAPTER 1

THE MODEL

Overview

The original intention was to choose one from the multitude of available models and quickly move on to the control experiments. Predictably, "the multitude of available models" soon narrowed down to two almost suitable ones, choosing either of which implied some degree of alteration and reestimation. Consequently, more emphasis is placed on the model than was intended.

This chapter illustrates the close link between the properties of this particular model and the outcome of the control experiments. In fact, with enough understanding of the model, one might argue that the control experiments are almost redundant since their outcomes seem predictable. This chapter is meant to give enough background on the model to make the control experiments understandable.

1.1 Choice of Model

The model should be the simplest set of equations available which "adequately" describes how the monetary and fiscal authorities affect the economy. Since this study is designed to demonstrate methodology, "adequately" is taken to mean acceptable to economists as a reasonable and non-controversial intermediate-level-textbook view of the world. Since the model is to be used for policy analysis, a two- to four-year time frame is pertinent, and unemployment and inflation should be endogenous.

These considerations suggest that an appropriate choice might be a small, short-run, linear, quarterly Keynesian macro-model. This means: 1) a GNP identity: GNP equals consumption plus investment plus government expenditure (the foreign sector is ignored); 2) behavioral relations for consumption and investment; 3) an interest rate equation which feeds into investment; and finally, 4) price and unemployment relations. The fiscal instrument, government expenditure, enters through the GNP identity; the monetary instrument, the money supply, enters through the interest rate equation. Thus, a minimum-complexity model might have one identity and four behavior relations. A model this simple does not explain the economy very well, so the models considered here are slightly more complicated.

Two alternative candidates are considered: Pindyck's quarterly model of the post-Korean war U.S. economy (P2) and Moroney and Mason's quarterly dynamic model of aggregate (U.S.) demand (Mo1). Both are small demand-side models with the fiscal authority explicitly controlling government expenditures and the monetary authority the supply of money.

Pindyck's model reflects his belief that aggregate investment is not well-explained in a minimum complexity model because its various components exhibit widely differing behaviors. He disaggregates investment into non-residential, residential and inventory investments. To describe their behaviors he includes both long- and short-run interest rates. He also introduces a proportional tax relation and a wage equation, expanding the simple model to three identities and ten behavioral relations. This model has a drawback in that two of its thirteen equations are nonlinear.

Moroney and Mason are primarily interested in the impact of monetary instruments so they model money-market determination in a more detailed way, with simultaneous supply of money, demand for money, long- and short-run interest rate equations. (These equations can be reduced to a form equivalent to Pindyck's interest rate block by enforcing the money supply equals demand identity.) As they believe that the simplest models perform badly because the foreign sector is ignored, Moroney and Mason introduce a behavioral relation for imports and make exports an exogenous input. They further include a proportional tax relation, but leave out the price and unemployment equations because they choose to study the impact of policy on GNP. Thus, their model contains three identities and six behavioral equations.

The question becomes whether it is easier to linearize Pindyck's model or to add price and unemployment to Moroney and Mason's model. The choice is made to work with Pindyck's model as more is known about its dynamic behavior since numerous simulations and policy experiments have been run, and, more importantly, it has behaved reasonably in previous control experiments (P2), (P3).

1.2 Structure and Estimates

Table 1.1 lists the variables in the Pindyck model and Figure 1.1 illustrates its structure without dynamics. Since causality can be traced from each to every other endogenous variable, it is immediately apparent that the endogenous variables form a single highly interdependent block structure. For the same reason, the weight of every exogenous input is ultimately felt by each of the endogenous variables.

The short-term nature of the model is evident, assuming that it is dynamically stable, as both technological and population factors are ignored (see Appendix D for stability). The only way in which such a model can exhibit systematic growth is through the exogenous driving forces: G, GNPP, M, TR and WLTH.

Figure 1.1 helps one visualize adjustment within the model by abstracting the dynamics. For an example, change in the short-term bond rate, directly and through the long-term rate, reapportions the real economic flows: consumption, inventory investment, nonresidential and residential investments, setting a new level of inventories. As GNP adjusts, the rates of unemployment and inflation through YD respond, calling for a new rate of wage growth and adding an additional shift into short-term bond rate which starts the process anew.

Detailing dynamic adjustment is postponed until Section 1.2 where the model is slightly modified for the control experiments. The remainder of this section describes the final estimated form of each dynamic equation. Since Pindyck and Rubinfeld's textbook cover it, economic justification for the various equations is not presented except where substantive changes have been made. The focus is on a concise enumeration of the coefficients and associated statistics. For reference, the previous equations are listed in Appendix A.

Reestimation is carried out using a version of Two Stage Least Squares (2SLS) implemented in TROLL, a computer package for simulation, regression and data analysis and transformation supported by the Center for Computational Research in Economics and Management Science at M.I.T.

TABLE 1.1: Variables in the Model

ENDOGENOUS:

C	Consumption, real	behavioral
GNP	Gross National Product, real	identity
IIN	Inventory Investment, real	behavioral
INR	Nonresidential Investment, real	behavioral
INV	Stock of Inventories, real	identity
IR	Residential Investment, real	behavioral
RGP	Rate of Growth of Prices, nominal	behavioral
RGW	Rate of Growth of Wages, nominal	behavioral
RL	Long-term Interest Rate, nominal	behavioral
RS	Short-term Interest Rate, nominal	behavioral
T	Taxes, real	behavioral
UR	Unemployment Rate	behavioral
YD	Disposable Income, real	identity

EXOGENOUS

G	Government Spending, real
GNPP	Potential GNP, real
M	Money Supply, real
TR	Transfer Payments, real
WLTH	Wealth, real

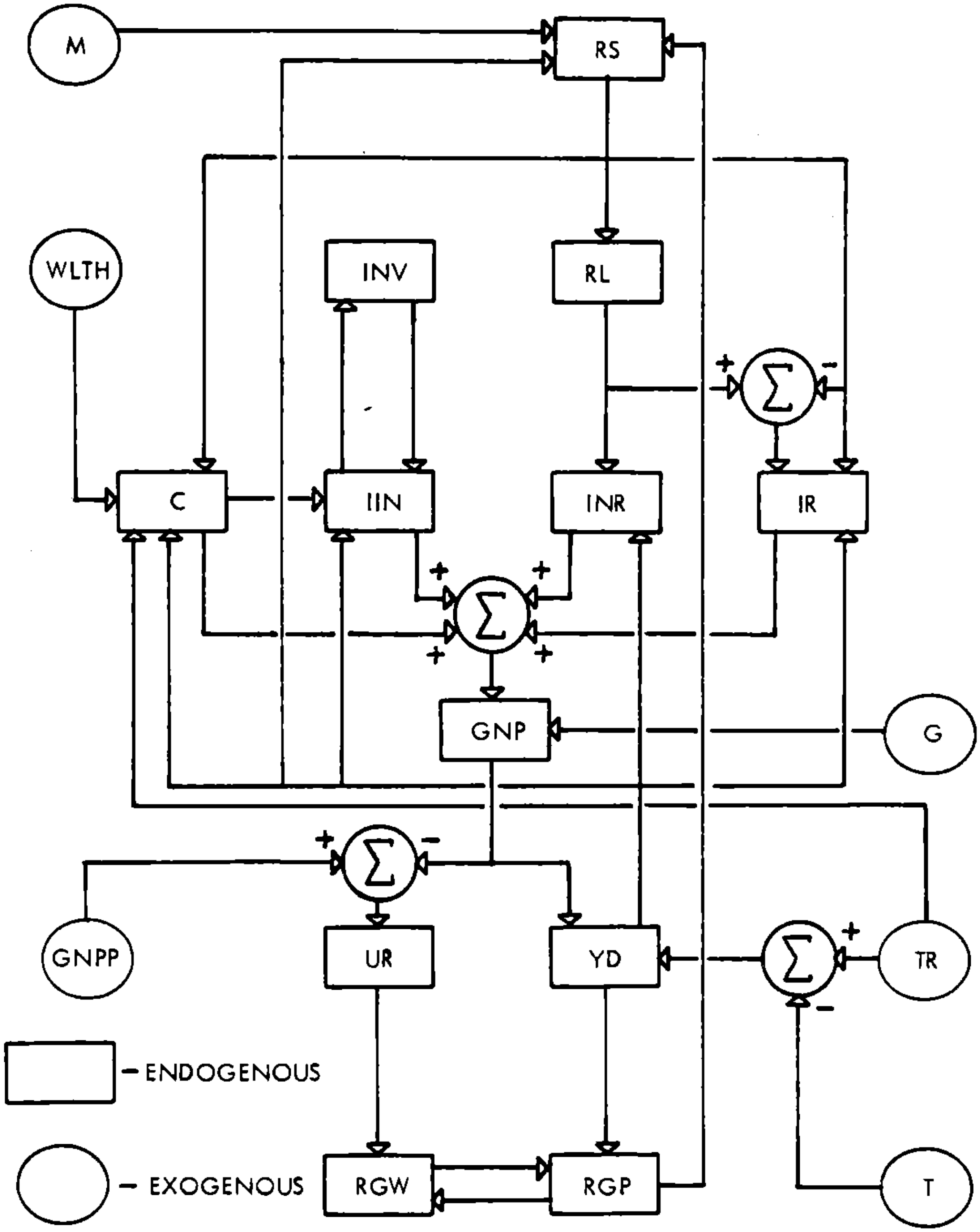


FIGURE 1.1 Static Block Diagram of Pindyck's Model (M-MODEL)

2SLS is an orthogonal projection single-equation approach prefaced by a "first stage" regression of each of the equation's right-hand side jointly determined (in time) variables on a set of predetermined variables which appear in the model. Because it is assumed that the variables are independent across time periods, the first stage is meant to cleanse the right-hand side jointly determined variables of their correlation with the residuals. The fitted values of the jointly determined variables are then substituted into the right-hand side of the equation and a "second stage" ordinary least squares regression is run which yields asymptotically unbiased and consistent parameter estimates as long as the assumption of independence across time periods holds (J1, pp. 380-384). When the Durbin-Watson statistic (P2, pp. 113-116) indicates significant first-order autocorrelation, a correction is made via a Cochrane-Orcutt procedure available in TROLL. This involves an iterative search for the value of the correlation coefficient which yields the lowest sum of the squared residuals for the estimation (J1, p. 262).

The 2SLS procedure is chosen as a compromise between cost and efficiency. Simultaneous equation methods are available which yield more efficient parameter estimates because they take into account cross-equation correlations. However, these methods clearly involve much higher order systems of equations are thereby significantly increased cost. A simpler, cheaper method such as ordinary least squares yields biased estimates since it ignores the correlation between the left- and right-hand side jointly determined variables.

The time bounds for the estimation are 1956-1 to 1976-1. All of the data except WLTH (household net worth) are obtained from the NBER data bank in the TROLL system; WLTH was constructed for the Federal Reserve - MIT - Penn Model and supplied by F. Modigliani of MIT (W1). The series and their precise definitions are in Appendix B. At the beginning of the estimation work, March, 1978, the data were available through the last quarter of 1977; the regression bounds are set to allow an ex post forecast in judging model performance.

Five estimation statistics are reported with each behavioral equation:

1) t-statistics for each coefficient test the null hypothesis that the coefficient should be zero (P2, p. 30);
2) R^2 is the ratio of explained to total variance in the dependent variable (P2, p. 35);
3) SER is the standard error of the regression (P2, p. 28);
4) F-statistic for the equation tests the existence of a nontrivial linear relationship between the left-hand and right-hand side variables (P2, pp. 38,39);
5) DW(0), the Durbin-Watson statistic, tests for first-order autocorrelation (P2, pp. 113-116).

To simplify the notation, a variable without a subscript, i.e., GNP, signifies its value at time t while lagged values are subscripted so that GNP_{-1} is GNP in period t-1.

The GNP identity is self-explanatory, remembering that there is no foreign sector (exports equal imports):

(1.2.1) $GNP = C + INR + IR + IIN + G$

Disposable income, YD, is defined to be total income minus taxes net of transfer payments:

(1.2.2) $YD = GNP - T + TR$

This relation is approximated by arbitrarily defining an average tax rate, t, (this is equivalent to a behavioral relation for taxes, T):

(1.2.3) $t = (T - TR)/GNP$

and an identity:

(1.2.4) $YD = (1.0 - t)*GNP$

The average tax rate is the historical mean of that rate over the estimation period: 0.11925. The last identity defines the stock of inventories:

(1.2.5) $INV = INV_{-1} + IIN/4.0$

Of all the behavioral equations, the consumption equation is most changed from its form in Pindyck and Rubinfeld's textbook. This is the result of instabilities encountered when simulating the whole model with reestimated versions of the old consumption relationship. The heavy dependence of consumption upon disposable income, both directly and through feedbacks from the inventory investment equation, coupled with the large proportion of disposable income which consumption comprises, produces a marginal propensity to consume (MPC) out of disposable income very close to exceeding one, thus destabilizing the model.

Two changes are made to cure this problem: 1) the narrowly defined wealth proxy, LIQ, (savings and time deposits), is replaced by an inclusive construct, WLTH, which is an implicitly price-deflated version of Modigliani's wealth series; and 2) disposable income is disaggregated into transfer and non-transfer incomes.

The wealth variable inclusion reflects a modified permanent income or life-cycle hypothesis that consumption depends less strongly on income flow than on perception of present and future income flows which are closely related to wealth as well as income. Thus, disposable income dependence is lessened by letting the change in the level of wealth take on some of the explanation in the Koyck lag relationship (P2, p. 214).

Disaggregating disposable income into transfer and non-transfer incomes is based on the hypothesis that the proportion consumed out of transfer income exceeds that out of non-transfer income. This is plausible since a large part of transfers is comprised of welfare-type payments which redistribute income from rich to poor; the other major component is social security-type payments which are dispensed to the old or to young dependents whose urge to save is low. Social security payments also represent other household's present savings that are not included in disposable income thereby biasing the MPC out of disposable income higher as the proportion of disposable income made up by transfers increases, as it has over the sample period. Thus one expects non-transfer income to have a significantly lower MPC than transfer income.

A final change is the inclusion of a four-quarter moving average of the short term interest rate to reflect incentives to save and the cost of consumer credit: as interest rates rise foregone consumption becomes more attractive and consumer credit tighter, both decreasing consumption.

(1.2.6)
$$\begin{aligned} C = \underset{(0.58)}{1.77276} &+ \underset{(2.98)}{0.14020}*(YD - TR) + \underset{(2.62)}{0.47305}*TR + \underset{(9.50)}{0.78927}*C_{-1} \\ &+ \underset{(4.00)}{44.1008}*\Delta WLTH - \underset{(-1.74)}{0.18347}*(RS + RS_{-1} + RS_{-2} + RS_{-3}) \end{aligned}$$

$R^2 = 0.99931$, SER = 2.3861, F(5/75) = 2.17E+04, DW(0) = 2.13

Disturbing features of these coefficient estimates are the implied values of the long run MPC's out of transfer and non-transfer incomes (about 2.2 and .67, respectively). One might reason that the MPC out of transfers net of social security payments could exceed 1.0 since per capita real receipts of such transfers have been growing faster than per capita real disposable income and transfer recipients should have expectations of constantly growing real funds for consumption, thereby fueling their demand for consumption credit. Such expectations could equally well enhance the ability of transfer recipients to obtain that credit. However, this reasoning does not hold for social security distributions which represent a large part of transfers; they are merely a cashing in on savings made in the past at a known and fixed rate of return that does not grow in real terms. In sum, the value 2.2 is hard to accept. Likewise, a long run MPC out of non-transfers well below .8 seems implausible.

Perhaps the best way to make the results palatable is to look at the long run MPC out of reaggregated disposable income. Noting the percentage comprised of disposable income by transfers in 1956, 1966, and 1976, the reaggregated MPC's can be computed as .73 in 1956, .75 in 1966, and .81 in 1976. These numbers are low but not too far out of line for nonlinear consumption functions (P2, pp. 233-234); since the MPC increases in time, a time-invariant relationship must be nonlinear and eq. (1.2.6) can be thought of as a linearization.

The nonresidential investment relation is virtually identical to the previous version. Once again the equation is estimated in differenced form to include a capital stock effect proxied by the two-quarter moving sum of nonresidential investment. The bulk of the explanation comes from disposable income through a second-degree polynomial distributed lag of fifth-order. The long-term interest rate enters with a substantial lag.

$$\Delta INR = \underset{(-3.61)}{-0.00531}*(INR_{-1} + INR_{-2}) + \underset{(3.92)}{0.08036}*\Delta YD + \underset{(6.06)}{0.06307}*\Delta YD_{-1}$$

$$+ \underset{(4.16)}{0.05266}*\Delta YD_{-2} + \underset{(4.82)}{0.04912}*\Delta YD_{-3} + \underset{(2.88)}{0.05246}*\Delta YD_{-4} \qquad (1.2.7)$$

$$- \underset{(-2.17)}{1.35601}*\Delta RL_{-4}$$

$R^2 = 0.61697$, SER = 0.9602, $F(4/76) = 30.605$, DW(0) = 1.94, $\hat{\rho} = 0.2238$

The residential investment equation differs from the older version in that the housing market is allowed to take on strong internal dynamics which are largely independent of what goes on in other sectors. This is accomplished by modeling residential investment as a second-order autoregressive process - second-order because of the observed oscillatory behavior of housing starts over the estimation period and the relative lack of cycling in its main driver, disposable income. Even the short and long run rates of interest fail to exhibit such systematic oscillations as residential investment. It is interesting to note that this internal pendulum does not alter the flavor of the old relationships with disposable income and the mortgage and credit availability proxies, the short rate and the difference between the long and the short rates of interest. The dummy for the steep drop in housing that occurred between 1966-2 and 1967-4 loses statistical significance and is dropped from the equation.

(1.2.8)

$$
\begin{aligned}
IR = &\underset{(-0.53)}{-0.33033} + \underset{(4.50)}{0.01149}*YD + \underset{(1.98)}{0.47200}*(RL_{-2} - RS_{-2}) \\
&- \underset{(-2.19)}{0.38887}*RS_{-1} + \underset{(12.97)}{1.29240}*IR_{-1} - \underset{(-4.88)}{0.45175}*IR_{-2}
\end{aligned}
$$

R^2 = 0.977, SER = 0.9436, F(5/75) = 637.178, DW(0) = 1.93

Inventory investment is a very volatile quantity; its mean value is about the same as its standard deviation. This volatility is explained by a tight balancing of opposing tendencies: positive income and inertia effects versus negative consumption and stock adjustment mechanisms.

(1.2.9)

$$
\begin{aligned}
IIN = &\underset{(-3.31)}{-4.10794} + \underset{(4.18)}{0.13038}*YD_{-1} + \underset{(4.51)}{0.37372}*\Delta_2 YD - \underset{(-4.44)}{0.56866}*\Delta_2 C \\
&- \underset{(-3.90)}{0.40114}*INV_{-1} + \underset{(4.00)}{0.36996}*IIN_{-2}
\end{aligned}
$$

R^2 = 0.81781, SER = 2.1537, F(5/75) = 67.329, DW(0) = 1.85

This equation differs from the previous version only in that the lag on RHS inventory investment is increased to second-order, introducing a mild cycle to the intertia effect.

The issue of how to go about linearization arises in the short-term interest rate equation. Referring to Appendix A, it is apparent that at least two of the model's equations must be altered. The choice is made to retain a rate of inflation representation for prices and to convert the wage level to a rate of growth of wages relation, thus requiring three equations to be linearized: the price, wage, and unemployment equations.

Consequently, short-term interest rate explanation remains the same as in the old version: the rate increases with income and smoothed inflation (the rate of growth of the demand for money), and decreases with the rate of growth of the money supply, RGM.

$$\begin{aligned} RS = & \underset{(-0.21)}{-0.21727} + \underset{(3.14)}{0.00630}*YD + \underset{(1.48)}{0.01380}*\Delta YD_{-1} - \underset{(-2.58)}{24.50340}*RGM \\ & + \underset{(3.19)}{37.85490}*(RGP_{-1} + RGP_{-2} + RGP_{-3}) \end{aligned} \qquad (1.2.10)$$

$R^2 = 0.3483$, SER = 0.5215, F(4/76) = 10.154, DW(0) = 1.60, $\hat{\rho} = 0.8184$

The long-term interest rate responds with a long lag to the level and the first-difference of the short-term rate (via the Koyck lag).

$$RL = \underset{(1.52)}{0.12535} + \underset{(1.91)}{0.04534}*RS + \underset{(3.04)}{0.13063}*\Delta RS + \underset{(28.86)}{0.94306}*RL_{-1} \qquad (1.2.11)$$

$R^2 = 0.98465$, SER = 0.1564, F(3/77) = 1946.070, DW(0) = 2.10

This differs from the old equation since the second-difference in disposable income has dropped out of the relationship due to statistical insignificance.

The price equation is linearized by changing the rate of growth of disposable income term to a two period difference in that variable. This approximation is appropriate because the level of disposable income changes very slowly relative to its (first or) second difference.

The most prominent feature in the inflation data series is the sharp jump during late 1973 and 1974. This is easily explained from the supply side: steep increases occurred in oil as well as grain and other food prices. However, the demand-side model is largely blind to such shocks, so they are recorded by means of an exogenous dummy variable, DUM, which takes on the value 1.0 over 1973-4 to 1974-4, and 0.0 elsewhere.

The series for excess demand (GNP - GNPP) in the old equation does not hold statistical validity in the new one, nor does the dummy for wage and price controls during 1971-3 to 1972-4, so both are dropped from the equation. Otherwise, the relation is very much unchanged, with inflation positively dependent on the rate of growth of wages, the linearized rate of growth of disposable income, and a moving average of its own past values.

$$\text{(1.2.12)} \quad \begin{aligned} RGP = & \underset{(-0.86)}{-0.00156} + \underset{(1.76)}{0.21818}*RGW + \underset{(2.66)}{0.00011934}*\Delta_2 YD + \underset{(3.45)}{0.00763}*DUM \\ & + \underset{(7.23)}{0.32983}*(RGP_{-1} + RGP_{-2}) \end{aligned}$$

R^2 = 0.74547, SER = 3.30E-03, F(4/76) = 55.647, DW(0) = 1.98

The old wage level equation is converted to a rate of growth of wages relation. Inspecting the old form one would suspect that wage inflation should be fueled by price inflation and the real rate of growth of disposable income and damped by the rate of unemployment. However, estimation rejects the statistical validity of the income term; one might conjecture that a rate of growth of the labor force effect is buried in and counteracts the income relation with wages. The wage and price control dummy variable is also rejected.

$$(1.2.13)\quad RGW = \underset{(5.32)}{0.01677} + \underset{(4.65)}{0.48601}*RGP - \underset{(-2.12)}{0.00116}*UR_{-3}$$

$R^2 = 0.28912$, SER = 5.55E-03, F(2/78) = 15.862, DW(0) = 2.19

The low R^2 indicates how much harder it is to predict rates of growth than levels of such "trendy" variables. In the old level equation, most of the explanation came from the lagged wage level and a large chunk from prices. The rate of growth of wages is its scaled first difference (like the time derivative of the natural logarithm in continuous time), which is a transformation that distills the proportional scaling out of the level and then focuses on the time rate of change of the normalized variable. The explanation of the lagged level is thus eliminated and the order of variations increased by one, leaving finer-grained prediction to prices and unemployment.

The final equation, the rate of unemployment relation, must be linearized by replacing the wage level with the rate of growth of wages. Oddly, the wage inflation term is not statistically significant in this unemployment formulation which argues that a long run rate of 8.35 percent will prevail in the absence of real disposable income growth and/or excess demand.

$$\begin{aligned} UR = {} & \underset{(3.00)}{0.50222} - \underset{(-7.36)}{0.04062}*\Delta YD_{-1} - \underset{(-1.90)}{0.00128}*(GNP_{-1} - GNPP_{-1}) \\ & + \underset{(27.22)}{0.93255}*UR_{-1} \end{aligned} \quad (1.2.14)$$

$R^2 = 0.93986$, SER = 0.3184, F(3/77) = 401.149, DW(0) = 1.73

As is true for all the variables studied, many relationships are implied by the model's causality loop which are not explicit in the individual equations. Here, wages affect prices, feeding the short-term interest rate which, in turn drives the components of GNP and thereby unemployment. There is a philosophical difference between such indirect effects and the direct effects postulated in designing the model, and not finding the direct link from wages to unemployment is cause for concern over the theoretical justification for the wage and unemployment equations. However, it seems plausible that the rate of wage inflation is highly correlated with excess demand and with changes in disposable income through prices, and that the lag between changes in wages and unemployment is very long, so that the direct relationship between wages and unemployment is obscured in this regression.

1.3 The RSB-MODEL: Block Structure Analysis

The intent in the experiments is for the monetary authority to control the short-term interest rate, RS, and the fiscal authority, government spending, G, as in Fair's study (F1). However, RS is endogenous to Pindyck's model so a lower-order model needs to be defined. The money supply is dropped and the short-term interest is made exogenous (exogenous RS is called "RSB").

To differentiate between the models in future discussion, Pindyck's model is called the M-MODEL and the lower-order version, the RSB-MODEL. Figure 1.2 can be compared with Figure 1.1 to clarify the structural change.

In distinction to the M-MODEL, the RSB-MODEL embodies the assumption that the real economy is independent of the nominal economy since the feedback is removed from inflation to interest rates. Consequently, causality runs only downward in the diagram. As before, a change in RSB reapportions the real economic flows and sets a new level of inventories. However, as GNP adjusts and the rates of unemployment, inflation and wage growth respond, no additional shift occurs in RSB so that the process halts.

The RSB-MODEL's dynamic structure is presented in Figure 1.3, which is evidently Figure 1.2 with all the estimated relations plugged in. Three blocks of variables are grouped together on the basis of the unidirectional flow of causality between them: interest rate, real and nominal blocks.

The links between the blocks manage information flow throughout the system. Flow from the interest rate block to the real block begins slowly and builds up over several periods. Consumers are the first to acknow-

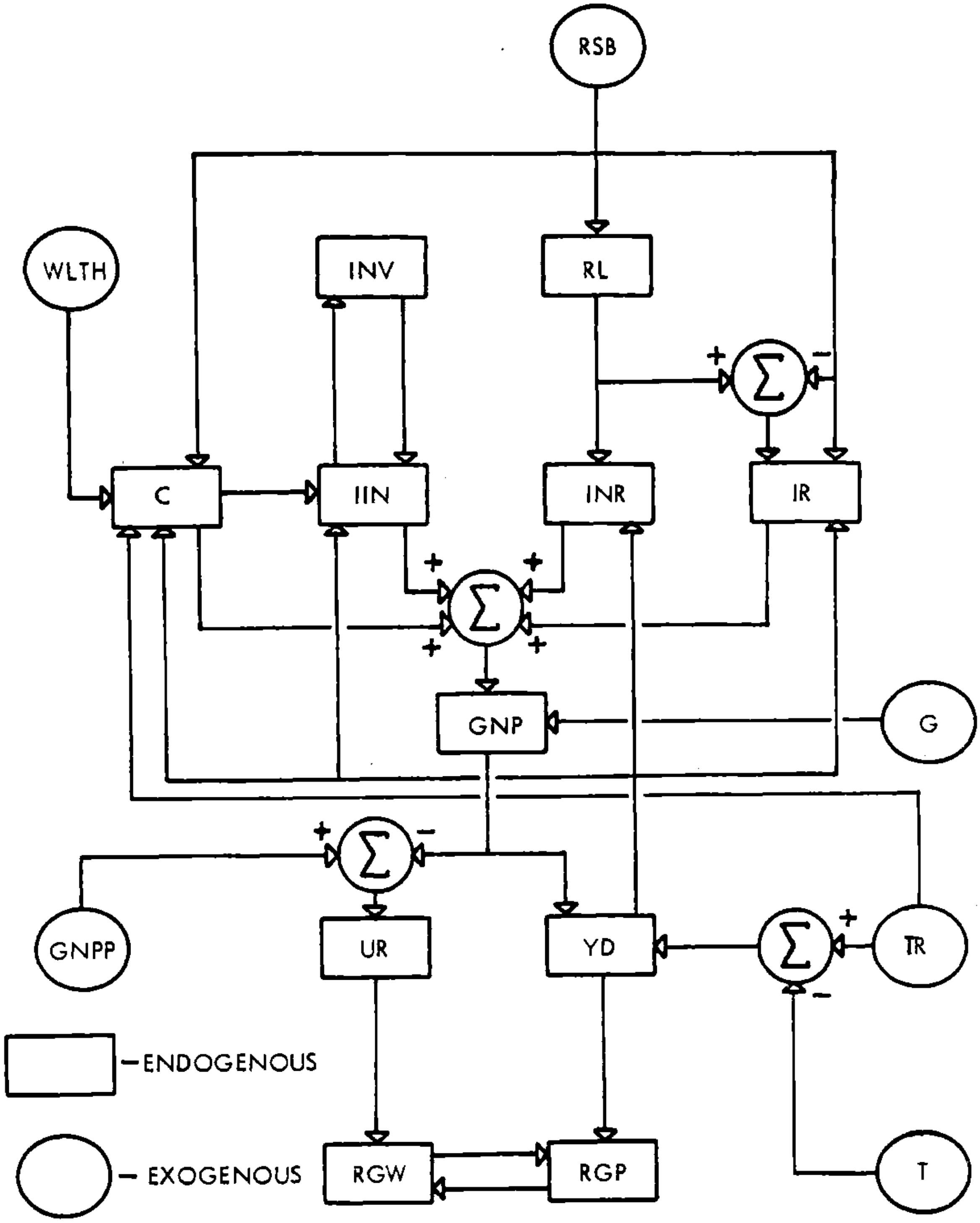


FIGURE 1.2 Static Block Diagram of Control Model (RSB-MODEL)

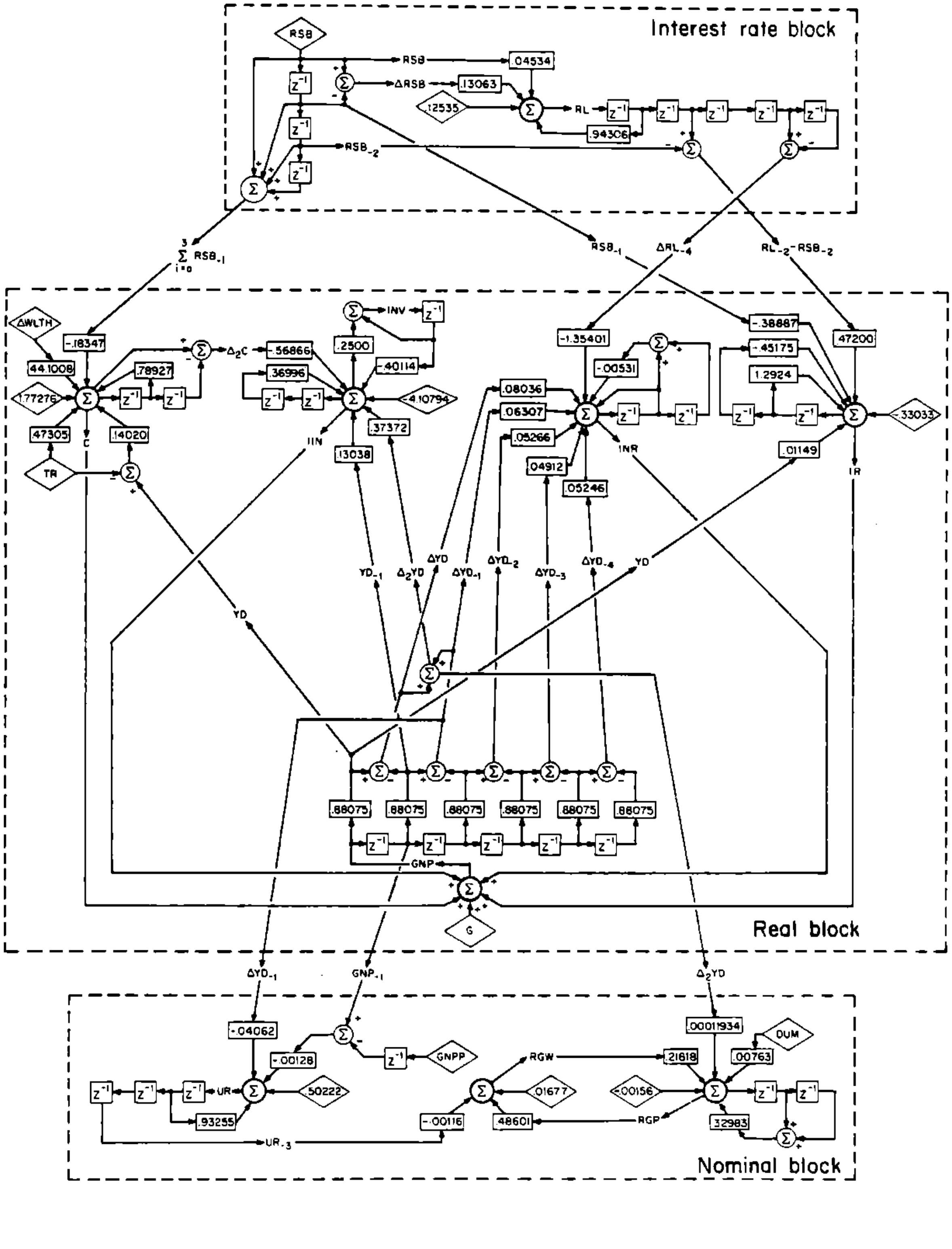


FIGURE 1.3 Dynamic Block Diagram of RSB-MODEL

ledge action in interest rates through their perception of the cost of credit: $\sum_{i=0}^{3} RSB_{-i}$. Mortgage rates and the availability of credit adjust with one- and two-period lags through RSB_{-1} and $(RL_{-2} - RSB_{-2})$. Finally long-term credit moves with ΔRL_{-4}.

Flow from the real to the nominal block is more impulsive. A growth in demand immediately bids up prices through $\Delta_2 YD$. In the following quarter the call for increased employment reaches its full urgency through ΔYD_{-1} and GNP_{-1}.

Variables within the blocks exhibit characteristic modes of dynamic response which are parameterized by system eigenvalues. An eigenvalue-eigenvector analysis of the RSB-MODEL is presented with mathematical motivation in Appendix D, from which pertinent findings are drawn for this discussion of the block structure.

Table 1.2 lists the eigenvalues associated with each block. In the interest rate block, it is easy to see where the sluggish .94306 eigenvalue comes from: RL_{-1} feeds back to RL with a gain of .94306. Consequently, monetary policy has quite a slow impact on the long-term rate of interest and thereby on INR via the ΔRL_{-4} linkage. For the same reason, a drop in RSB will not be largely cancelled by a consequent drop in RL in the $(RL_{-2} - RSB_{-2})$ linkage to IR; that is, credit availability is enhanced by a drop in the short rate.

The particular sources of the real block eigenvalues are not as obvious. However, the slowest mode: $.9715 \pm .0333j$ probably derives from stabilizing feedback from GNP to INR. An increase in nonresidential investment draws down inventories (negative IIN) so that GNP increases

TABLE 1.2: RSB-MODEL: Characteristic Dynamic Behavior of Each Block

Interest Rate	.94306
Real	.9715 ± .0333j
	.8908
	.6614 ± .1862j
	.5588 ± .2185j
	-.0151 ± .5788j
	-.4485 ± .1863j
Nominal	.93255
	.81928
	-.45033

less than INR. A similar mechanism could reasonably damp C in setting up the .5588 ± .2185j oscillatory mode and the single first-order mode: .8908. Since the feedback from GNP to IR is so small, IR's dynamic response is determined by its internal feedbacks almost exclusively, yielding the .6614 ± .1862j eigenvalue. Finally, the two slowest modes must derive from the high degree of coupling between IIN, INV and the other variables.

It is easy to see where the nominal block modes come from. The most sluggish eigenvalue: .93255 is precisely the feedback from UR_{-1} to UR; the unemployment sector adjusts slowly. The faster .81928 and oscillating -.45033 modes derive from a combination of the RGW and RGP equations; their main motivation lies in the formation of inflationary expectations: $(RGP_{-1} + RGP_{-2})$. When a trend in RGP reverses, it sets up a highly damped oscillation in expectations; when no reversal occurs, the trend is expected to die out more slowly.

It is clear that the monetary policy-makers face more delay in impacting GNP than the fiscal policy-makers as RSB must pass through the interest rate-to-real block linkages.

1.4 Simulations and Forecasts

Simulations and forecasts of past or future economic behavior obtained by providing the model with sets of initial conditions for the endogenous variables and trajectories for the exogenous variables, and stepping it through a specific period of time to generate paths for the endogenous variables. Simulations indicate how well the model can reproduce historical behavior and forecasts yield its future predictions.

A specific terminology characterizes simulations and forecasts on the basis of the time period they cover. *Ex post* simulations are run to coincide with portions of the historical data series used in estimation, *ex post* forecasts coincide with portions of the data not used, and *ex ante* forecasts begin at the end of the historical data series.

In this section an *ex post* simulation is presented for both the M- and the RSB-MODELs. The discussion focuses on understanding several of the RSB-MODEL's weaknesses rather than its virtues since the shortcomings provide more insight. The M-MODEL simulations are included because comparison is revealing. In the best case, the two models' performances should differ only in that the M-MODEL simulations should be relatively smoothed due to its endogenous RS equation (the RSB-MODEL employs exogenous RSB data).

Two shorter *ex post* simulations and an *ex post* forecast are relegated to Appendix E since they add little to what is apparent in the longer simulation:

1) Short "Control Period" Simulation: 1968-4 to 1973-4;

2) Short "Volatile" Simulation: 1972-1 to 1976-1;

3) Forecast: 1976-1 to 1977-4.

Long Simulation

Table 1.3 compares the RMS and RMS% errors for the M- and RSB-MODELs over the long simulation. The lower-order model does not generally perform better according to these measures. RL is predicted more accurately as it is driven by RS alone, but of the remaining endogenous variables, only IR compares favorably.

TABLE 1.3: Results of Long Ex Post Simulation

	1956-1 to 1976-1		1956-1 to 1976-1	
	M-MODEL		RSB-MODEL	
Variable	RMS error	RMS % error	RMS error	RMS % error
C	9.43	2.03	9.82	2.63
INR	5.18	7.52	5.82	10.23
IR	3.97	14.44	2.94	10.03
IIN	3.89	245.5	3.83	246.8
INV	3.28	1.90	4.74	3.25
RS	0.99	29.71	NA	NA
RL	0.43	9.07	0.24	5.06
RGP	4.3E-3	158.42	5.2E-3	197.07
RGW	5.7E-3	123.84	6.1E-3	128.88
UR	0.77	13.09	0.85	15.26
GNP	17.81	2.52	18.08	3.10

Turning to the graphs in Figures 1.4 and 1.5, the expected relationship between the M- and RSB-MODEL simulations is revealed. Particularly noticeable in the investment trajectories is the mechanism of RS in the smoothing process. When RS and thereby RL are markedly understated over 1969-1 to 1970-4, overstated from 1971-3 to 1973-1 and understated again over 1973-2 to 1974-3, INR and IR follow the opposite pattern due to their inverse relationship with respectively characteristic longer and shorter lags. Since the RSB-MODEL employs the historical short-term interest rate, this pattern does not appear in its simulation.

On the other hand, the exaggeration of GNP over 1960-1 to 1965-4 in the RSB-MODEL is a deviation from the pattern. This signals the near instability in the real flow block of the model. The instigator seems to be INR which is the first to systematically overstate, beginning about 1958-1. The consequent bloating of GNP, and thereby YD, feeds into the other flows, (C, IR and IIN) and further exacerbates the problem. The M-MODEL performs better on this score because RS is overstated enough in being smoothed to depress IR, counteracting INR's tendency to bloat YD.

Another deviation and source of error lies in the RL equation. Even when the historical RS data is employed, (in the M-MODEL simulation), RL tracks about one-third point too high over 1962-1 to 1967-2. This pushes IR above the historical, further bloating GNP.

A final anomaly gives perhaps the most insight into the RSB-MODEL's weaknesses: why is the mini-recession of 1970 rendered more violently by both models than the recession of 1974-1975? Two factors are key to understanding the 1974-1975 recession which are not adequately modeled

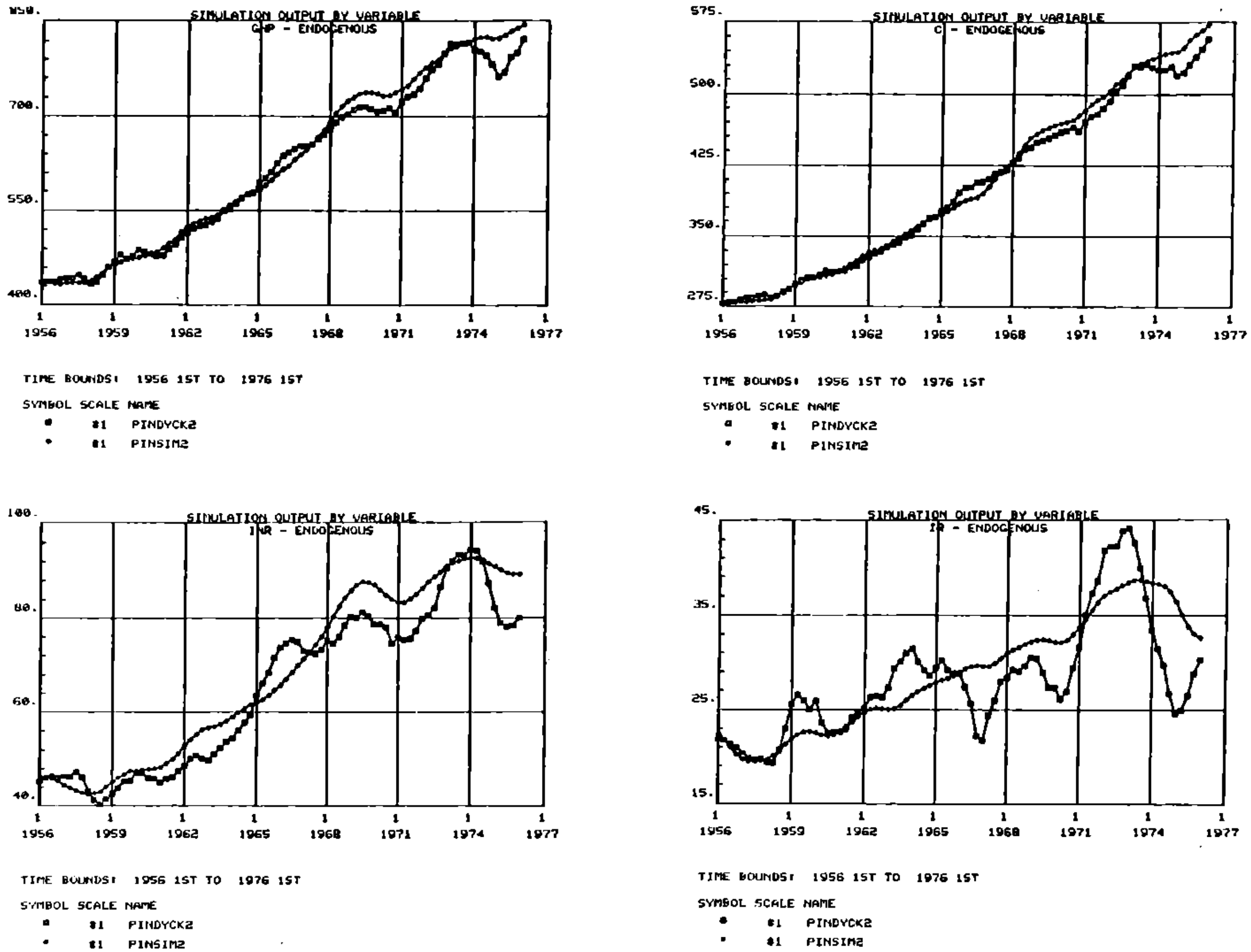
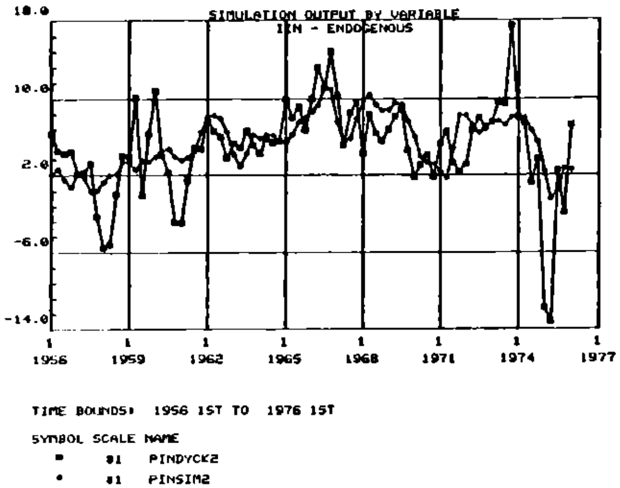
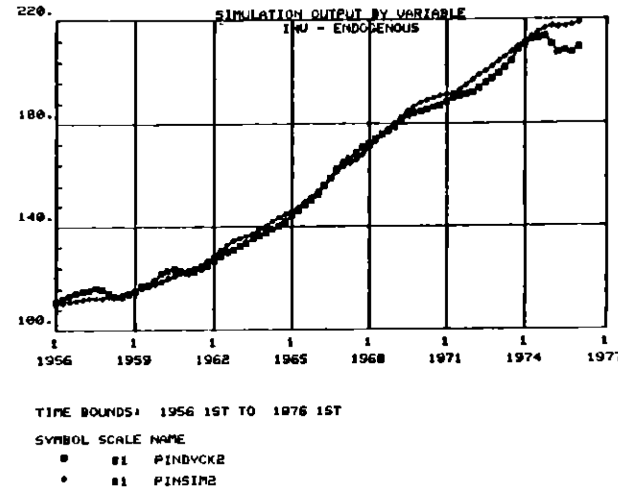
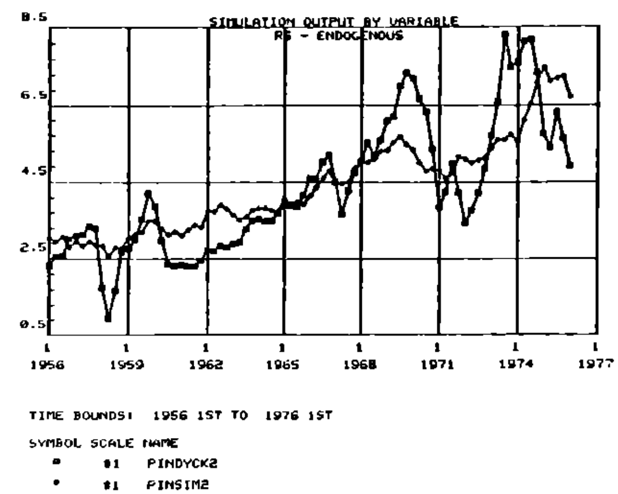


FIGURE 1.4.a Results of Long Ex Post Simulation - M-MODEL







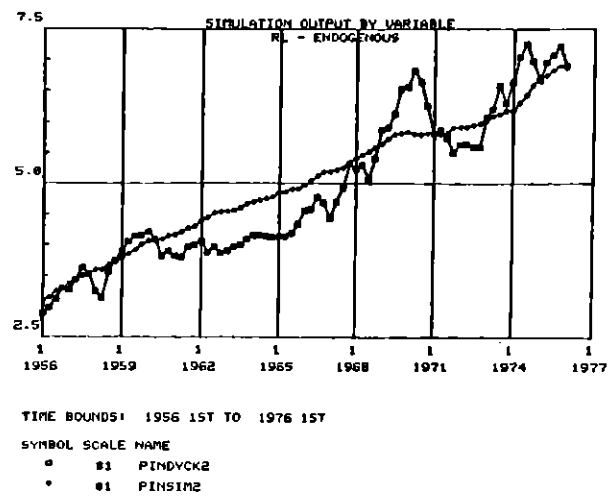
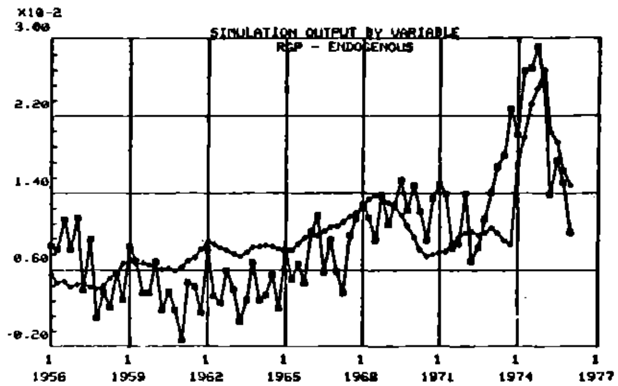
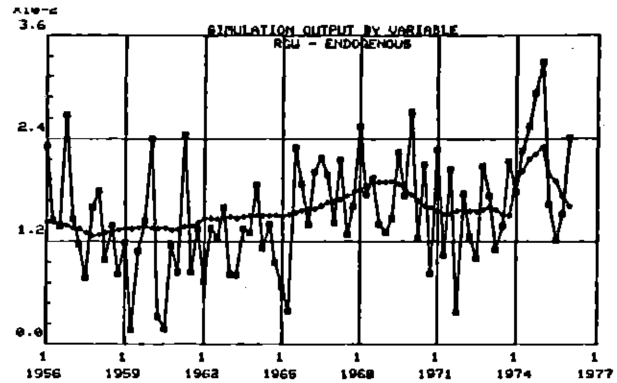


FIGURE 1.4.b Results of Long Ex Post Simulation - M-MODEL



TIME BOUNDS: 1956 1ST TO 1976 1ST

SYMBOL SCALE NAME
■ #1 PINDYCK2
• #1 PINSIM2



TIME BOUNDS: 1956 1ST TO 1976 1ST

SYMBOL SCALE NAME
■ #1 PINDYCK2
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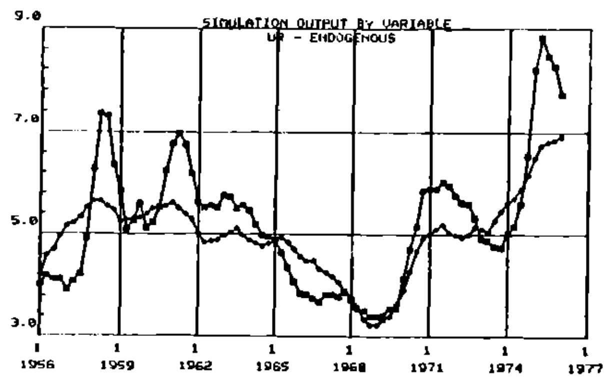


TIME BOUNDS: 1956 1ST TO 1976 1ST

SYMBOL SCALE NAME
■ #1 PINDYCK2
• #1 PINSIM2

FIGURE 1.4.c Results of Long Ex Post Simulation - M-MODEL

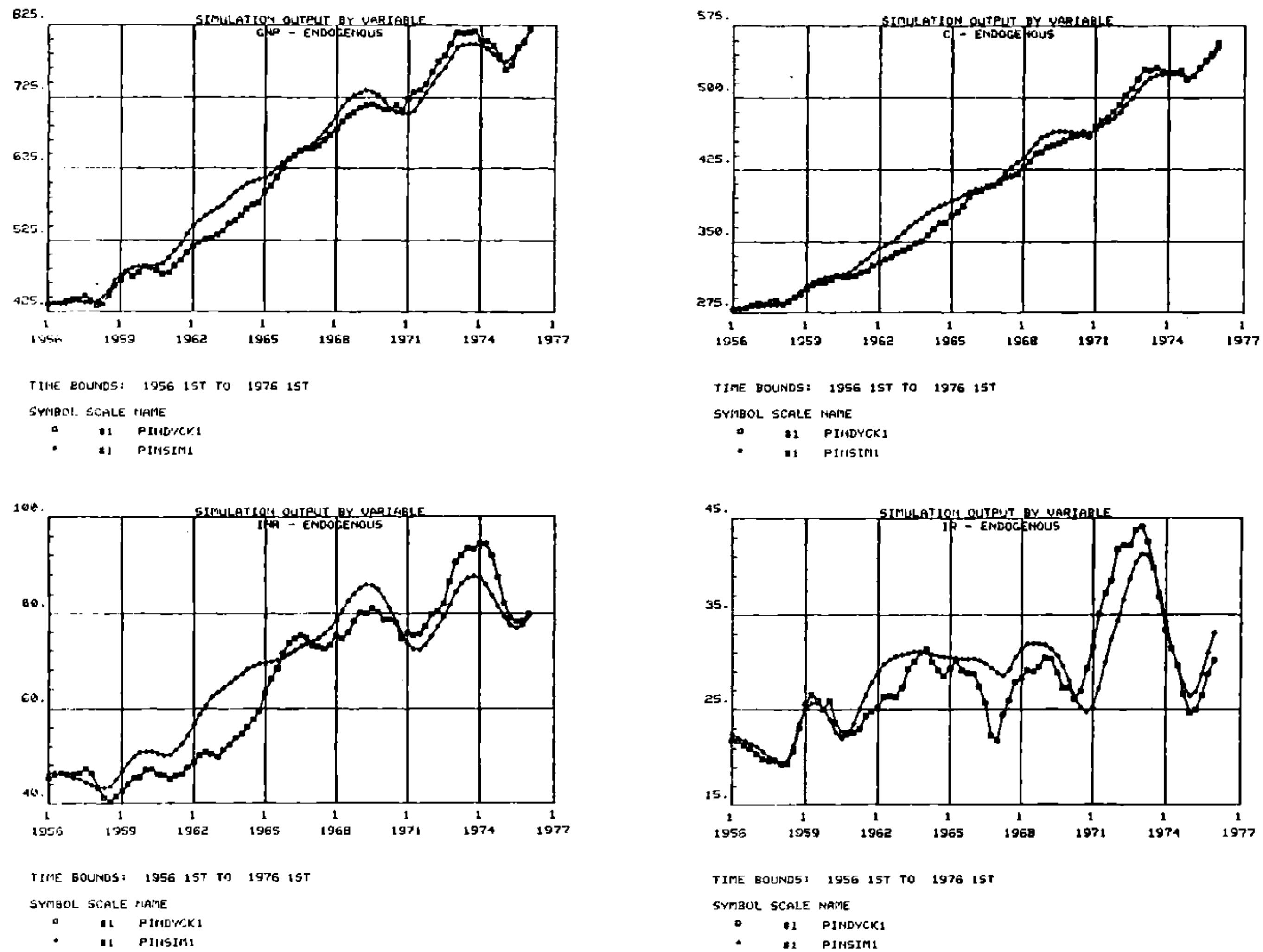


FIGURE 1.5.a Results of Long Ex Post Simulation - RSB-MODEL

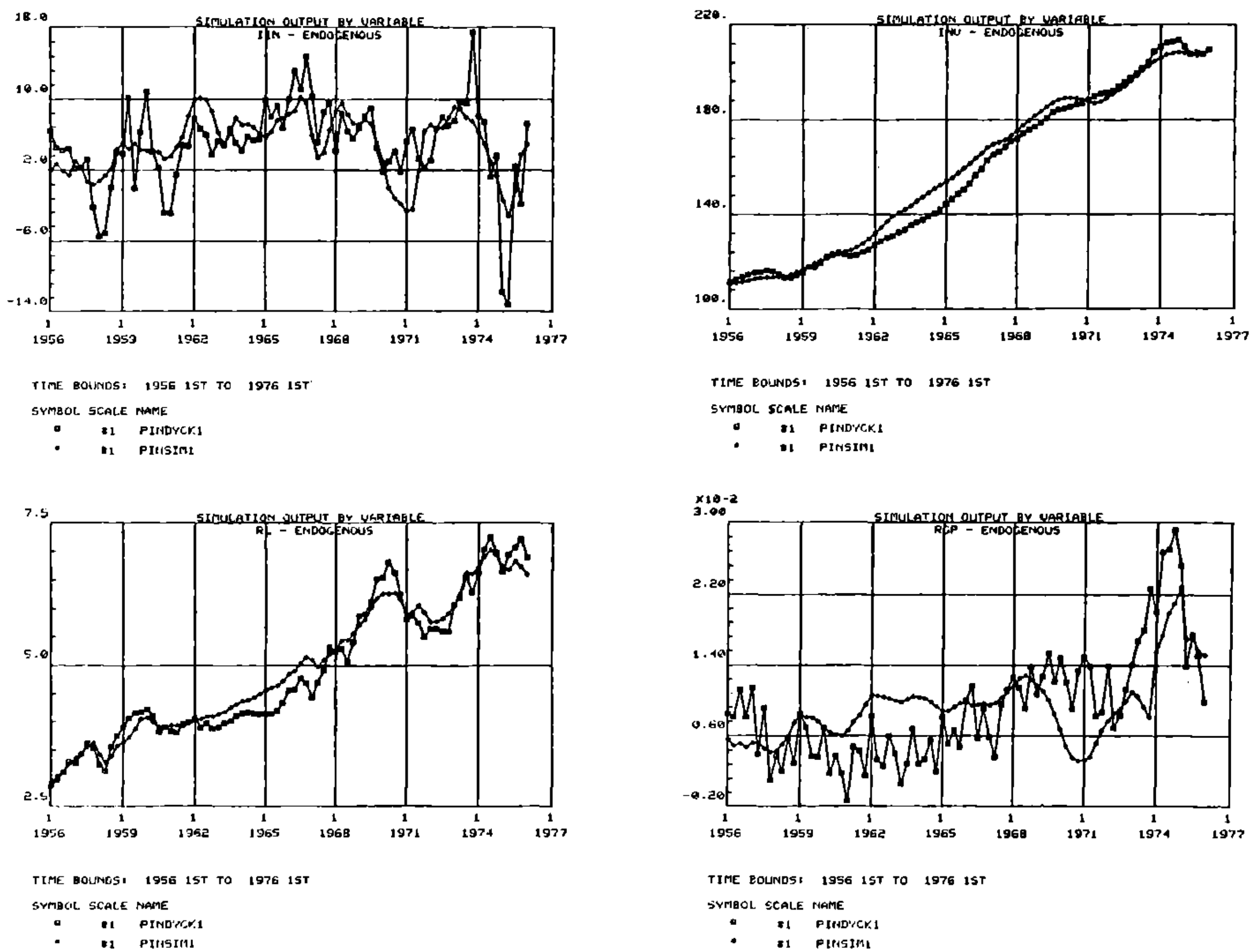
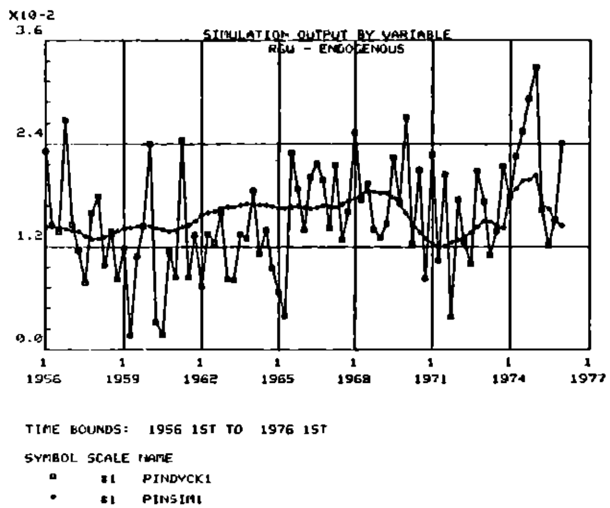


FIGURE 1.5.b Results of Long Ex Post Simulation - RSB-MODEL



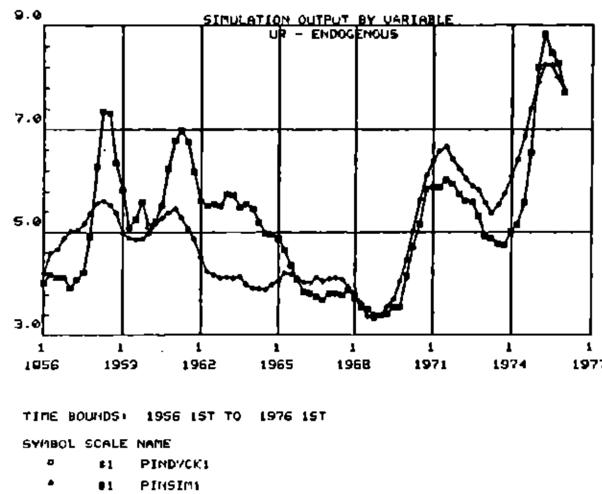


FIGURE 1.5.c Results of Long Ex Post Simulation - RSB-MODEL

and which were not important in the mini-recession: the price hikes of 1974 and the government deficit of 1975. The effect on money of the oil and food price hikes is acknowledged in the model through the RGP equation when RS is endogenous and through RSB when it is exogenous; however, this supply shock probably had a more fundamental effect on production possibilities than is indicated merely by the cost of funds. Since government expenditure held a steady path throughout the recession, and the proportional tax mechanism indicated a drop in taxes of less than 8 billion dollars based on the 60 billion dollar plunge in GNP, the model had no inkling of the record government deficit in 1975.

The consequence is plain. Since the estimation process tries hardest to fit the most volatile data in the last few years, and not enough impetus exists in the exogenous variables to adequately explain the variation, the leverages of G and RS are exaggerated. Since the behavior of the 1960s is, however, quite steady, this overstated leverage is counterbalanced by an exaggerated stiffness or sluggishness in the model. A compromise between these effects is made which leads to near-instability and an overly-violent rendition of the 1970 mini-recession.

These results coincide with what one would expect, given the RSB-MODEL's characteristic modes. The nearly unstable $.9715 \pm .0333j$ eigenvalue in the real block has been associated with INR, rendering quite predictable INR's systematic exaggeration. Moreover, since this and other modes in the real block are so sluggish, the tendency is not surprising for errors to introduce long-lasting bias into the real block and the dependent nominal block variables. RL's intolerance to error follows directly from its .94306 eigenvalue.

1.5 Dynamic Multipliers

The dynamic multiplier generated by an exogenous in an endogenous variable is the difference in paths of the endogenous variable when two simulations are run which are identical except for a given change in the data series of the exogenous variable. The four multipliers presented deal with the effect of monetary and fiscal instruments on the level of GNP. For the M-MODEL, the fiscal multiplier is generated by a once-and-for-all $1 billion increase in G, the monetary is generated by a once-and-for-all $1 billion increase in M. Since G enters the model as a level, its multiplier corresponds to a step response in engineering terminology. M, on the other hand, enters the RS equation as a rate-of-growth so that its multiplier is almost equivalent to an impulse response; the difference is that while M is increased by $1 billion for only one quarter, $\Delta M/M$ is biased slightly higher from that time on, relative to $\Delta M/M$ in the unaltered M series (this discrepancy is ignored for the purpose of the discussion).

The M-MODEL multipliers are graphed in Figure 1.6. The dynamic responses are of the expected shape: the step response climbs rapidly, overshoots and descends slowly towards a steady-state value. The impulse response is the first-difference of the step response: it climbs as the step response builds up speed, declines as it slows and crosses zero as it reaches its peak, going negative during its descent to steady-state.

However, the responses are exaggerated in time and magnitude. One

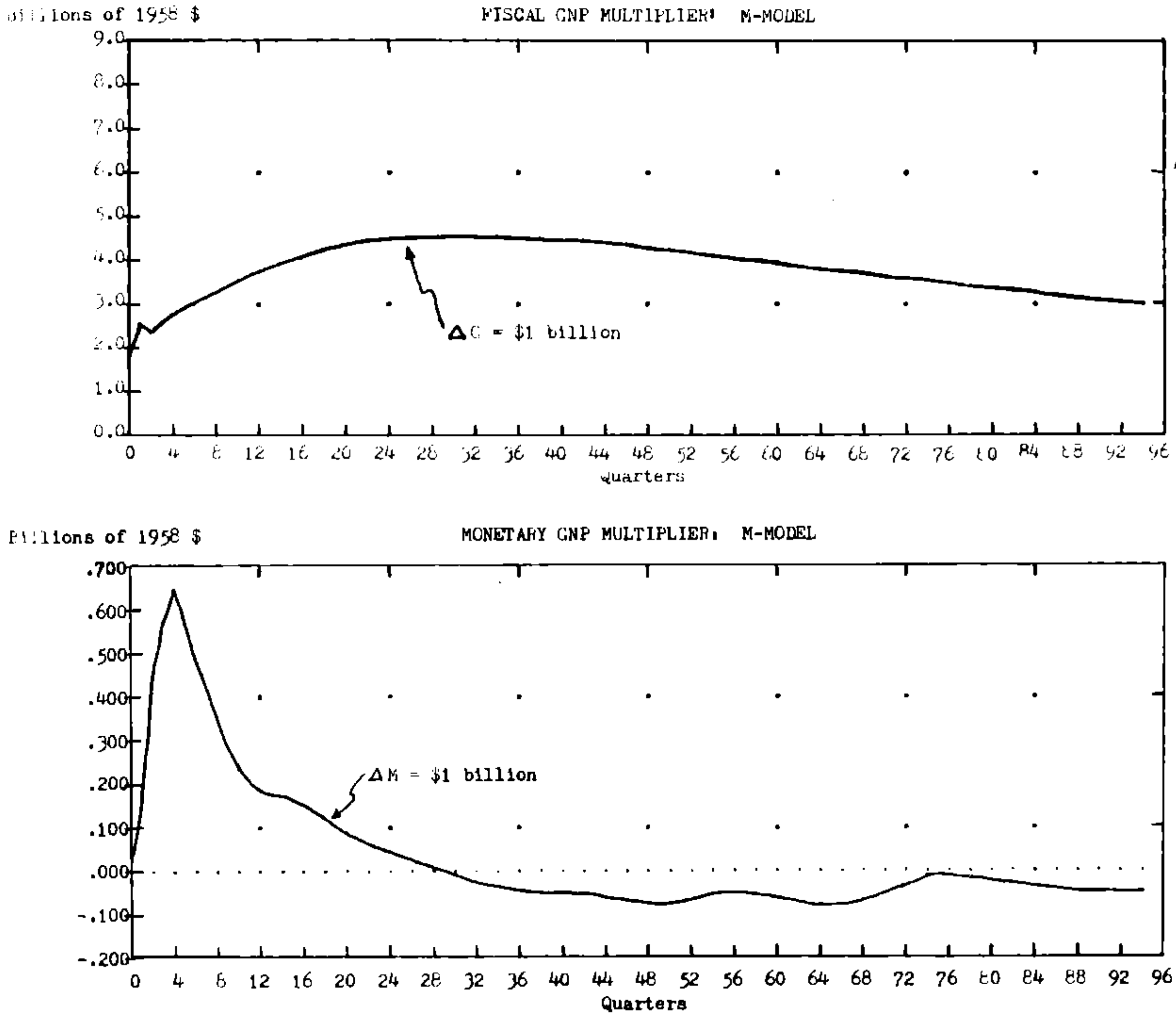


FIGURE 1.6 Fiscal and Monetary GNP Multipliers: M-MODEL

would like the model to exhibit steady-state response much sooner: within 16 or 20 quarters. The overshoot should be small. It is generally expected that impact and long-run multipliers for G should be on the order of 1.5 and 2.5, respectively, a bit lower than here. Consequently, these multipliers reinforce the argument that the model is too sluggish and exaggerates the leverage of its inputs.

An identical fiscal multiplier is calculated for the RSB-MODEL; its monetary multiplier is generated by a once-and-for-all increase of 1% in RSB (a step response). Figure 1.7 presents graphs of these results. The G multiplier is more exaggerated in the RSB-MODEL because the positive feedback of YD to RS no longer actively restrains growth in GNP. Consequently, the steady-state multiplier is higher. However, the shape and timing of the response are very similar. The RSB multiplier follows the same pattern, reflected into the negative quadrant. The magnitudes of the G and RSB multipliers can be compared by noting that a $1 billion increase in G represents about a .7% change while a 1% increase in RSB represents a 22% change. Thus, the magnitude of the peak overshoot in the G multiplier is around four times that in the RSB multiplier.

The characteristics of these four multipliers are not surprising when related to the eigenvalues. It is obvious that beyond about 16 quarters, the four slowest eigenvalues: RL's .94306, UR's .93255 and the real block's .9715 $\pm$ .0333j and .8908 can be the only significant contributors in the two M-MODEL multipliers; only the real block eigenvalues in the RSB-MODEL fiscal multiplier and additionally RL's .94306 in its monetary multiplier. That there is any activity in the multipliers

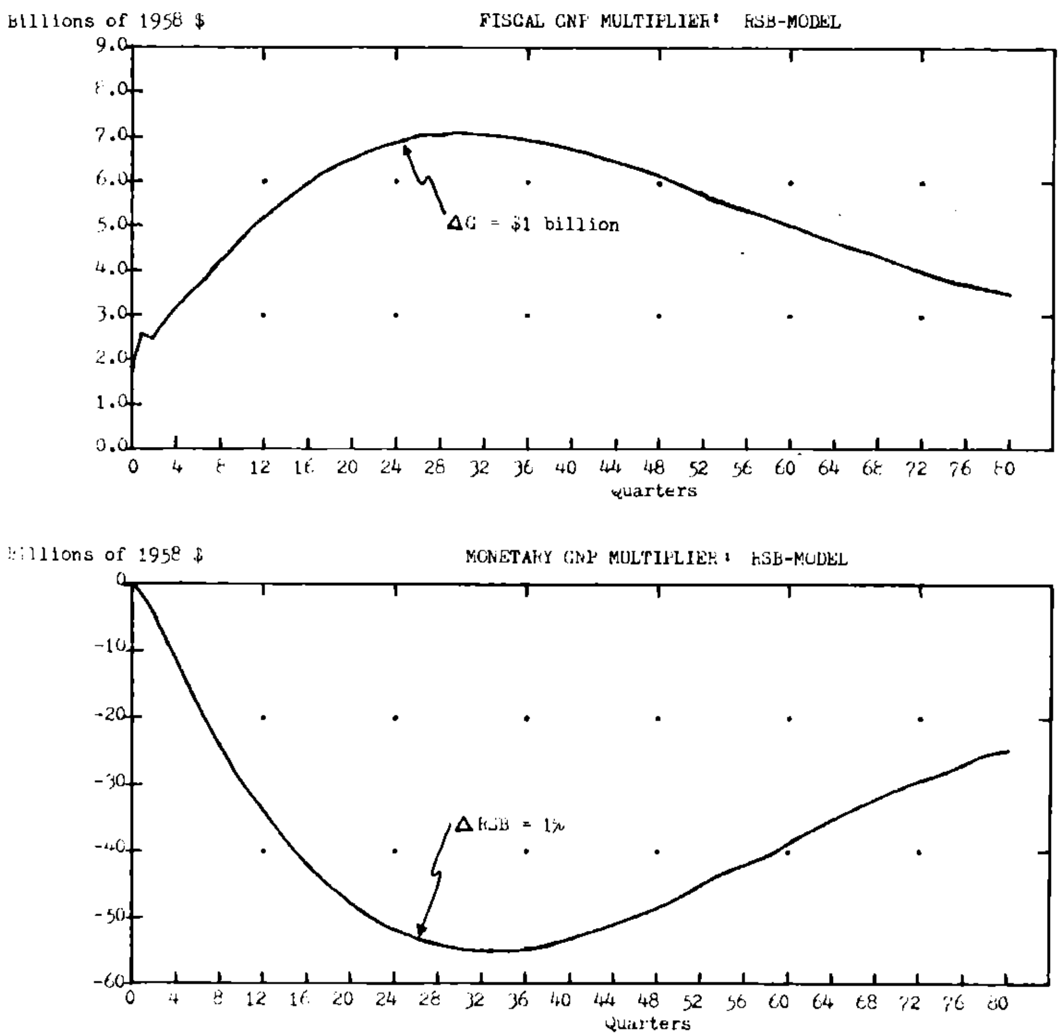


FIGURE 1.7 Fiscal and Monetary GNP Multipliers: RSB-MODEL

beyond 64 quarters shows that $.9715 \pm .0333j$ plays an important role.

The presentation of the model and analysis of its dynamic properties ends here. One must agree with Pindyck and Rubinfeld that one "probably would not want to rely on this model as a serious tool for macroeconomic forecasting" (P2, p. 386). However, Pindyck's model "acts like a real economy," is simple and easily manipulated, and should therefore serve its purpose quite well in this methodological study.

CHAPTER 2

THE EXPERIMENTS

2.1 Decentralized Interaction Assumptions

This study adopts the concept of mathematical optimality to guide the policymakers in choosing their stabilization strategies. Optimality means that the authorities design strategies to minimize functions representing costs to deviating from their targets given the constraints of an econometric model and assumptions governing interaction. In the context of the linear RSB-MODEL and the quadratic cost functions selected, optimality defines a unique pair of fiscal and monetary strategies associated with each of the proposed interactions over the 20 quarter control period. Except for the interaction assumptions, the experiments are identical; hence differences in the experimental outcomes result unquestionably from the changing framework for interaction:

A. Centralized: one decisionmaker designs both fiscal and monetary policies;

B. One-sided Exogenous: either authority is restricted to a fixed, exogenous strategy while the other chooses optimally;

C. One-sided Endogenous "Reaction": either authority is restricted to an empirically based "reaction" function (essentially a feedback control relation) while the other chooses optimally;

D. Two-sided Endogenous "Reaction": both authorities follow their "reaction" functions;

E) Open- and F) Closed-loop Nash Competition: the authorities simultaneously choose optimal policies;

G) Nash Bargaining: coordinated optimal strategies are chosen based on previously negotiated agreement.

The various interactions imply quite different interpretations of optimality. The centralized solution is a strategy which best achieves the objectives of the joint authority: this is an "over-all" optimality.

A competitive Nash solution expresses an equilibrium in which each authority does the best it can, given the other's strategy: a simultaneous "one-sided" optimality (N2).

Likewise, the one-sided exogenous and endogenous "reaction" solutions are optimal in a "one-sided" sense: from the point of view of the optimizing authority given the constraint imposed by the other's not necessarily optimal behavior.

Nash bargaining embodies yet another type of optimality. The two authorities negotiate a best bargain such that movement toward it from any nearby feasible bargain increases one authority's gain proportionately more than decreases the other's (where the gains are relative to a threatened stance); at the best bargain, one authority's proportionate gain to moving away exactly equals the other's proportionate loss. The solution strategy is "compromise" optimal in relation to the bargain which is secured (N1).

No concept of optimality is involved in the two-sided "reaction" experiment.

The differing interpretations of optimality relate the experiments to some of the questions posed in the Introduction. It is assumed that "society's aggregate stabilization desires" are expressed in the centralized cost function. Consequently, the "over-all" optimal stabilization policy is a benchmark: "the best society can hope for."

For the games, society's desires are divided between the monetary and fiscal cost functions to provoke extreme consequences to the balance of power. The fiscal and monetary authorities are assumed to harbor diametrically opposed objectives: the fiscal policymakers single-mindedly promote a low rate of unemployment by means of target-deviations in government expenditure while the Federal Reserve Board of Governors deals out short-term interest rate target-deviations with the sole aim of nurturing a low rate of inflation.

The simultaneous "one-sided" optimality of the Nash competitive games leads to a strategy tug-of-war which highlights the potential for counterproductive stabilization efforts when "power is being balanced." These experiments show which authority is more powerful and why it has an advantage.

Nash bargaining yields sizable gains to cooperation: when opposing teams in a tug-of-war recognize beforehand which will win, they can achieve a better ultimate result (less exertion) if the winner pulls and the loser "pushes!" Comparison with the tug-of-war indicates the extent and character of counterproductivity in Nash competition as well as the distinguishing features of cooperation. The relation of bargaining to the centralized "benchmark" suggests how the division of power biases stabilization in the "best case" of cooperation.

The endogenous "reaction" functions attempt to capture the relationship between stabilization objectives and instruments which characterized each authority's historical strategy-formation. In the two-sided "reaction" experiment these functions evaluate what the authorities would have done had they faced the economic scenario embodied in these experiments (which obviously only approximates what was really going on). Assuming that the shortcomings of the model and the "reaction" functions can be distilled, the one-sided "reaction" experiments show how either authority might have improved its historical strategy-formation.

The one-sided exogenous experiments show the extent to which either authority puts itself at a competitive disadvantage by holding to a fixed (announced) strategy. Fixed fiscal policies are virtually the rule given the long lag between recognizing the need to alter government spending and actually implementing a change in policy. The monetary lag is usually taken to substantially shorter. However, a fixed bond rate policy might arise if the monetary decisionmakers were to attempt to stabilize one sector of the economy, for instance the construction sector.

In Nash competition a distinction is made between open- and closed-loop games. Open- and closed-loop have quite different meanings in the decentralized than in the centralized context. To avoid confusion, an open-loop centralized strategy will be called "a strategy represented as a sequence of values," and a closed-loop centralized strategy, "a strategy represented as a feedback control law."

In the decentralized setting, playing open-loop means assuming the opponent's strategy is represented as a sequence of values, and closed-loop, as a feedback control law: assumptions about the other player's choice of representation (C.1, Ch.2). The players always know about their opponent's strategy due to the postulate of perfect knowledge.

It is apparent that four possibilities exist for the Nash competition:

1) Each player assumes the other chooses a sequence of values representation;

2) Each assumes the other chooses a feedback representation;

3,4) One assumes the other chooses values and the other assumes a feedback representation.

Only 1) and 2) are considered in this study and for notational convenience 1) is simply called "open-loop" and 2) "closed-loop."

It can be deduced that an opponent's strategy representation is important by observing that a pair of optimal open-loop sequences needs no longer comprise an equilibrium when expressed in feedback form in the closed-loop game. If a player attempts to reproduce his open-loop sequence by representing it as a feedback control law, the other player can almost surely benefit by deviating from his open-loop sequence because his deviation forces the "open-loop" player's law to produce non-optimal values.

The open- vs. closed-loop distinction relates to plausible behavioral assumptions. The lag in federal government policy-formation makes a feedback control law representation of fiscal policy unrealistic.

However, the Federal Reserve Board of Governors forms policy on a weekly basis so feedback control is more the rule in monetary policy. Consequently, the fiscal authority should enjoy a potential for "manipulation" advantage in playing closed-loop while the monetary authority should not.

The concept of threat is essential to Nash bargaining. Each player threatens with a strategy which puts the other in the worst possible position taking full account of any countermeasures he may employ. Seen from the opposite side of the coin, each player tries to optimize his position in the event that the other chooses a maximally injuring strategy. Thus, the threat to which both players agree is the simultaneous "one-sided" optimal equilibrium of Nash competition.

The issue remains what combination of open- or closed-loop competition leads to the most relevant threat. It is postulated that of the two considered here, the authorities will choose the equilibrium from which neither has an incentive to deviate; that is, if both do better in one of the two games, that game will be the threat.

2.2 Optimization Problem Statements and Solutions

The fiscal and monetary policy-makers are presented a single model with an initial condition which specifies how their separate policy instruments affect the future course of the U.S. economy:

$$x_{t+1} = Ax_t + B_1u_{1t} + B_2u_{2t} + Cz_t \tag{2.2.1}$$

$$x_t\big|_{t=0} = x_0 \tag{2.2.2}$$

where x_t is a vector of n state variables, u_{1t} and u_{2t} are vectors of r_1

and r_2 control variables determined by the fiscal and monetary authorities, respectively, and z_t is a vector of s uncontrollable exogenous variables whose time-paths are known. Thus, A, B_1, B_2 and C are nxn, nxr_1, nxr_2 and nxs matrices, respectively. (These definitions correspond to those in Appendix C except that u_{t+1} and z_{t+1} have been relabeled u_t and z_t, respectively, and B and u_t have been partitioned conformally to separate the fiscal and monetary instruments: $Bu_t \triangleq B_1u_{1t} + B_2u_{2t}$.)

The policy-makers are asked to choose strategies for their own control variables over t=0,...,N-1 subject to interaction assumptions in order to minimize given objective functions. In all except the centralized case, each authority has its own quadratic objective function:

$$J_1 = 1/2(x_N - \hat{x}_{1N})^T Q_1 (x_N - \hat{x}_{1N}) + 1/2 \sum_{t=0}^{N-1} \Big\{ (x_t - \hat{x}_{1t})^T Q_1 (x_t - \hat{x}_{1t}) + (u_{1t} - \hat{u}_{1t})^T R_{11} (u_{1t} - \hat{u}_{1t}) + (u_{2t} - \hat{u}_{2t})^T R_{12} (u_{2t} - \hat{u}_{2t}) \Big\} \tag{2.2.3a}$$

$$J_2 = 1/2(x_N - \hat{x}_{2N})^T Q_2 (x_N - \hat{x}_{2N}) + 1/2 \sum_{t=0}^{N-1} \Big\{ (x_t - \hat{x}_{2t})^T Q_2 (x_t - \hat{x}_{2t}) + (u_{1t} - \hat{u}_{1t})^T R_{21} (u_{1t} - \hat{u}_{1t}) + (u_{2t} - \hat{u}_{2t})^T R_{22} (u_{2t} - \hat{u}_{2t}) \Big\} \tag{2.2.3b}$$

where $\hat{x}_{1t}$, $\hat{x}_{2t}$, $\hat{u}_{1t}$ and $\hat{u}_{2t}$ are fixed target values for the states and controls, respectively, over t=0,1,...,N-1 and Q_1, Q_2, R_{11}, R_{12}, R_{21} and R_{22} are given, appropriately dimensioned weighting matrices. Q_1, Q_2, R_{12} and R_{21} are positive semidefinite and R_{11} and R_{22} are positive definite.

A. The Centralized Assumption

According to the centralized assumption, the authorities join forces in minimizing a common objective function:

$$J = 1/2(x_N - \hat{x}_N)^T Q(x_N - \hat{x}_N) + 1/2 \sum_{t=0}^{N-1} \Big\{ (x_t - \hat{x}_t)^T Q(x_t - \hat{x}_t) \tag{2.2.4}$$
$$+ (u_{1t} - \hat{u}_{1t})^T R_{11}(u_{1t} - \hat{u}_{1t}) + (u_{2t} - \hat{u}_{2t})^T R_{22}(u_{2t} - \hat{u}_{2t}) \Big\}$$

Since they cooperate, it is convenient to reaggregate the control vector:

(2.2.5) $u_t^T = (u_{1t} \; \vdots \; u_{2t})^T$

and its associated matrices:

$$B = (B_1 \; \vdots \; B_2) \tag{2.2.6}$$
$$R = \begin{bmatrix} R_{11} & \vdots & 0 \\ \cdots & \cdot & \cdots \\ 0 & \vdots & R_{22} \end{bmatrix}$$

so that the model is rewritten:

(2.2.7) $x_{t+1} = Ax_t + Bu_t + Cz_t$

and the objective function becomes:

$$J = 1/2(x_N - \hat{x}_N)^T Q(x_N - \hat{x}_N) + 1/2 \sum_{t=0}^{N-1} \Big\{ (x_t - \hat{x}_t)^T Q(x_t - \hat{x}_t) \tag{2.2.8}$$
$$+ (u_t - \hat{u}_t)^T R(u_t - \hat{u}_t) \Big\}$$

Optimization Problem Statement

The joint authority must minimize J with respect to u_t given the constraints imposed by the dynamics of the model: eq (2.2.7) and the initial condition: eq (2.2.2).

This is a centralized optimal tracking problem for which the solution via the minimum principle is well-known (P1, Ch. 2, 3).

Hamiltonian:

(2.2.9)
$$H(x_t, p_{t+1}, u_t) = 1/2 \left\{ (x_t - \hat{x}_t)^T Q (x_t - \hat{x}_t) + (u_t - \hat{u}_t)^T R (u_t - \hat{u}_t) \right\} + p_{t+1}{}^T (Ax_t + Bu_t + Cz_t)$$

Canonical equations:

(2.2.10) $$x^*_{t+1} = \left.\frac{\partial H}{\partial p_{t+1}}\right|_* = Ax^*_t + Bu^*_t + Cz_t$$

(2.2.11) $$p^*_t = \left.\frac{\partial H}{\partial x_t}\right|_* = Q(x^*_t - \hat{x}_t) + A^T p^*_{t+1}$$

Boundary conditions:

(2.2.12) $$x^*_0 = x_0$$

(2.2.13) $$p^*_N = Q(x^*_N - \hat{x}_N)$$

Hamiltonian minimization

(2.2.14) $$\left.\frac{\partial H}{\partial u_t}\right|_* = R(u^*_t - \hat{u}_t) + B^T p^*_{t+1} = 0$$

i.e.

(2.2.15) $$u^*_t = -R^{-1} B^T p^*_{t+1} + \hat{u}_t$$

Look for solution in which optimal costates are linearly related to optimal states:

(2.2.16) $p_t^* = K_t x_t^* + g_t$

This leads to the solution:

Riccati and Tracking equations:

(2.2.17) $K_t = Q + A^T K_{t+1} E_{t+1}^{-1} A$

(2.2.18) $A^T\left[K_{t+1} E_{t+1}^{-1}\left\{B(\hat{u}_t - R^{-1}B^T g_{t+1}) + Cz_t\right\} + g_{t+1}\right] - Q\hat{x}_t$

where

(2.2.19) $E_t = I + BR^{-1}B^T K_t$

Terminal conditions:

(2.2.20) $K_N = Q$

(2.2.21) $g_N = -Q\hat{x}_N$

Control sequence:

(2.2.22) $u_t^* = -R^{-1}B^T\left[K_{t+1} E_{t+1}^{-1}\left\{Ax_t^* + B(\hat{u}_t - R^{-1}B^T g_{t+1}) + Cz_t\right\} + g_{t+1}\right] + \hat{u}_t$

B. One-sided Exogenous Assumption

In this case, either the fiscal or the monetary authority is restricted to a fixed, exogenous strategy which is known to the other authority when it chooses an optimal strategy according to its objective function. The equations are developed for the case of a fixed strategy for the ith authority:

(2.2.23) $u_{it} = \bar{u}_{it}$ $(i,j) = (1,2)$ or $(2,1)$

Optimization Problem Statement

The jth authority is to minimize J_j in eq (2.2.3) with respect to its own control: u_{jt} given the constraints imposed by the dynamics of the model: eq. (2.2.1), the initial condition: eq. (2.2.2), and $\bar{u}_{it}$.

Once again, this falls into the category of a centralized optimal tracking problem since the jth authority must treat $\bar{u}_{it}$ the same way as z_t: as an exogenous, uncontrollable input. Consequently, the equations for the centralized case do perfectly well here, with obvious substitutions of Q_j's for the Q's and so on. To be perfectly clear, the essential elements of the solution are presented:

Riccati and Tracking equations:

(2.2.24) $$K_{jt} = Q_j + A^T K_{j,t+1} E_{t+1}^{-1} A \qquad (i,j) = (1,2) \text{ or } (2,1)$$

(2.2.25) $$g_{jt} = A^T \left[K_{j,t+1} E_{t+1}^{-1} \left\{ B_j (\hat{u}_{jt} - R_{jj}^{-1} B_j^T g_{j,t+1}) + C z_t \right\} + g_{j,t+1} \right] - Q_j \hat{x}_{jt}$$

$(i,j) = (1,2)$ or $(2,1)$

where:

(2.2.26) $$E_t = I + B_j R_{jj}^{-1} B_j^T K_{jt}$$

Terminal conditions:

(2.2.27) $$K_{jN} = Q_j$$

(2.2.28) $$g_{jN} = -Q_j \hat{x}_{jN}$$

Control sequence:

$$u^*_{jt} = -R^{-1}_{jj}B^T_j\left[K_{j,t+1}E^{-1}_{t+1}\left\{Ax^*_t + B_i\bar{u}_{it} + B_j(\hat{u}_{jt} - R^{-1}_{jj}B^T_j g_{j,t+1}) + Cz_t\right\} + g_{j,t+1}\right] + \hat{u}_{jt} \qquad (i,j) = (1,2) \text{ or } (2,1) \tag{2.2.29}$$

State trajectory:

$$x^*_{t+1} = Ax^*_t + B_i\bar{u}_{it} + B_j u^*_{jt} + Cz_t \tag{2.2.30}$$

with x^*_0 determined by eq. (2.2.2).

C. One-sided Endogenous "Reaction" Assumption

The difference between this and the previous case is that here, the ith authority is constrained to an endogenous rather than an exogenous strategy. In particular, the endogenous strategy is postulated to relate that authority's control sequence to the others'. This relation is embodied in an estimated "reaction" function of the form:

$$\tilde{u}_{it} = D_{i1}x_{t+1} + D_{i2}x_t + E_{ii}\tilde{u}_{it} + E_{ij}u_{jt} + F_i z_t \qquad (i,j) = (1,2) \text{ or } (2,1) \tag{2.2.31}$$

where D_{i1}, D_{i2}, E_{i1}, E_{i2} and F_i are $r_i$xn, $r_i$xn, r_ixr_1, r_ixr_2 and $r_i$xs matrices, respectively. (The x_{t+1} term looks strange until one remembers that u_{it} and z_t refer to the controls and exogenous inputs at time t+1 due to the relabeling mentioned at the outset of this section.)

Optimization Problem statement

The jth authority must minimize J_j in eq. (2.2.3) with respect to u_{jt}

given the constraints imposed by the model: eq. (2.2.1), the initial condition: eq. (2.2.2), and the reaction function: eq. (2.2.31).

This problem fits into the same centralized optimal tracking framework when eq. (2.2.1) is substituted into eq. (2.2.31) to remove x_{t+1} dependence:

(2.2.32)
$$\tilde{u}_{it} = (I - E_{ii} - D_{i1}B_i)^{-1}\Big\{(D_{i1}A + D_{i2})x_t + (E_{ij} + D_{i1}B_j)u_{jt} + (F_i + D_{i1}C)z_t\Big\} \qquad (i,j) = (1,2) \text{ or } (2,1)$$

and eq. (2.1.32) is substituted back into eq. (2.1.1):

(2.2.33)
$$\begin{aligned} x_{t+1} &= \Big\{A + B_i(I - E_{ii} - D_{i1}B_i)^{-1}(D_{i1}A + D_{i2})\Big\} x_t \\ &+ \Big\{B_j + B_i(I - E_{ii} - D_{i1}B_i)^{-1}(E_{ij} + D_{i1}B_j)\Big\} u_{jt} \\ &+ \Big\{C + B_i(I - E_{ii} - D_{i1}B_i)^{-1}(F_i + D_{i1}C)\Big\} z_t \\ &= \tilde{A}_j x_t + \tilde{B}_j u_{jt} + \tilde{C}_j z_t \qquad (i,j) = (1,2) \text{ or } (2,1) \end{aligned}$$

<u>Riccati and Tracking equations</u>:

(2.2.34) $$K_{jt} = Q_j + \tilde{A}_j^T K_{j,t+1} E_{t+1}^{-1} \tilde{A}_j \qquad (i,j) = (1,2) \text{ or } (2,1)$$

(2.2.35)
$$g_{jt} = \tilde{A}_j^T \Big[K_{j,t+1}E_{t+1}^{-1}\Big\{\tilde{B}_j\ (\hat{u}_{jt} - R_{jj}\tilde{B}_j^T g_{j,t+1}) + \tilde{C}_j z_t\Big\} + g_{j,t+1}\Big] - Q_j \hat{x}_{jt} \qquad (i,j) = (1,2) \text{ or } (2,1)$$

where

(2.2.36) $$E_t - I + \tilde{B}_j R_{jj}^{-1} \tilde{B}_j^T K_{jt}$$

Terminal conditions:

(2.2.37) $K_{jN} = Q_j$

(2.2.38) $g_{jN} = -Q_j\hat{x}_{jN}$

Control sequence:

(2.2.39)
$$u^*_{jt} = -R^{-1}_{jj}\tilde{B}^T_j\Big[K_{j,t+1}E^{-1}_{t+1}\Big\{\tilde{A}x^*_t + \tilde{B}_j(\hat{u}_{jt} - R^{-1}_{jj}\tilde{B}^T_j g_{j,t+1}) + \tilde{C}_j z_t\Big\} + g_{j,t+1}\Big] + \hat{u}_{jt} \qquad (i,j) = (1,2) \text{ or } (2,1)$$

D. Two-sided Endogenous "Reaction" Assumption

There is no optimization problem in this case. Rather, the model is simulated with both reaction functions: $\tilde{u}_{1t}$ and $\tilde{u}_{2t}$ as given by eq. (2.2.31). These can be combined to yield (assuming the required inverse exists):

(2.2.40)
$$\tilde{u}_t \stackrel{\Delta}{=} \begin{pmatrix}\tilde{u}_{1t}\\ \cdots \\ \tilde{u}_{2t}\end{pmatrix} = \begin{bmatrix} I - D_{11}B_1 - E_{11} & -(D_{11}B_2 + E_{12}) \\ -(D_{21}B_1 + E_{21}) & I - D_{21}B_2 - E_{22}\end{bmatrix}^{-1}\left\{\begin{bmatrix} D_{11}A + D_{12} \\ D_{21}A + D_{22}\end{bmatrix}x_t + \begin{bmatrix} D_{11}C + F_1 \\ D_{21}C + F_2\end{bmatrix}z_t\right\}$$

Eq. (2.2.40) can be substituted into the aggregated-control model's eq. (2.2.7) to eliminate the unknown: $u_t = \tilde{u}_t$, so that a simulation can be performed.

E. Open-loop Nash Competitive Assumption

This introduces the first true game situation.

Optimization Problem Statement

The two authorities are asked to simultaneously minimize their individual objective functions in eq. (2.2.3) with respect to their own control sequences, chosen from the set of open-loop strategies, given the constraints imposed by the dynamics of the mode: eq. (2.1.1), and the initial condition: eq. (2.2.2).

This is precisely the open-loop problem addressed by Pindyck (P3):

Hamiltonian:

(2.2.41)
$$H_j(x_t, p_{j,t+1}, u_{1t}, u_{2t}) = 1/2\Big\{(x_t - \hat{x}_{jt})^T Q_j (x_t - \hat{x}_{jt}) + (u_{1t} - \hat{u}_{1t})^T R_{j1}(u_{1t} - \hat{u}_{1t}) + (u_{2t} - \hat{u}_{2t})^T R_{j2}(u_{2t} - \hat{u}_{2t})\Big\} + p^T_{j,t+1}(Ax_t + B_1u_{1t} + B_2u_{2t} + Cz_t)$$
$$j = 1,2$$

Canonical equations:

(2.2.42) $$x^*_{t+1} = \frac{\partial H_j}{\partial p_{j,t+1}}\bigg|_* = Ax^*_t + B_1u^*_{1t} + B_2u^*_{2t} + Cz_t \qquad j = 1,2$$

(2.2.43) $$p^*_{jt} = \frac{\partial H_j}{\partial x_t}\bigg|_* = Q_j(x^*_t - \hat{x}_{jt}) + A^Tp^*_{j,t+1} \qquad j = 1,2$$

Boundary conditions:

(2.2.44) $$x^*_0 = x_0$$

(2.2.45) $$p^*_{jN} = Q_j(x^*_N - \hat{x}_{jN}) \qquad j = 1,2$$

Hamiltonian minimization:

$$\left.\frac{\partial H_j}{\partial u_{jt}}\right|_* = R_{jj}(u^*_{jt} - \hat{u}_{jt}) + B_j^T p^*_{j,t+1} \qquad j = 1,2 \tag{2.2.46}$$

i.e.

$$u^*_{jt} = -R_{jj}^{-1} B_j^T p^*_{j,t+1} + \hat{u}_{jt} \qquad j = 1,2 \tag{2.2.47}$$

Look for solution in which optimal costates are linearly related to optimal states: eq. (2.2.16).

This leads to solution:

Riccati and Tracking equations:

$$K_{jt} = Q_j + A^T K_{j,t+1} E_{t+1}^{-1} A \qquad j = 1,2 \tag{2.2.48}$$

$$g_{jt} = A^T \left[K_{j,t+1} E_{t+1}^{-1} \left\{ B_1(\hat{u}_{1t} - R_{11}^{-1} B_1^T g_{1,t+1}) + B_2(\hat{u}_{2t} - R_{22}^{-1} B_2^T g_{2,t+1}) + Cz_t \right\} + g_{j,t+1} \right] - Q_j \hat{x}_{jt} \qquad j = 1,2 \tag{2.2.49}$$

where

$$E_t = I + B_1 R_{11}^{-1} B_1^T K_{1t} + B_2 R_{22}^{-1} B_2^T K_{2t} \tag{2.2.50}$$

Terminal conditions:

$$K_{jN} = Q_j \qquad j = 1,2 \tag{2.2.51}$$

$$g_{jN} = -Q_j \hat{x}_{jN} \qquad j = 1,2 \tag{2.2.52}$$

Control sequence:

$$u^*_{jt} = -R^{-1}_{jj}B^T_j\left[K_{j,t+1}E^{-1}_{t+1}\left\{Ax^*_t + B_1(\hat{u}_{1t} - R^{-1}_{11}B^T_1 g_{1,t+1}) + B_2(\hat{u}_{2t} - R^{-1}_{22}B^T_2 g_{2,t+1}) + Cz_t\right\} + g_{j,t+1}\right] + \hat{u}_{jt} \qquad j = 1,2 \tag{2.2.53}$$

F. Closed-loop Nash Competitive Assumption

This game is identical to the last except that closed-loop strategies must be chosen.

Optimization Problem Statement

The two authorities are asked to simultaneously minimize their individual objective functions in eq. (2.2.3) with respect to their own control sequences, chosen from the set of closed-loop strategies, given the constraints imposed by the dynamics of the model: eq. (2.2.1), and the initial condition: eq. (2.2.2).

Once again, this is precisely the closed-loop problem treated in Pindyck (P3). Now, the controls are such that:

$$u_{jt} = f_j(x_t) \qquad j = 1,2 \tag{2.2.54}$$

All that changes in the necessary conditions is the costate equation:

$$p^*_{jt} = \left.\frac{\partial H_j}{\partial x_t}\right|_* = Q_j(x^*_t - \hat{x}_{jt}) + \left.\left(\frac{\partial u_{it}}{\partial x_t}\right)^T\right|_* R_{ji}(u^*_{it} - \hat{u}_{it}) + A^T p^*_{j,t+1} + \left.\left(\frac{\partial u_{it}}{\partial x_t}\right)^T\right|_* B^T_i p^*_{j,t+1} \qquad (i,j) = (1,2) \text{ or } (2,1) \tag{2.2.55}$$

Look for solution in which optimal control deviations are linearly related to optimal states:

$$(u^*_{it} - \hat{u}_{it}) = -R^{-1}_{ii}B^T_i \left[K_{i,t+1}x^*_{t+1} + g_{i,t+1}\right] \tag{2.2.56}$$

In conjunction with the necessary conditions, eq. (2.2.56) implies that:

$$\left.\frac{\partial u_{it}}{\partial x_t}\right|_* = -R^{-1}_{ii}B^T_i K_{i,t+1}E^{-1}_{t+1}A \qquad i = 1,2 \tag{2.2.57}$$

Thus:

$$\begin{aligned} p^*_{jt} = Q_j(x^*_t - \hat{x}_{jt}) + A^T\Big\{ & p^*_{j,t+1} + (E^{-1}_{t+1})^T K^T_{i,t+1}B_i(R^{-1}_{ii})^T \\ & \left[R_{ji}R^{-1}_{ii}B^T_i p^*_{i,t+1} - B^T_i p^*_{j,t+1}\right]\Big\} \qquad (i,j) = (1,2) \text{ or } (2,1) \end{aligned} \tag{2.2.58}$$

This leads to solution:

<u>Riccati and Tracking equations:</u>

$$\begin{aligned} K_{jt} = Q_j + A^T\Big\{ & K_{j,t+1} + (E^{-1}_{t+1})^T K^T_{i,t+1}B_i(R^{-1}_{ii})^T(R_{ji}R^{-1}_{ii}B^T_iK_{i,t+1} \\ & -B^T_iK_{j,t+1})\Big\} E^{-1}_{t+1}A \qquad (i,j) = (1,2) \text{ or } (2,1) \end{aligned} \tag{2.2.59}$$

$$\begin{aligned} g_{jt} = A^T\Big[& \Big\{K_{j,t+1} + (E^{-1}_{t+1})^T K^T_{i,t+1}B_i(R^{-1}_{ii})^T(R_{ji}R^{-1}_{ii}B^T_iK_{i,t+1} \\ & - B^T_iK_{j,t+1})\Big\} E^{-1}_{t+1}\Big\{B_1(\hat{u}_{1t} - R^{-1}_{11}B^T_1g_{1,t+1}) + B_2(\hat{u}_{2t} - R^{-1}_{22}B^T_2g_{2,t+1}) \\ & + Cz_t\Big\} + \Big\{g_{j,t+1} + (E^{-1}_{t+1})^T K^T_{i,t+1}B_i(R^{-1}_{ii})^T(R^{-1}_{ji}R_{ii}B^T_ig_{i,t+1} \\ & - B_ig_{j,t+1})\Big\}\Big] - Q_j\hat{x}_{jt} \qquad (i,j) = (1,2) \text{ or } (2,1) \end{aligned} \tag{2.2.60}$$

The terminal conditions and control sequence are given by eq. (2.2.51), eq. (2.2.52), and eq. (2.2.53).

G. Nash Bargaining Assumption

In Nash bargaining, the two authorities agree to a particular division of power parameterized by a scalar α^*, $0 \leq \alpha^* \leq 1$, according to which they join forces in minimizing $J(\alpha^*)$:

$$(2.2.61) \quad J(\alpha^*) \triangleq \alpha^* J_1 + (1-\alpha^*) J_2$$

where J_1 and J_2 are given by eq. (2.2.3). The optimization results in respective costs: J_{1,α^*} and J_{2,α^*}. The particular value of α^* is determined by the relation of $(J_{1,\alpha^*}, J_{2,\alpha^*})$ to a "threat point:" $(J_{1,T}, J_{2,T})$ defined by either the open- or closed-loop Nash competition. α^* is chosen to maximize the area: $(J_{1,T} - J_{1,\alpha})(J_{2,T} - J_{2,\alpha})$ over $\alpha \in (0,1)$. Thus, a series of optimizations must initially be run for varying values of α to map out the feasible pairs: $(J_{1,\alpha}, J_{2,\alpha})$.

Optimization Problem Statement

The joint authority must minimize $J(\alpha)$ with respect to u_t, (defined by eq. (2.2.5)), given the constraints imposed by the dynamics of the model: eq. (2.2.7) and the initial condition: eq. (2.2.2).

This is a centralized optimal tracking problem, again. Its solution is very similar to that for case A:

Hamiltonian:

$$H(x_t, p_{t+1}, u_t) = 1/2 \Big\{ (x_t - \hat{x}_{1t})^T \alpha Q_1 (x_t - \hat{x}_{1t})$$

(2.2.62) $$+ (x_t - \hat{x}_{2t})^T (1-\alpha) Q_2 (x_t - \hat{x}_{2t}) + (u_t - \hat{u}_t)^T R_\alpha (u_t - \hat{u}_t) \Big\}$$

$$+ p_{t+1}^T (Ax_t + Bu_t + Cz_t)$$

where

(2.2.63) $$R_\alpha \triangleq \left[\begin{array}{c:c} \alpha R_{11} + (1-\alpha) R_{21} & 0 \\ \hdashline 0 & \alpha R_{12} + (1-\alpha) R_{22} \end{array} \right]$$

Canonical equations:

(2.2.64) $$x_{t+1}^* = \left. \frac{\partial H}{\partial p_{t+1}} \right|_* = Ax_t^* + Bu_t^* + Cz_t$$

(2.2.65) $$p_t^* = \frac{\partial H}{\partial x_t}_* = (\alpha Q_1 + (1-\alpha) Q_2) x_t - (\alpha Q_1 \hat{x}_{1t} + (1-\alpha) Q_2 \hat{x}_{2t}) + A^T p_{t+1}^*$$

Boundary conditions:

(2.2.66) $$x_0^* = x_0$$

(2.2.67) $$p_N^* = (\alpha Q_1 + (1-\alpha) Q_2) x_N^* - (\alpha Q_1 \hat{x}_{1N} + (1-\alpha) Q_2 \hat{x}_{2N})$$

Hamiltonian minimization:

(2.2.68) $$\left. \frac{\partial H}{\partial u_t} \right|_* = R_\alpha (u_t^* - \hat{u}_t) + B^T p_{t+1}^*$$

i.e.

(2.2.69) $u_t^* = -R_\alpha^{-1}B^T p_{t+1}^* + \hat{u}_t$

Look for solution in which optimal costates are linearly related to optimal states: eq. (2.2.16). This leads to solution:

Riccati and Tracking equations:

(2.2.70) $K_t = (\alpha Q_1 + (1-\alpha)Q_2) + A^T K_{t+1} E_{t+1}^{-1} A$

(2.2.71)
$$g_t = A^T \left[K_{t+1} E_{t+1}^{-1} \left\{ B(\hat{u}_t - R_\alpha^{-1} B^T g_{t+1}) + Cz_t \right\} + g_{t+1} \right] - (\alpha Q_1 \hat{x}_{1t} + (1-\alpha) Q_2 \hat{x}_{2t})$$

where

(2.2.72) $E_t = I + BR_\alpha^{-1}B^T K_t$

Terminal conditions:

(2.2.73) $K_N = (\alpha Q_1 + (1-\alpha)Q_2)$

(2.2.74) $g_N = -(\alpha Q_1 \hat{x}_{1N} + (1-\alpha)Q_2 \hat{x}_{2N})$

Control sequence:

(2.2.75) $u_t^* = -R_\alpha^{-1}B^T \left[K_{t+1} E_{t+1}^{-1} \left\{ Ax_t^* + B(\hat{u}_t - R^{-1}B^T g_{t+1}) + Cz_t \right\} + g_{t+1} \right] + \hat{u}_t$

Once the feasible pairs: $(J_{1,\alpha}, J_{2,\alpha})$ have been found, it remains to choose the particular value of α^* to which the two authorities will agree.

Choice of α^*:

The joint authority chooses α^* to maximize the area: $(J_{1,T} - J_{1,\alpha})(J_{2,T} - J_{2,\alpha})$ over $\alpha \in [0,1]$. It is assumed for this analysis that the feasible pairs map into (J_1, J_2)-space as a continuous concave function of α: $b(\alpha)$.

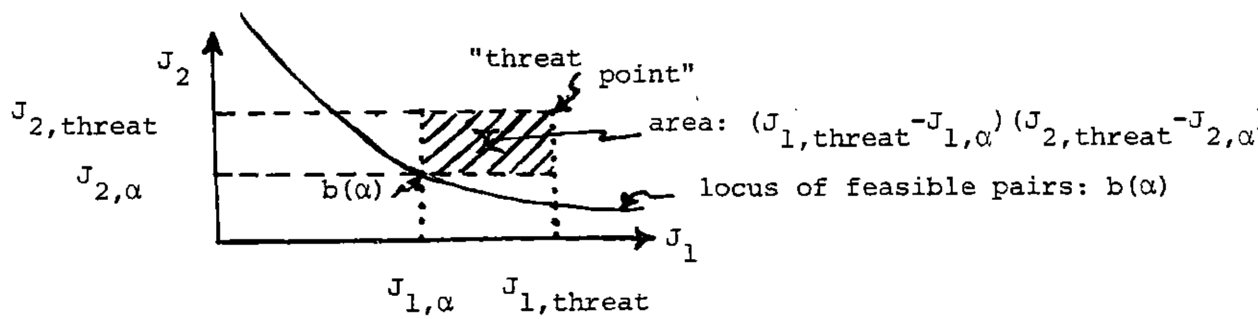


Figure 2.1

The area is maximized for:

$$(2.2.76)\quad \left.\frac{\partial b}{\partial \alpha}\right|_* = -\left.\frac{(J_{2,T} - J_{2,\alpha})}{(J_{1,T} - J_{1,\alpha})}\right|_*$$

This is to say that the slope of the tangent to $b(\alpha)$ at α^* must be equal to the negative of the slope of the line joining $(J_{1,\alpha}, J_{2,\alpha})$ to $(J_{1,T}, J_{2,T})$, (M1).

All of the optimization solutions boil down to the sets of algebraic equations whose uniqueness follows trivially when the required inverses exist as is guaranteed by the positive semidefiniteness of the Q's and the positive definiteness of the R's in the objective functions. That the solutions represent minima follows from the convexity of the objective functions.

2.3 Reaction Functions

The "reaction functions" are meant to represent historical averages of the monetary and fiscal policy-formation processes. Their specifications assume that the authorities choose strategies primarily in response to economic indicators: the level of unemployment, the rate of inflation, the rate of growth of real GNP. Such an assumption turns out to make more sense for the monetary than the fiscal authority in the context of this model.

The concept of reaction functions has been introduced into this study to allow Fair's findings in (F1) to be compared with Pindyck's in (P3) and the others contained herein. Consequently, this study's monetary reaction function is chosen to be as similar as possible to Fair's, quoting his paper:

$$\text{"}RBILL_t = \underset{(-2.93)}{-11.1} + \underset{(16.30)}{0.841}RBILL_{t-1} + \underset{(1.69)}{0.0497}\%PD_{t-1} + \underset{(2.97)}{0.0352}J^*_t \tag{2.3.1}$$

$$+ \underset{(1.62)}{0.0427}\%GNPR_t + \underset{(1.36)}{0.188}\%GNPR_{t-1} + \underset{(2.10)}{0.0251}\%M1_{t-1};$$

$\hat{\rho} = 0.229$, $SE = 0.474$, $R^2 = 0.939$, $DW = 1.82$

Sample period = 1954-1 to 1976-2,

where RBILL = three-month treasury bill rate, percentage points,

%PD = percentage change at an annual rate in the price deflator for domestic sales, percentage points,

J* = a measure of labor market tightness in the model,

%GNPR = percentage change at an annual rate in real GNP, percentage points,

$\%M_1$ = percentage change at an annual rate in the money supply, percentage points."

This study's monetary reaction function is a modification of Fair's. In the interest of retaining linearity, the rate of change in real GNP is approximated by ΔGNP. The money supply term is dropped since M is not part of the RSB-MODEL. The rate of unemployment is substituted for Fair's measure of labor market tightness on the assumption that the two should move contrariwise.

The equation is estimated with 2SLS over 1956-1 to 1976-1, employing instrumental variables on RSB_{-1} as well as the unlagged endogenous variables to allow consistent estimation with a first-order Cochrane-Orcutt autocorrelation correction. This method of dealing with autocorrelation in the presence of lagged dependent variables on the right-hand side is presented in Johnston (J1, pp 319-20).

$$\begin{aligned} RSB = \underset{(2.28)}{0.988} + \underset{(12.65)}{0.872}RSB_{-1} + \underset{(1.62)}{29.53}RGP_{-1} - \underset{(-2.43)}{0.161}UR + \underset{(1.95)}{0.0235}\Delta GNP \\ + \underset{(1.23)}{0.0112}\Delta GNP_{-1} \end{aligned} \tag{2.3.2}$$

$\hat{\rho} = 0.2246$, $R^2 = 0.867$, $F(5/75) = 98.027$, $SER = 0.513$, $DW(0) = 1.84$.

This result is very much in line with Fair's (note that $RGP \cong 400\ (\%PD)$, and $\Delta GNP \cong .4(\%GNPR)$), and as Fair points out, the monetary authority seems to "lean against the wind," tightening the reins when the economy is growing, inflation is high and unemployment is low.

Hypothesizing an analogous fiscal reaction function: $G = g(G_{-1}, \Delta GNP, RGP, UR)$ and estimating it via 2SLS over 1956-1 to 1976-1 yields counterintuitive behavior with little statistical validity:

$$(2.3.3) \quad G = \underset{(1.52)}{1.91} + \underset{(99.7)}{0.993}G_{-1} - \underset{(-0.51)}{18.07}RGP_{-1} - \underset{(-0.17)}{0.0219}UR - \underset{(-0.11)}{0.0025}\Delta GNP_{-1}$$

$R^2 = .996$, $F(4/76) = 4832.47$, $SER = 1.39$, $DW(0) = 1.31$

where the fiscal authority seems to work to promote unemployment! This gives all the explanation to G_{-1} and signals autocorrelation. An attempt to apply an autocorrelation correction to the equation, (as was done for the monetary reaction function), results in a very poor fit with $\hat{\rho} = 1.000$, suggesting specification error.

A similar specification: $\Delta G = g(\Delta G_{-1}, \Delta GNP, RGP, UR)$ makes more sense, but is also statistically shaky:

$$(2.3.4) \quad \Delta G = \underset{(1.18)}{0.794} + \underset{(3.42)}{0.368}\Delta G_{-1} - \underset{(-1.47)}{38.28}RGP + \underset{(0.25)}{0.0295}UR - \underset{(-0.81)}{0.0207}\Delta GNP$$

$R^2 = 0.159$, $F(4/76) = 3.593$, $SER = 1.30$, $DW(0) = 2.15$.

The simplest explanation for this problem seems to be the importance of neglected exogenous factors. Two such factors are Johnson's "Great Society" and Vietnam War expenditures; in fact, comparison of a 2.7% growth-line to the actual trajectory for real government expenditures over 1956-1 to 1976-1 shows their effect cumulating in a $20 billion excess of actual G over the trend at the end of 1968 which disappears by 1973. Since these factors are exogenous to the model, their joint effect is proxied by a dummy variable: WARDUM, which has the value 1.0 over 1965-1 to 1968-3 and is 0 elsewhere. Including WARDUM yields a more satisfactory relationship:

$$\text{(2.3.5)} \quad \Delta G = \underset{(-1.59)}{-1.148} - \underset{(-2.56)}{0.0669\Delta GNP} = \underset{(-2.24)}{52.72RGP} + \underset{(3.24)}{0.442UR_{-1}} + \underset{(6.01)}{2.415WARDUM}$$

$R^2 = 0.315$, $F(4/76) = 8.736$, $SER = 1.1710$, $DW(0) = 1.97$.

The fiscal policy-makers also seem historically to lean against the wind.

It is interesting to note that eq.'s (2.3.2) and (2.3.5) are compatible with a situation characterized by no real growth in GNP or government expenditures accompanied by 4% unemployment, a 4.7% annual rate of inflation and RSB at 6.4% The coefficients of the reaction functions seem to be of the right magnitude.

While both authorities seem to "lean against the wind," the fiscal authority appears much more sensitive to stabilization objectives than the monetary. A 4% inflationary jump decreases G by only $.5 billion while RSB increases 1/2%; a 3% increase in unemployment increases G by $1.3 billion while RSB drops 1/2%. Figures 1.7's multipliers show how much stronger an effect follows the monetary than the fiscal response.

2.4 Defining Parameters

Each experiment is run over 20 quarters from a 1968-4 initial condition to 1973-4; the initial condition for the state is listed in Table 2.1. It is assumed that all fiscal stabilization policies are aimed at the current rate of inflation. The unemployment target is uniformly 2%, (i.e. $\hat{UR} = 2.0$ since UR is at an annual rate); the rate of inflation target is always 2% (i.e. $\hat{RGP} = .005$ since RGP is at a quarterly rate). Nominal trajectories for the policy instruments are chosen to reflect average historical behavior over the control period: $\hat{G}$ follows a .12% quarterly growth rate from

TABLE 2.1: State Initial Condition: (1968-4)

x(1)	177.5
x(2)	444.8
x(3)	78.58
x(4)	29.64
x(5)	5.58
x(6)	5.417
x(7)	0.0138
x(8)	3.4
x(9)	442.5
x(10)	76.21
x(11)	29.04
x(12)	6.37
x(13)	692.0
x(14)	680.4
x(15)	672.7
x(16)	5.073
x(17)	5.303
x(18)	5.243
x(19)	5.327
x(20)	0.0092
x(21)	3.533
x(22)	3.567
x(23)	139.4
x(24)	139.3
x(25)	5.7
x(26)	5.7
x(27)	5.7

\$139.5 billion in 1968-4; $\hat{RSB}$ is 5.7%. Uncontrollable exogenous variables are always taken to follow their historical trajectories.

The Q and R weighting matrices in the objective functions contain the final set of parameters to be determined: they are chosen to generate identical objective function values for identical state and control trajectories. This choice is made simple by restricting the R_{ij}'s to be zeros: so that neither authority cares how far the other deviates from its nominal control sequence. The objective functions in eq. (2.1.3) reduce to:

(2.4.1)

$$\underline{\text{fiscal}}: \quad J_1 = 1/2(q_{8,8})_1(UR_{20} - 2.0)^2 + 1/2 \sum_{t=0}^{19} \left\{ (q_{8,8})_1(UR_t - 2.0)^2 + (r_{1,1})_1(G_t - \hat{G}_t)^2 \right\}$$

$$\underline{\text{monetary}}: \quad J_2 = 1/2\,(q_{7,7})_2(RGP_{20} - .005)^2 + 1/2 \sum_{t=0}^{19} \left\{ (q_{7,7})_2(RGP_t - .005)^2 + (r_{2,2})_2(RSB_t - 5.7)^2 \right\}$$

where $(q_{8,8})_1$ is the 8,8 element of Q_1 and likewise for $(q_{7,7})_2$, $(r_{1,1})_1$ and $(r_{2,2})_2$. As stated above, $\hat{G}_t$ is a trend-line; for purposes of comparison, its magnitude is assumed to lie near 140. The centralized objective function in eq. (2.1.4) reduces to:

(2.4.2)

$$\underline{\text{joint}}: \quad J = 1/2 \left\{ (q_{7,7})_2(RGP_{20} - .005)^2 + (q_{8,8})_1(UR_{20} - 2.0)^2 \right\} + 1/2 \sum_{t=0}^{19} \left\{ (q_{7,7})_2(RGP_t - .005)^2 + (q_{8,8})_1(UR_t - 2.0)^2 + (r_{1,1})_1(G_t - \hat{G}_t)^2 + (r_{2,2})_2(RSB_t - 5.7)^2 \right\}$$

The relative magnitudes of the weights are selected in preliminary centralized experiments where the joint authority goes for both the UR and the RGP objectives. The motive is to find weights which yield a "reasonable" policy mix for the stabilization accomplished. The benchmark guess sets equal weights for $(1\%\ \text{deviation})^2$ from the target; that is, each weight is chosen to equal: $(2.0\times10^{-4})/(1\%\ \text{deviation})^2$:

coefficient	value	weighting on 1% deviation	(variable)
$(q_{7,7})_2$	80,000	1	(RGP)
$(q_{8,8})_1$	0.5	1	(UR)
$(r_{1,1})_1$	.0001	1	(G)
$(r_{2,2})_2$	.06	1	(RSB)

The result of equal weighting is far too much work done by G relative to RSB and very pronounced end-effects in G, while the stabilization is well-balanced. Increasing $(r_{1,1})_1$ to .001 improves the policy mix but the end-effects remain pronounced. Satisfactory weightings are found by increasing $(r_{1,1})_1$ and $(r_{2,2})_2$ by a further factor of 10. Thus the final weighting coefficients are:

coefficient	value	weighting on 1% deviation	(variable)
$(q_{7,7})_2$	80,000	1	(RGP)
$(q_{8,8})_1$	0.5	1	(UR)
$(r_{1,1})_1$	.01	10	(G)
$(r_{2,2})_2$	.6	$\sqrt{10}$	(RSB)

This set of coefficients is used in every case to evaluate the objective functions of the two authorities.

The series of experiments is comprised of:

A. <u>Centralized</u>

1) the joint authority goes for both UR and RGP objectives;

2) the joint authority goes for UR target alone;

3) the joint authority goes for RGP target alone.

B. <u>One-sided Exogenous</u>

1) fiscal authority pursues UR target, monetary authority holds to its nominal control;

2) monetary authority pursues RGP target, fiscal authority holds to its nominal control.

C. <u>One-sided Endogenous "Reaction"</u>

1) fiscal authority pursues UR target, monetary authority obeys its reaction function: eq. (2.2.2);

2) monetary authority pursues RGP target, fiscal authority obeys its reaction function: eq. (2.2.5).

D. <u>Two-sided Endogenous "Reaction:</u>

1) both authorities obey their reaction functions.

E. <u>Open-loop Nash Competitive</u>

1) authorities compete with open-loop strategies.

F. <u>Closed-loop Nash Competitive</u>

1) authorities compete with closed-loop strategies.

G. <u>Nash Bargaining</u> (to map out feasible pairs: $(J_{1,\alpha}, J_{2,\alpha})$

1) $\alpha = .1$

3) $\alpha = .3$

4) $\alpha = .4$

5) $\alpha = .5$

6) $\alpha = .6$

7) $\alpha = .7$

9) $\alpha = .9$

The objective functions have been defined such that the feasible bargaining solution for $\alpha = 0.5$ should be identical to the centralized solution. As α ranges from 0.0 to 1.0, the monetary-fiscal cost trade-off undergoes a continuous transition from very high fiscal and low monetary costs to very high monetary and low fiscal costs: clearly, if α were 0.0, wildly contractionary fiscal policy would force inflation to its target; if α were 1.0, monetary efforts alone would force unemployment to its target.

CHAPTER 3

THE RESULTS

3.1 Experimental Setting and Mock "Predictions"

It was suggested in Chapter 1 that a good understanding of the model might render the control experiments "almost redundant." To better understand how the experimental outcomes are determined, it is instructive to contrast the historical and experimental settings and to consider mock "predictions" which can be based on the experimental parameters, the model and the various interaction assumptions which have been described.

A comparison of the historical and experimental settings shows that it is difficult to infer from the experiments how the fiscal and monetary authorities could have improved their strategies even if one ignores the oversimplification of their objectives. Historically, the policy-makers were faced with a variable and confusing circumstance during the experiment's time period. The fiscal and monetary policy-makers entered the period in concert with contractionary stances, tapering down Johnson's Vietnam War and Great Society expenditures and trying to buck their inflationary consequences. Figure 3.1 compares the historical paths obtained by running a model simulation in which G and RSB follow their targets. The contraction proved to be alarmingly effective in braking GNP into a slight recession throughout 1970 and in eroding a happy 3% unemployment rate to an unhappy 6% rate. To top it off, inflation didn't budge from its 5% level, so the policies were swiftly shifted to a cautious

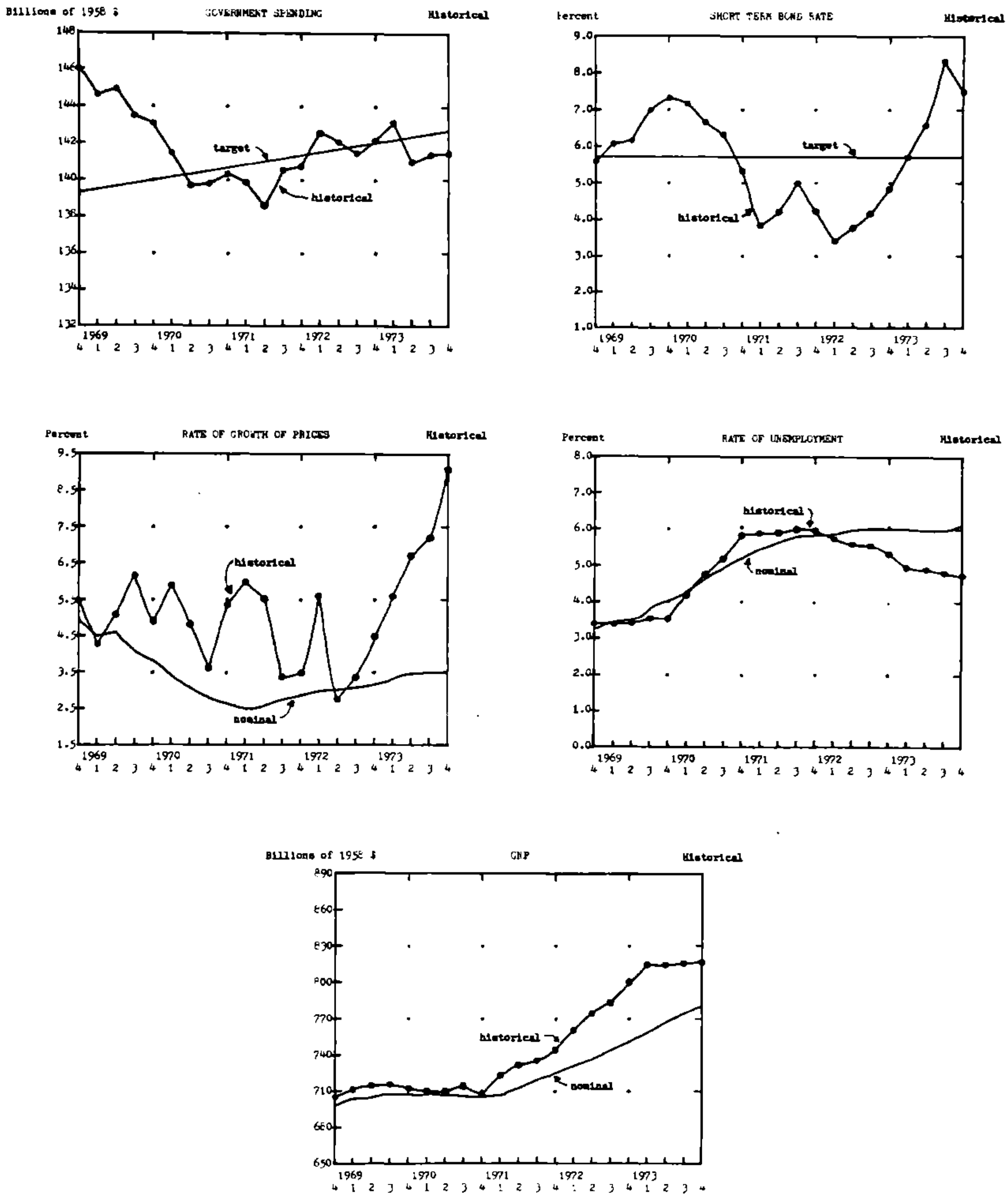


FIGURE 3.1 Historical Data vs. Nominal Trajectories

expansion. By mid-1972 the economy appeared to be settling down to a gradual decline in both unemployment and inflation and hopes were high that the economic disruptions of Johnson's expenditures had run their course and the Phillip's unemployment-inflation trade-off would become more favorable again. However, mid-1972 also marked the beginning of the rising prices that came to be attributed to the oil cartel and disastrously low anchovy and grain harvests. Unable to avert the impending crunch, the two authorities exited the control period with conflicting strategies: the fiscal stance remained cautiously expansive while the monetary authority attempted to damp the inflation by squeezing the money supply.

The "nominal" situation faced by the policy-makers in these experiments is not nearly as variable or confusing. When they follow their target strategies, the 1970-71 recession arrives with unemployment at 5% and inflation at a low 2.5%. As the targets are sustained to the period's close, GNP recovers into a 3% growth rate, unemployment steadies at 6% and inflation at 3.5, ignorant of the historical price hikes. There is a clear incentive from the centralized point of view, which does not exist historically, to move the trade-off toward less unemployment and more inflation.

From a decentralized point of view, another discrepancy arises. Because the fiscal authority single-mindedly pursues decreased unemployment and the monetary authority less inflation (in the experiments), the low nominal inflation trajectory gives the fiscal policy-makers a greater incentive to act than the monetary while historically their incentives are comparable.

Since the historical and experimental settings do not correspond well one cannot expect the "reaction" functions to reproduce the historical <u>policies</u> whether or not they capture historical <u>policy-formation</u> accurately.

A key property of the econometric model to the mock "predictions" is the differential in short-term policy-effectiveness between the two authorities when instrument target-deviations are chosen to incur identical costs in the stabilization objective functions. (Equal costs result when: $|G_t - \hat{G}_t| = 7.767|RSB_t - 5.7|$.) Fiscal policy alters current GNP directly while monetary policy must filter through a set of time-distributed and time-averaged linkages before influencing GNP. Figure 3.2 illustrates the point in dynamic RGP and UR multipliers resulting from once-and-for-all increases/decreases in G and RSB.

This property enables the fiscal authority to make substantial short-term gains in the monetary-fiscal competitive "tug-of-war." The shaded areas in Figure 3.2 show how much the fiscal policy-makers gain in UR and the monetary policy-makers lose in RGP when equally costly counter-measures are instituted simultaneously.

Incidentally, the multipliers illustrate the direct conflict inherent in the separate monetary and fiscal objective functions. Unemployment cannot be reduced without increased inflation and vice versa.

Since the fiscal authority perceives greater incentive to fight, greater short-term effectiveness, and no common ground with the monetary

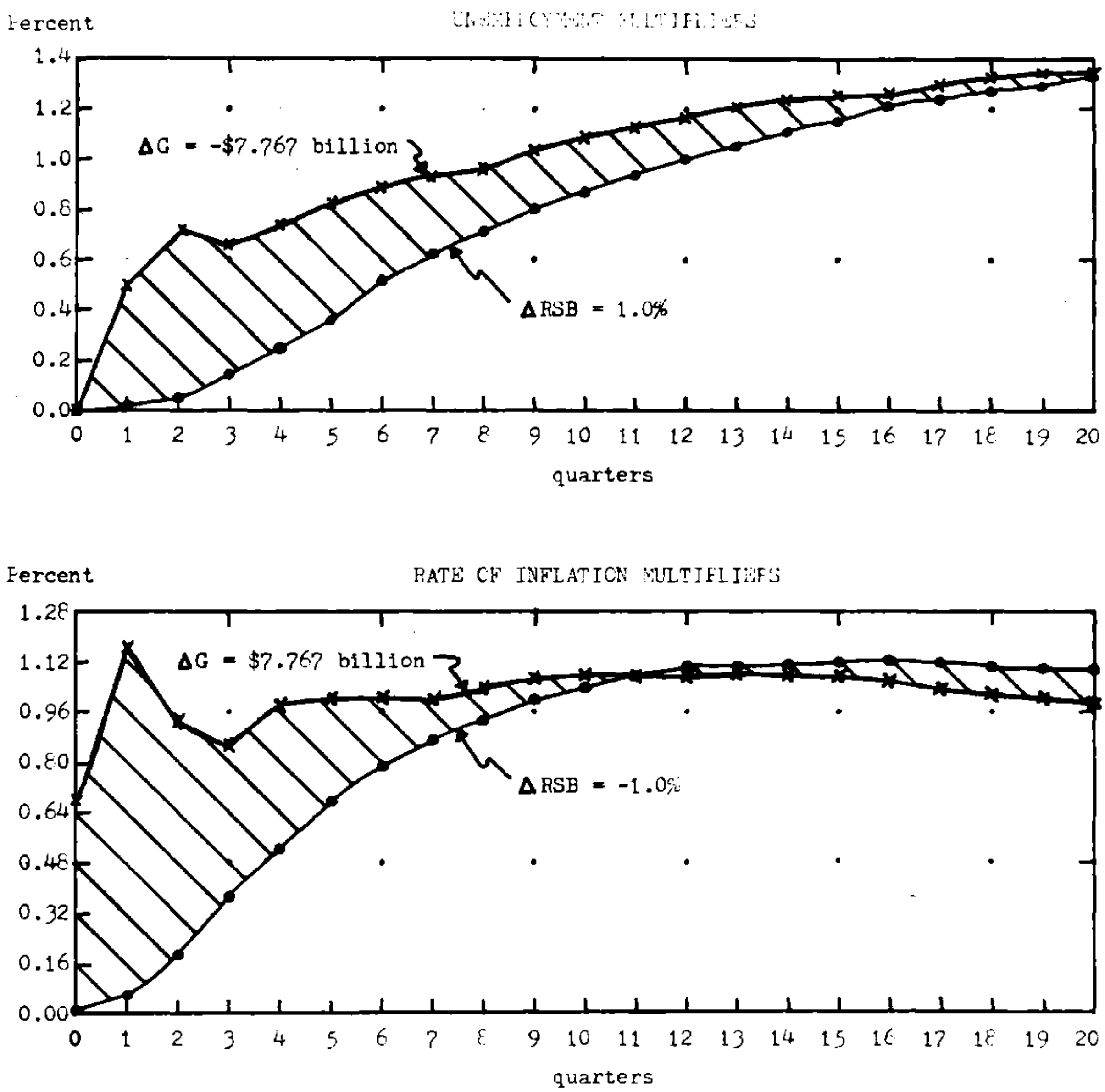


FIGURE 3.2 Equal Cost Policy Multipliers

authority, it is clear that a monetary-fiscal tug-of-war will lead to an expansionary fiscal policy which is enough stronger than the contractionary monetary policy to produce reduced unemployment and increased inflation. Moreover, since the monetary authority knows that the fiscal will "win" a tug-of-war, there is an incentive to secure a bargain which brings a similar stabilization result with less effort to both: coordinated expansionary policies.

The multipliers suggest a plausible way to interpret coordination. While the fiscal competitive incentive is to immediately pump up spending to take advantage of the policy-effectiveness advantage, the consequence is a costly (to the monetary authority and "society") inflationary spike. A coordinated policy can delay the reduction in unemployment until a smooth transition can be achieved which avoids the inflationary spike: drop RSB immediately and increase G gradually. Furthermore, since UR's dynamics are so slow relative to RGP's, the coordinated policy can switch to contraction at the end, momentarily lowering RGP while hardly affecting UR.

3.2 <u>The Results</u>

Figure 3.3 summarizes the results in a monetary versus fiscal cost frontier. Several "predicted" features are prominent:

1) The historical cost is out of line with the simultaneous "reaction" function simulation: D.1.

2) Nominally, the fiscal cost is more than 5 times the monetary cost.

3) The fiscal authority "wins" a monetary-fiscal tug-of-war: E.1 and F.1.

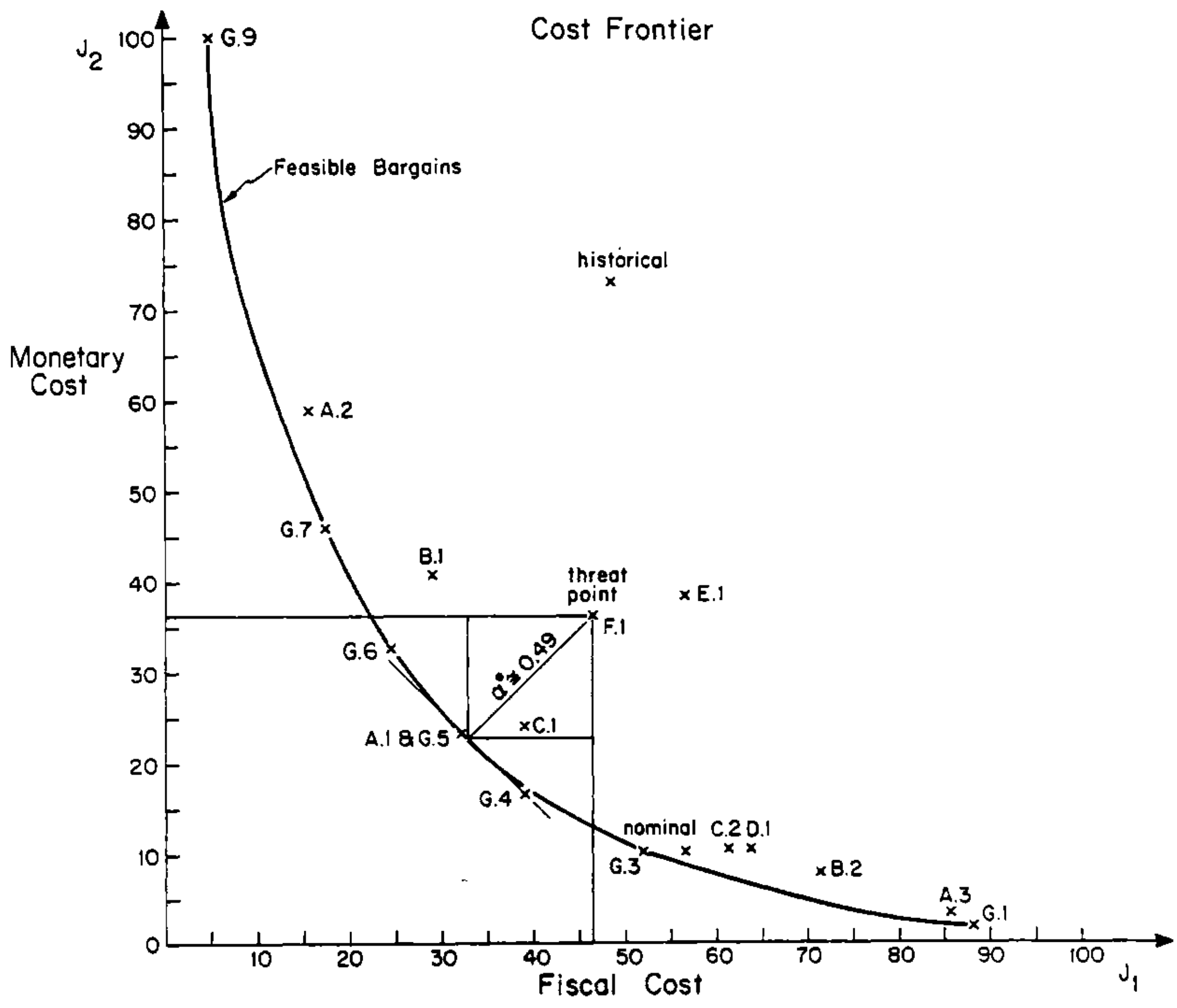


FIGURE 3.3 Cost Frontier

4) Both authorities can do better than competing by choosing coordinated policies: A.1, G.4, G.5 and G.6.

5) In Nash competition, searching for simultaneous "one-sided" optimality, the authorities achieve the worst simultaneous cost positions: E.1 and F.1.

Other features also emerge:

6) Both authorities do better in the closed-loop than in the open-loop Nash competitive equilibrium. Thus, the closed-loop represents the Nash bargaining threat point.

7) The relation of the threat point to the feasible bargains renders the optimal bargain: $\alpha^* = 0.49$ very near the centralized solution: A.1.

8) The "reaction" function strategies are better for the non-optimizing authority than fixed (target) strategies.

The remainder of this section will discuss these results in more detail. An attempt is made to distinguish from mechanical features the details which are important to understanding monetary and fiscal interaction.

A. Centralized Experiments

Figure 3.4 shows the control, inflation, unemployment and GNP trajectories for experiment A.1: "the best society can hope for." The controls exhibit the cooperative characteristics:

1) Gradual fiscal expansion;

2) Immediate monetary expansion; and

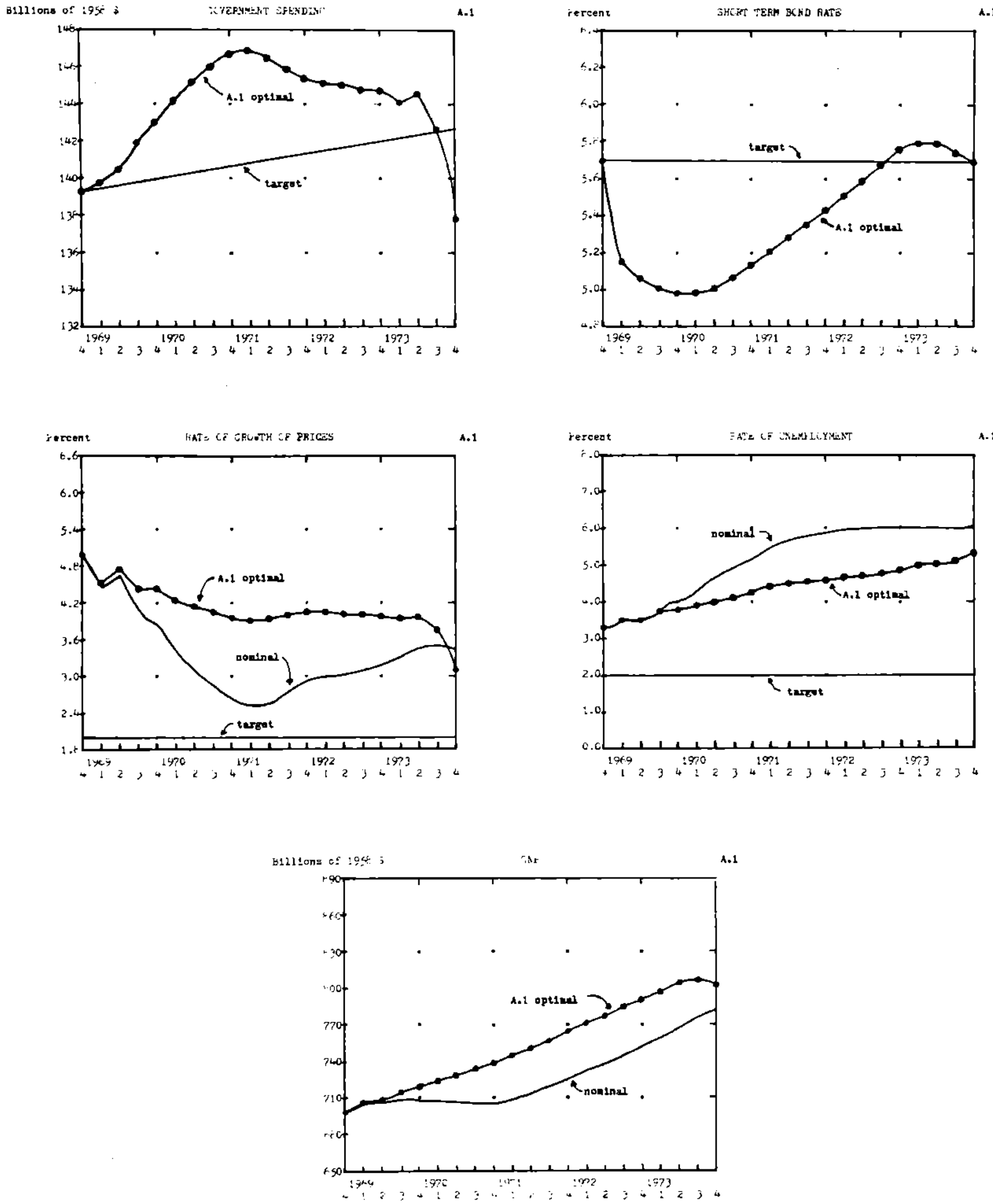


FIGURE 3.4   Experiment A.1

3) Policy-reversal at the end.

These result in a slow expansion of GNP which leads to an exchange of increased inflation for reduced unemployment.

Monetary policy tapers off dramatically toward the end because of its loss in effectiveness; that is, the monetary multipliers in Figure 3.2 show that a policy begun less than 12 quarters from the end of the control period has substantially less impact than it would, were it begun earlier. Like the policy-reversal at the end, this is clearly a mechanical detail which depends on the length of the control period. It is highly unlikely that an actual policy would be chosen to ignore consequences after 1973-74.

An interesting point is the form of cooperation: the indication is that there may be gain to "society" in a more gradual phasing of fiscal strategies from the old into the new hinting that monetary policies can be more sudden without the adverse consequences. Figures 3.5 and 3.6 relate A.1's inflation employment balance to that which the joint authority could achieve if it focused solely on either unemployment (A.2) or inflation (A.3). A.2 and A.3 call for extremes in expansionary and contractionary policies, respectively. These experiments define how far "society" would be willing to go toward realizing either inflation or unemployment objectives given the mode, the experimental setting and the cost criteria. They show that a roughly 1% decrease in inflation requires equally costly control policies to a 1% decrease in unemployment (as is apparent in Figure 3.2's multipliers). Because of the high nominal unemployment

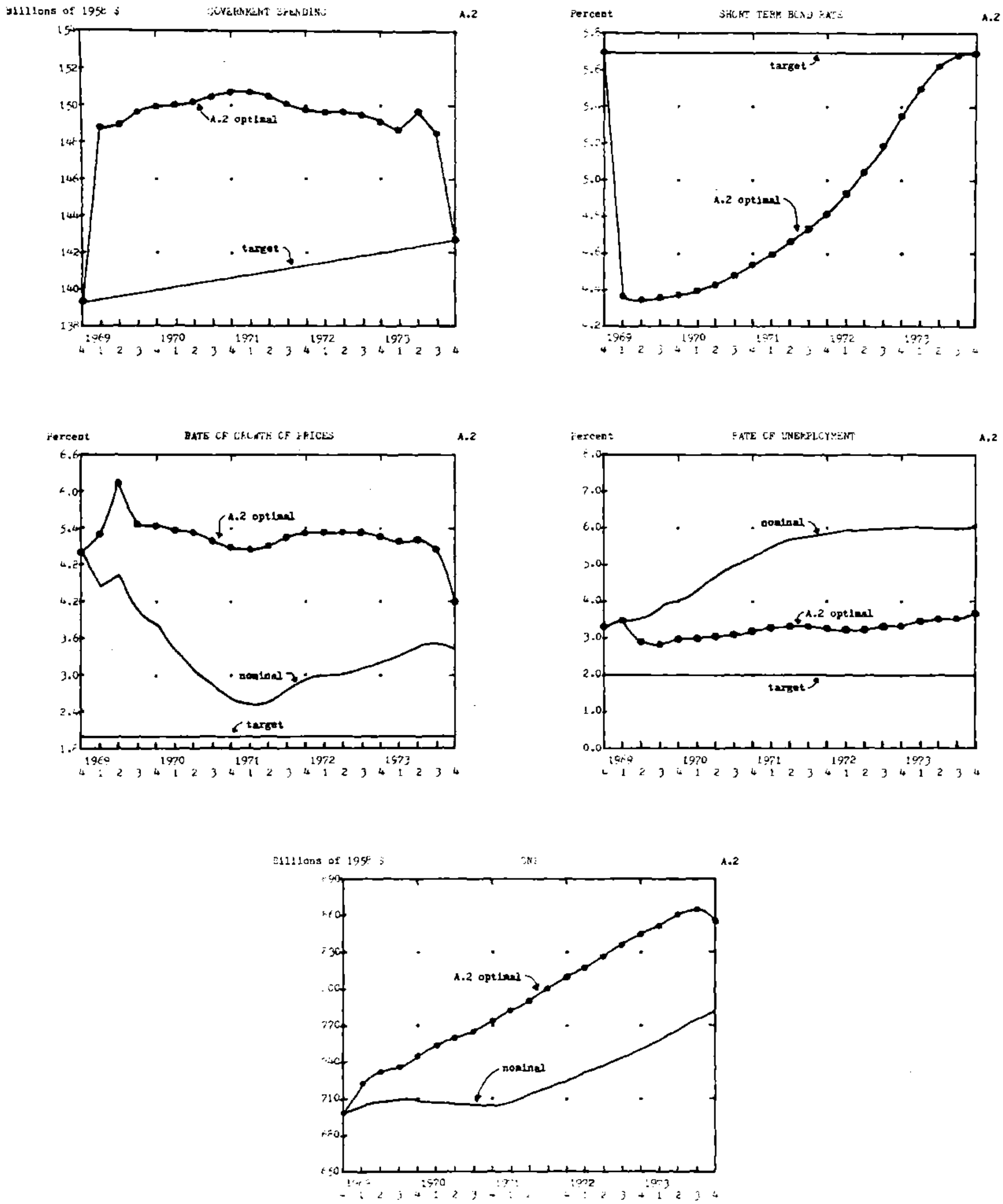


FIGURE 3.5 Experiment A.2

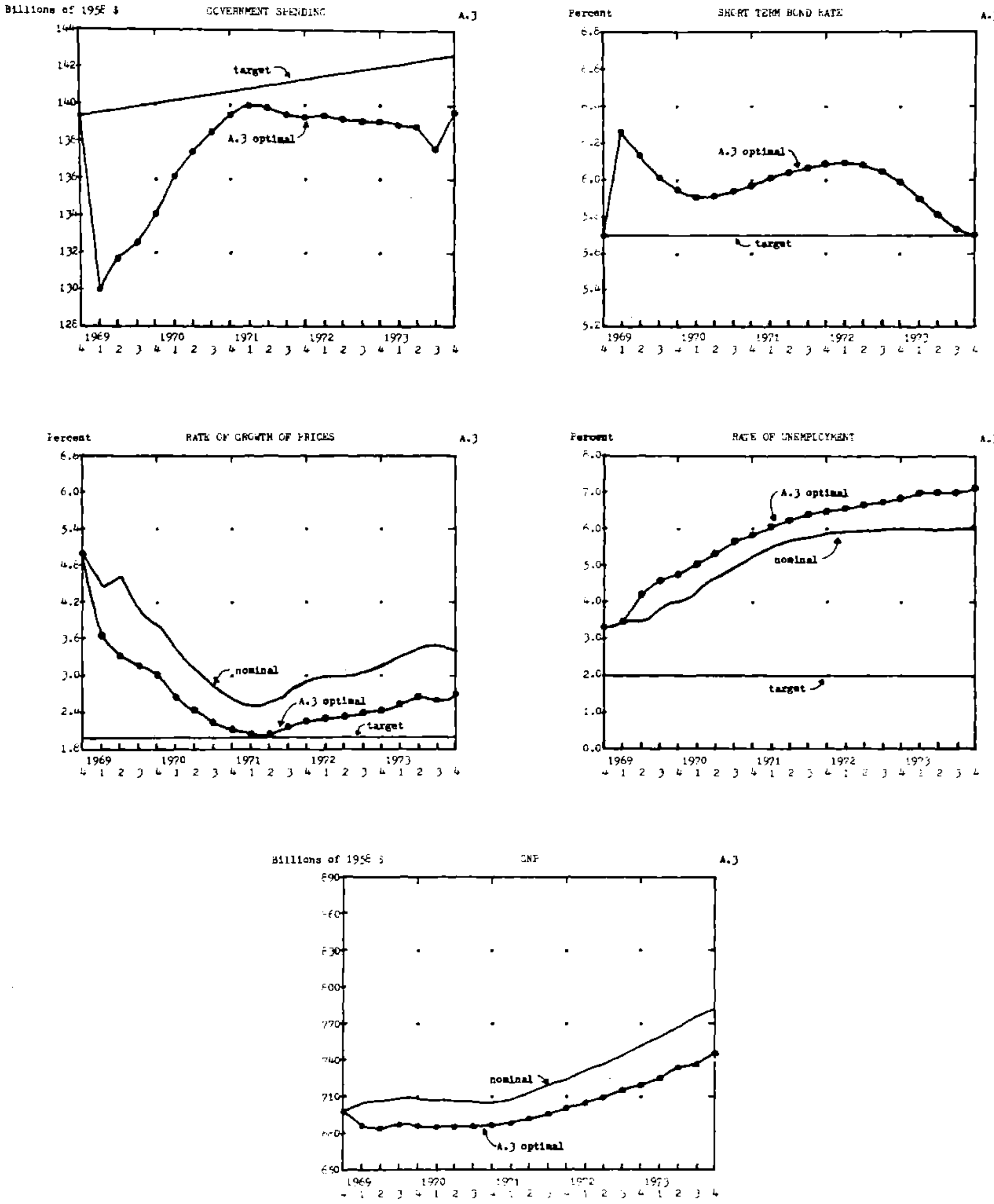


FIGURE 3.6 Experiment A.3

trajectory, it is too costly for the authorities to drive unemployment below 3% while inflation can be quite easily brought within about 1/2% of its objective. The dramatic shape of the inflation-aimed policies, particularly government spending, derives from the time-path of the nominal inflation target-deviation. The authorities are encouraged to enter the period with strongly contractionary policies, loosen up toward 1971 and exit with another contraction.

The inflationary spike inherent to sharply expansionary fiscal policy is quite evident in A.2. In A.3 this property is utilized to advantage in reverse by enabling a dramatic immediate relative deflation. The smooth fiscal expansion in A.1 avoids either response.

B. <u>One-Sided Exogenous</u>

It is important that conflicting objectives have been chosen for the two authorities. A comparison of B.1 in Figure 3.7 with A.2 and of B.2 in Figure 3.8 with A.3 shows that each policy-maker chooses virtually identical strategies in pursuing its goal whether alone or with the direct aid of the other.

Clearly, the non-optimizing authority does not choose well in adopting a fixed (target) strategy in these experiments when the other authority optimizes.

C. <u>One-Sided Endogenous "Reaction"</u>

C.1's monetary "reaction" reported in Figure 3.9 has very much the same "leaning against the wind" flavor as the historical trajectory for the short-term bill rate. As inflation becomes relatively high and

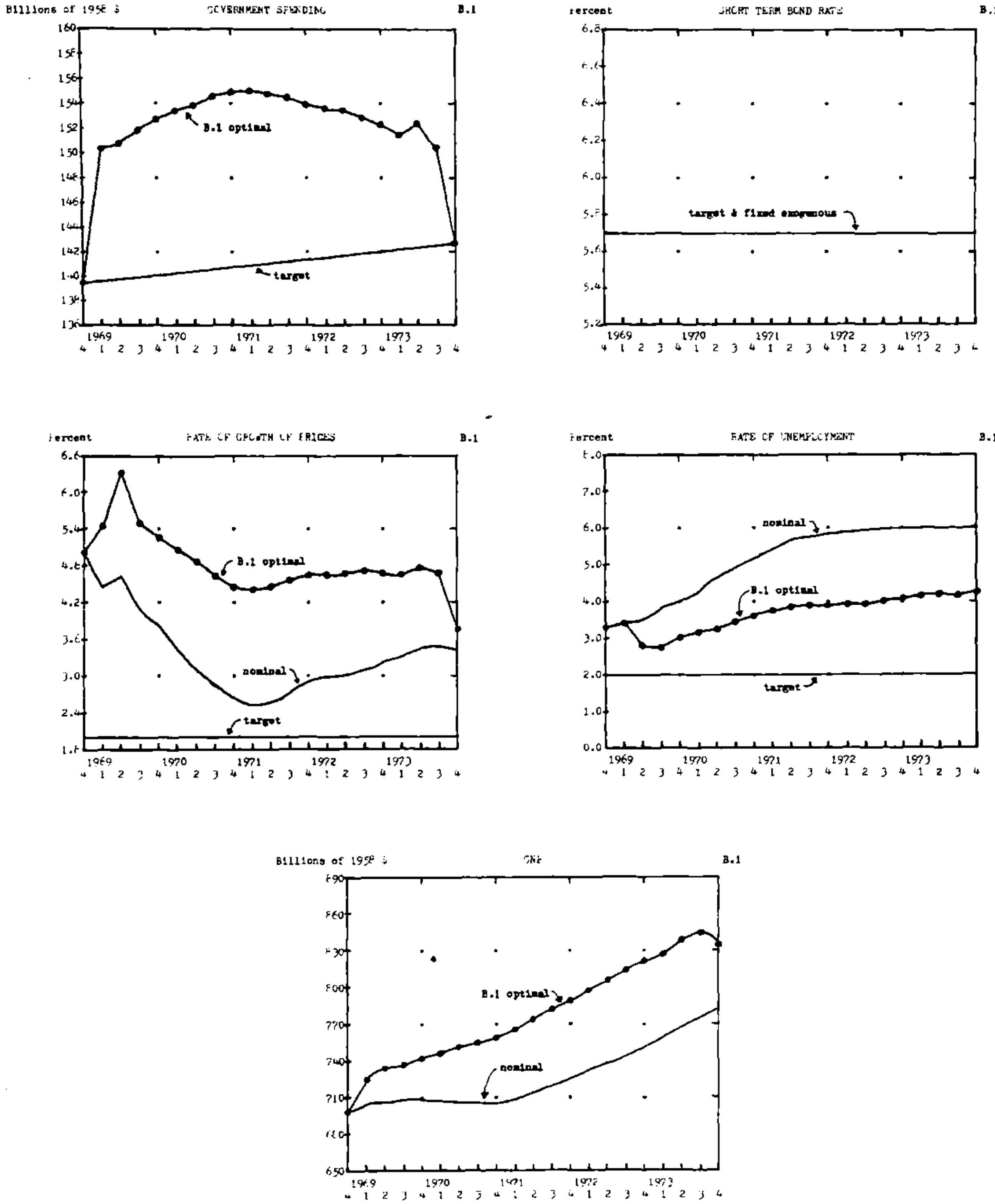
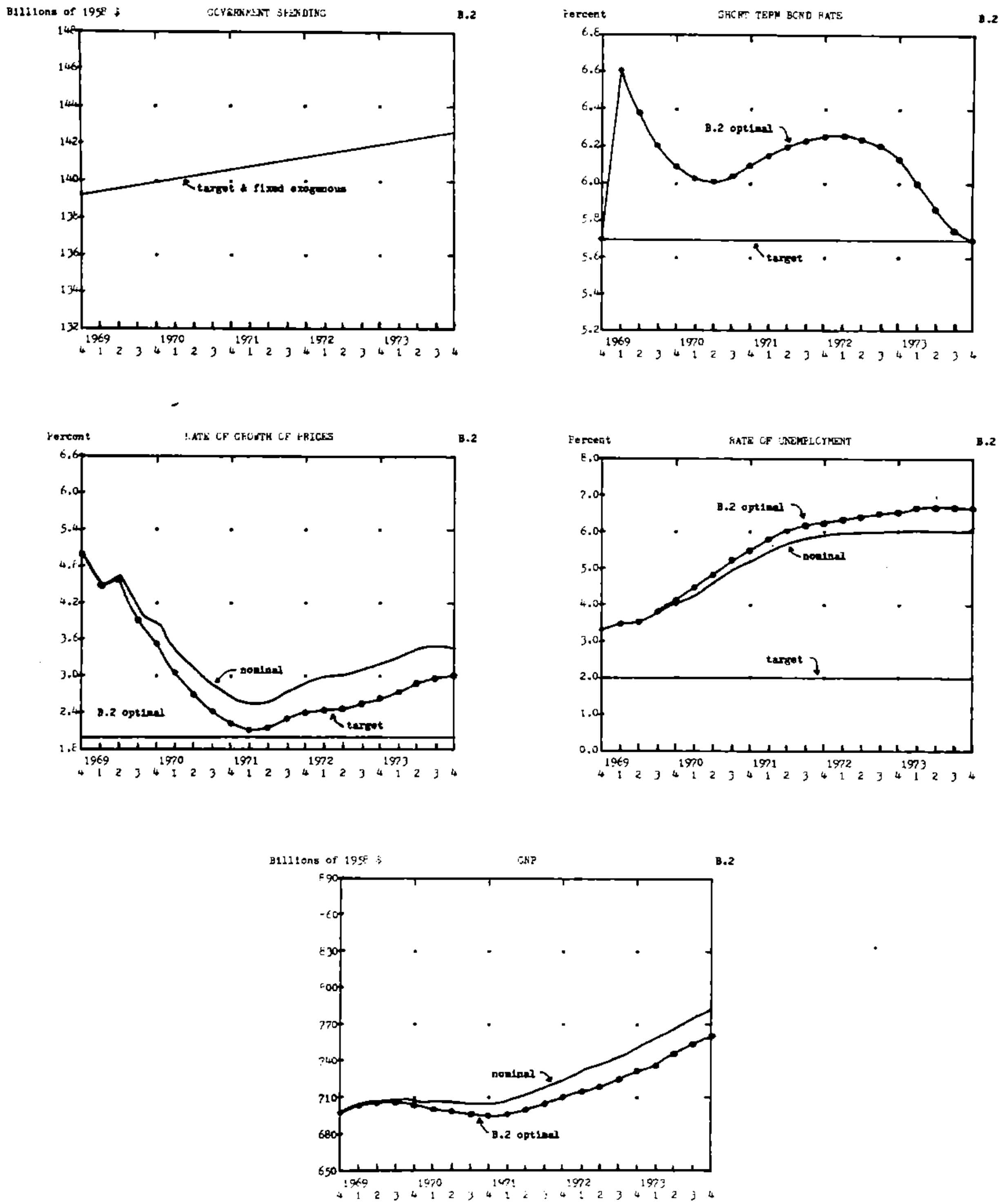


FIGURE 3.7 Experiment B.1



<u>FIGURE 3.8</u> Experiment B.2

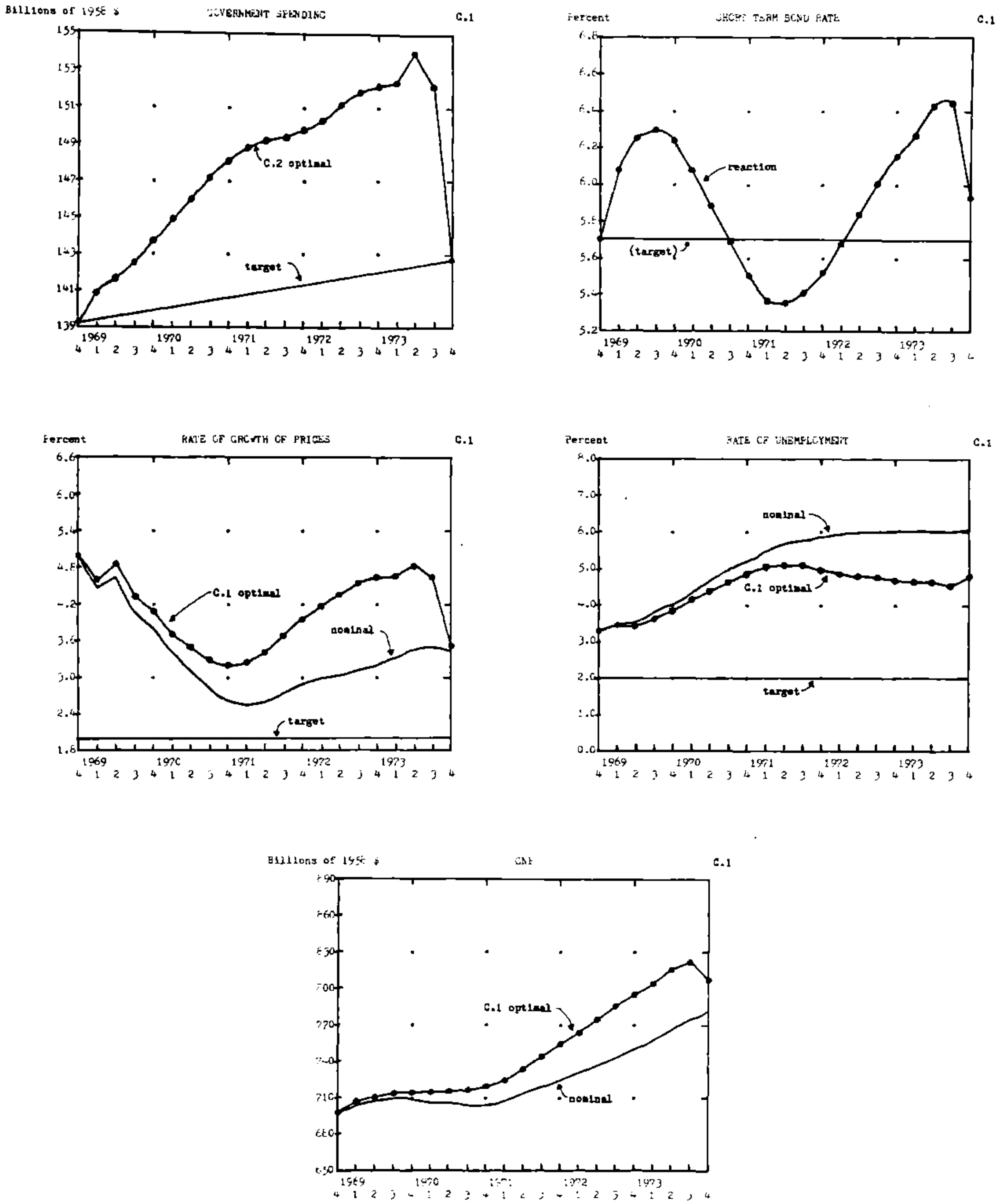


FIGURE 3.9 Experiment C.1

unemployment low, RSB increases to slow GNP down. Whn GNP levels out, inflation drops and unemployment climbs, RSB drops to stimulate GNP.

The fiscal authority, in choosing an optimal strategy, recognizes the quite large and sensitive reaction of the monetary: by building a slow but ever-increasing expansion, the monetary authority is maneuvered into boosting the expansion of the period's last 3 years, only to react too late to have great effect before the period's close.

This outcome suggests that if real-world monetary policy is of a fixed-rule nature which is in fact quite sensitive to the balance of stabilization objectives, there may be an incentive to the fiscal authority to manipulate that rule when objectives are conflicting.

On the other hand, fiscal policy appears quite insensitive to stabilization objectives. Figure 3.10 shows a fiscal reaction which nearly defies logic given the historical trajectory until one remembers that the experimental initial condition for G is $7 billion below the historical value and that nominal inflation is so much lower over the last two-thirds of the period than historical. The small scale of the response to these aberration makes sense in light of the relative insensitivity of the fiscal compared with the monetary reaction function.

While the fiscal reaction does not succeed in budging the unemployment-inflation trade-off, neither does the monetary authority (more than marginally) in choosing its optimal policy. This contrasts with B.2 in which the fiscal authority is unreacting.

Consequently, C.2 suggests the conjecture that the relative (short-term) insensitivity of fiscal "decision-rules" to stabilization objectives

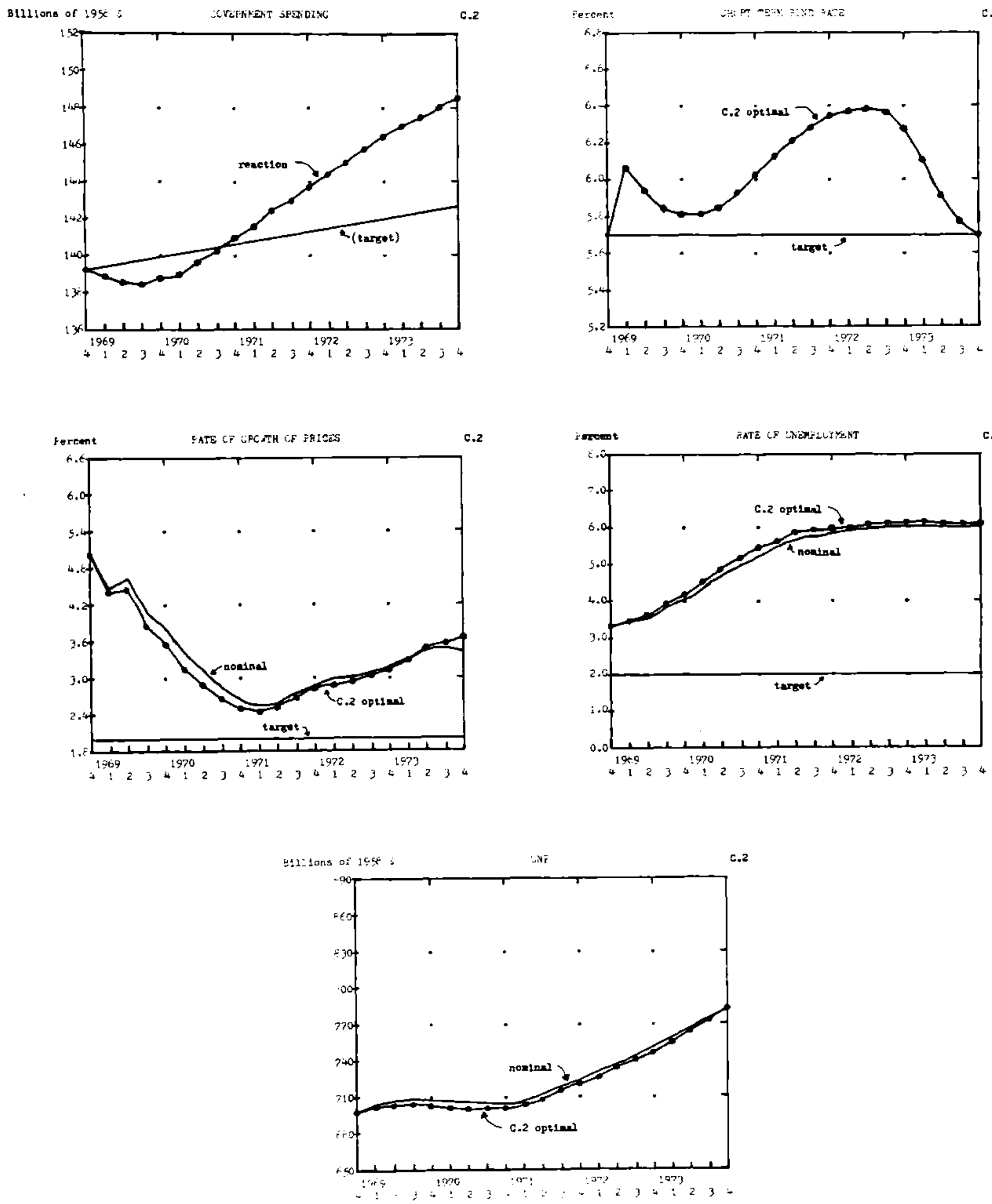


FIGURE 3.10 Experiment C.2

prevents the monetary authority from effectively manipulating these rules to its own advantage: the fiscal authority sticks to pretty much the same plan whatever happens.

D. Two-Sided "Reaction:

Given the fiscal insensitivity it is not surprising to find virtually the same fiscal reaction in the two-sided case (Figure 3.11) as in C.2. Neither the fiscal nor the monetary strategy resembles historical actions. This result reinforces the earlier conjecture that the historical and experimental settings do not correspond well.

E. Nash Open-Loop Competition

The fiscal authority's greater incentive and short-term policy-effectiveness lead to its success in lowering unemployment at the monetary expense of higher inflation (see Figure 3.12). Sharp fiscal action produces the inflationary spike and directly conflicting monetary response which characterize non-cooperation.

It is obvious on comparing E.1's trajectories to A.1's that a similar rebalancing of the unemployment-inflation trade-off is effected in both, while the policy-deviation costs are much greater. The fiscal authority succeeds in a short-lived lowering of unemployment relative to the centralized rate, but at the cost of three times the increase in spending. The monetary authority's response sends the short-term interest rate near 8% and above 7% over most of the control period. This policy succeeds in lowering inflation to centralized rates, but at roughly 10 times the control-deviation cost. Consequently, both authorities fare worse under competition.

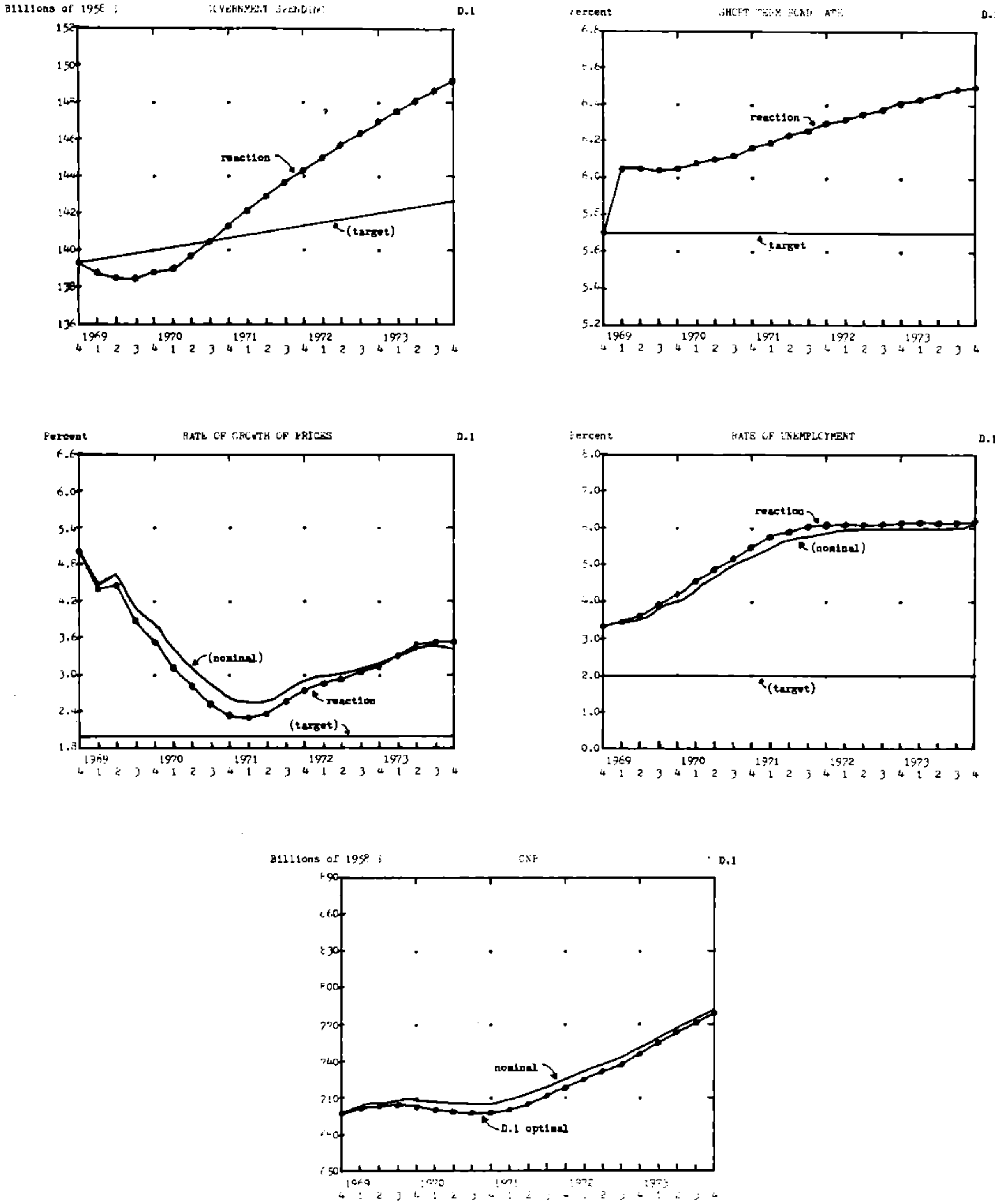


FIGURE 3.11 Experiment D.1

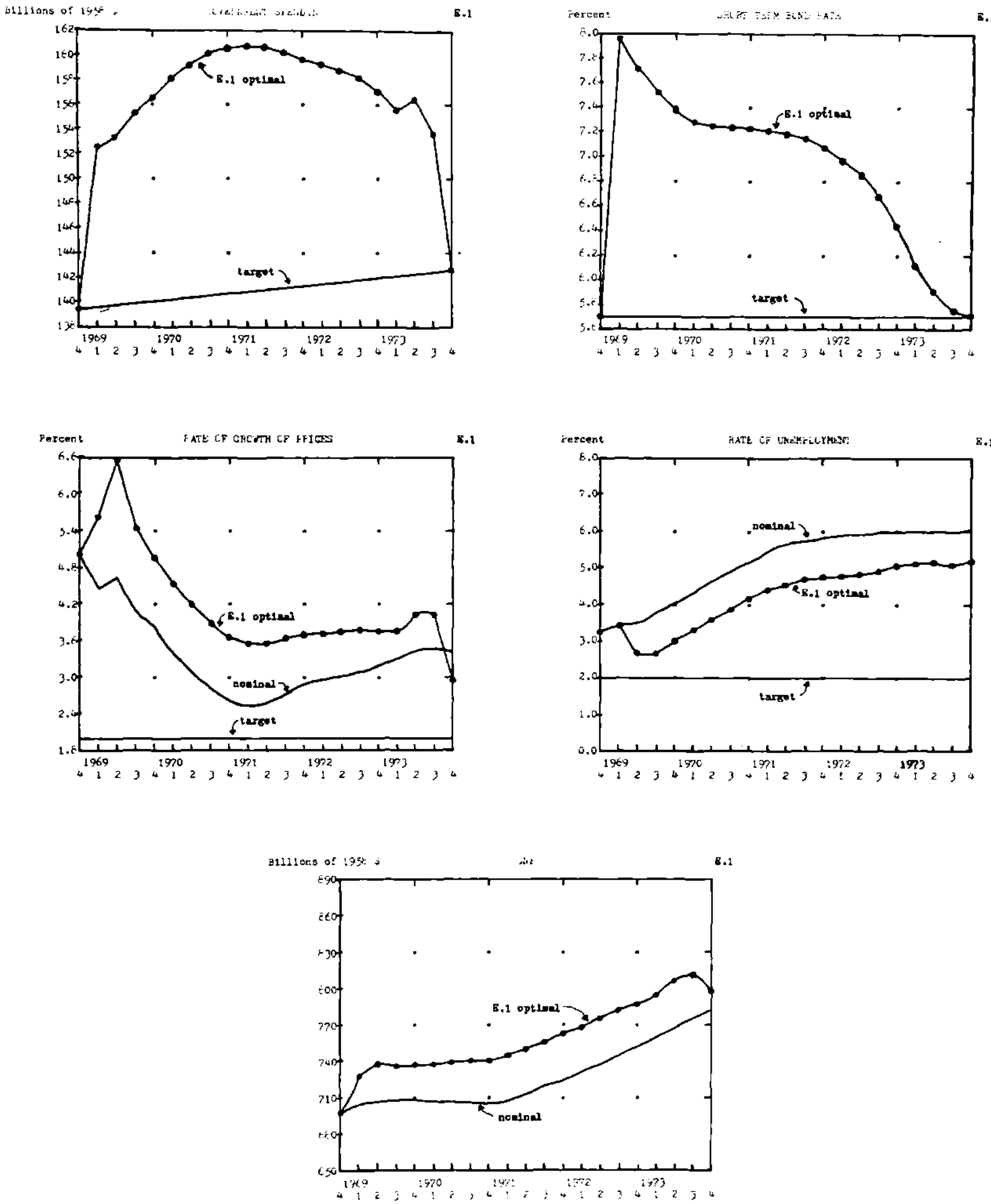


FIGURE 3.12 Experiment E.1

F. Nash Closed-Loop Condition

Figure 3.13 presents the closed-loop trajectories; by and large, these are qualitatively the same as the open-loop except that monetary contractionary policy is cut by one-third. In terms of unemployment and inflation objectives, the fiscal authority fares better in the closed-loop than open-loop competition, while the monetary fares a bit worse. However, the monetary policy-deviation cost is so reduced that both authorities are better off in terms of their objective functions.

The particular manner in which the closed-loop strategies relate to the open-loop strategies in these experiments does not provide insight into the relative abilities of the monetary and fiscal authorities to benefit from the feedback representation because both authorities do better. One suspects that the fiscal short-term effectiveness advantage should enhance its power in closed-loop since a government spending impulse always reduces unemployment and increases inflation before a monetary countermeasure can take effect while an impulse in the short-term bill rate can be counteracted as quickly as any effect manifests itself. Consequently, the fiscal authority should perceive more gain in moving away from its open-loop strategy than the monetary authority.

G. Nash Bargaining

Rather than discuss every feasible bargain, the nearest to the Nash bargain and its neighbors are presented in Figures 3.14, 3.15 and 3.16. The Nash bargain corresponds to $\alpha^* = 0.49$, which is so close to G.5 that the difference is negligible, suggesting only a slight monetary

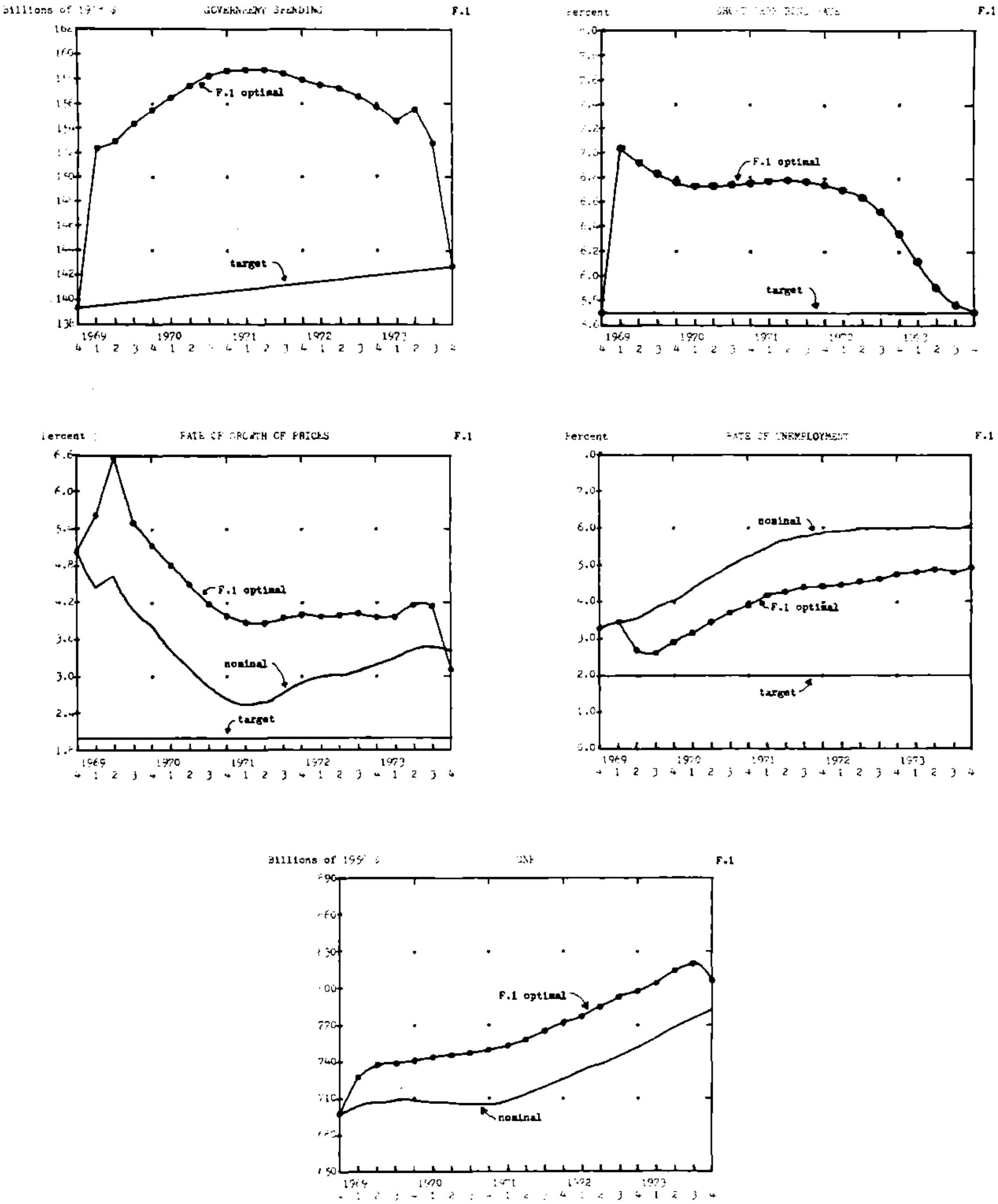


FIGURE 3.13 Experiment F.1

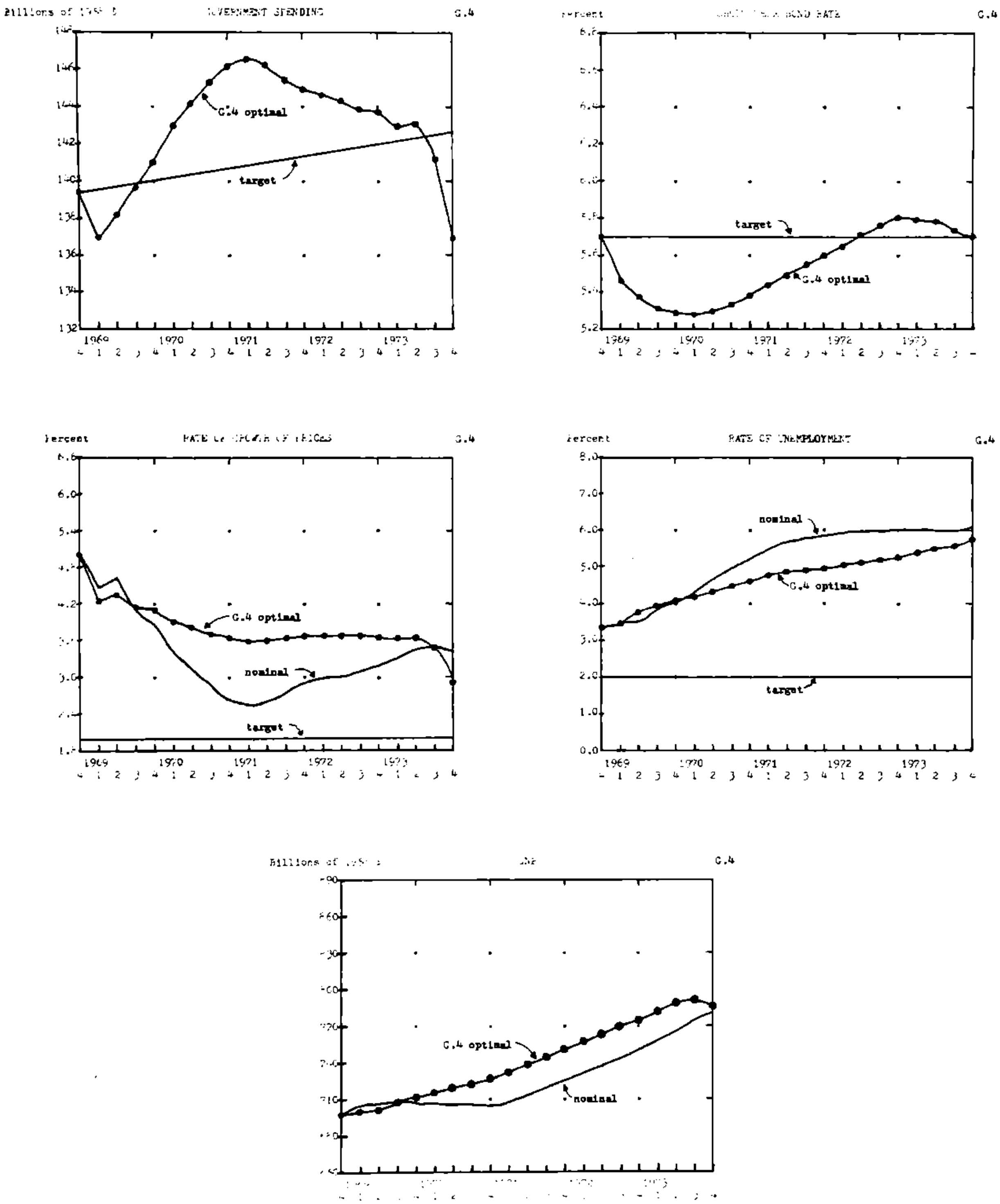


FIGURE 3.14 Experiment G.4

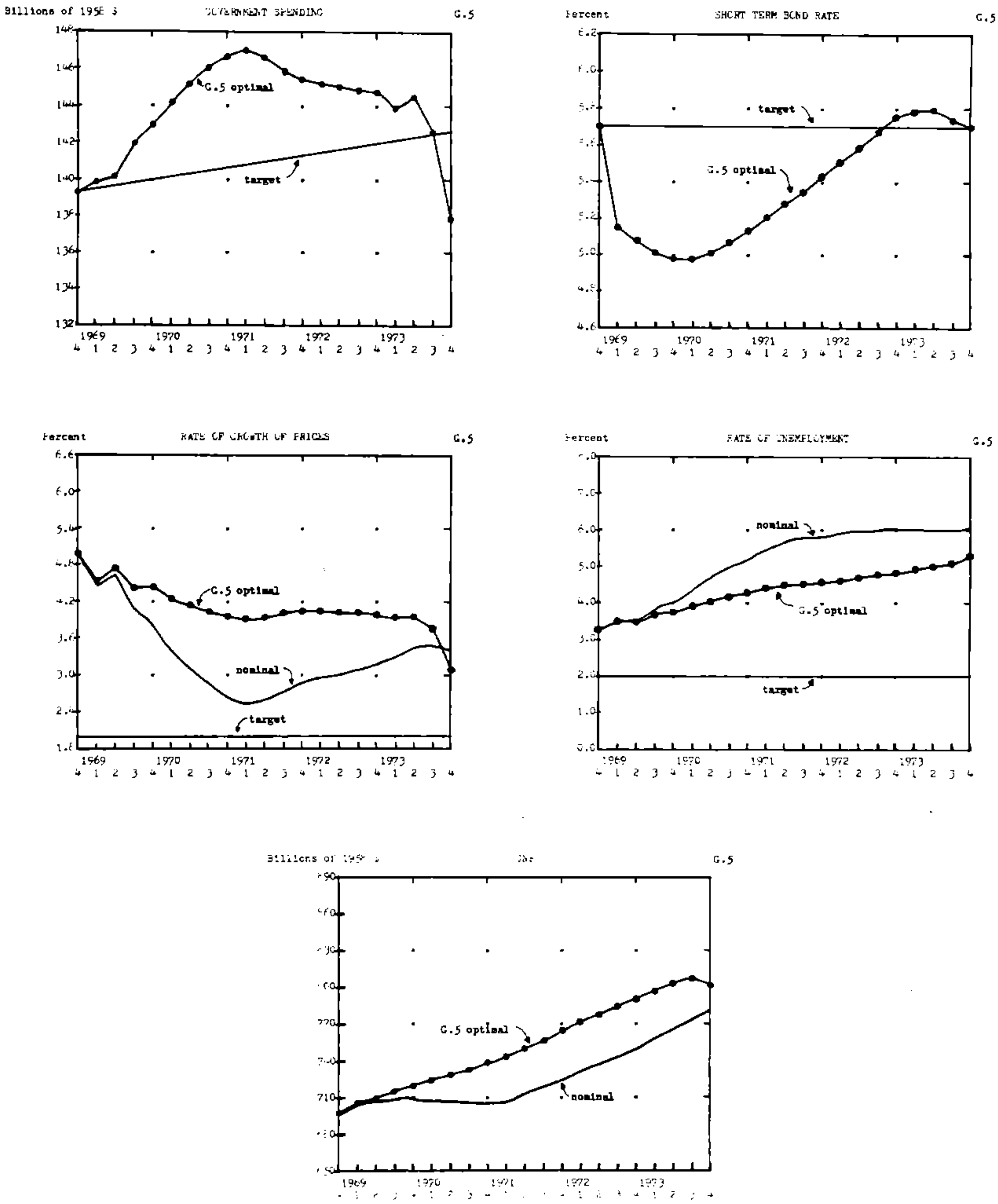


FIGURE 3.15 Experiment G.5

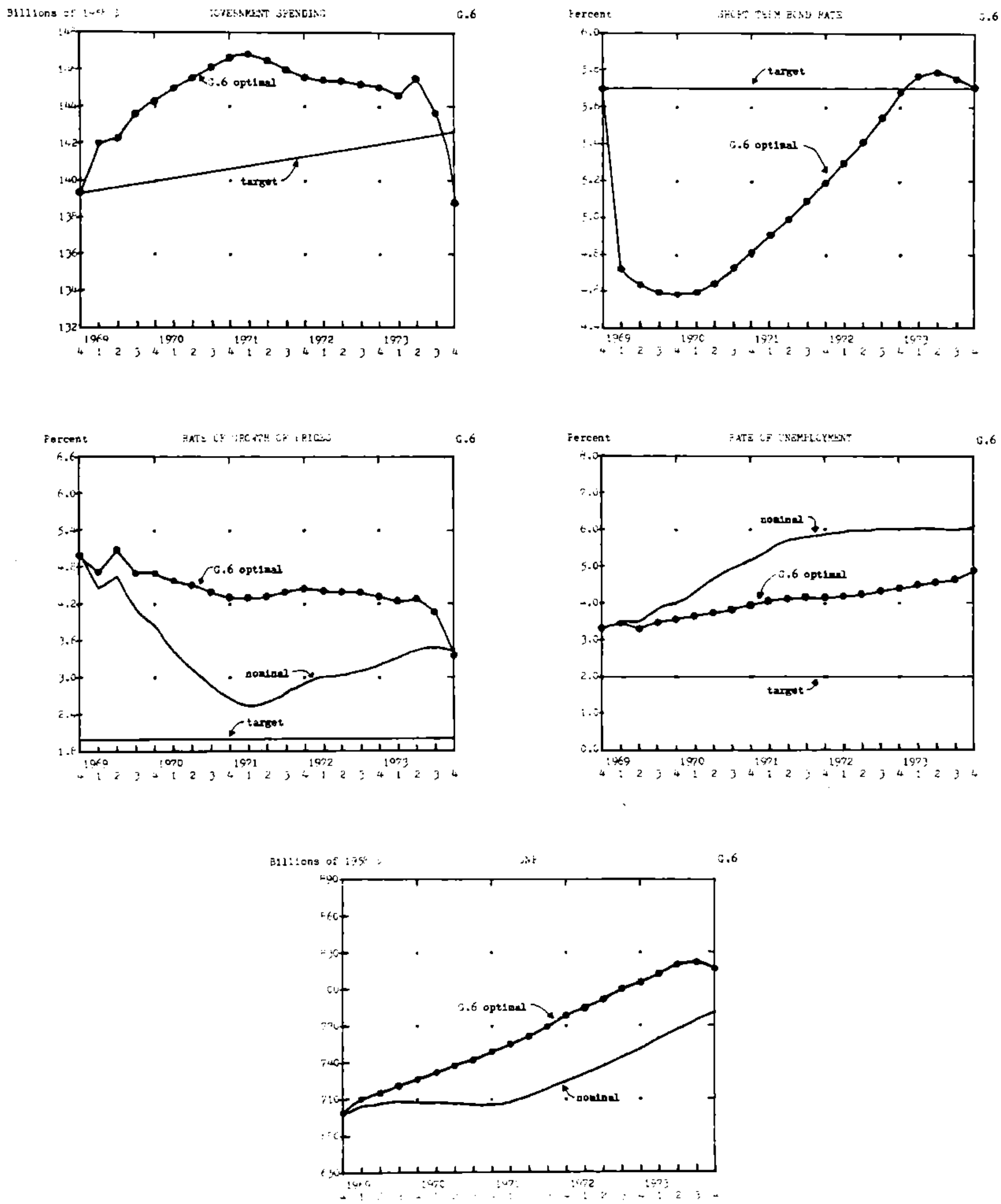


FIGURE 3.16 Experiment G.6

bias. The gain to cooperation is obvious in the small policy-deviations and the substantial stabilization rebalance. That the Nash bargain should be so close to the optimal solution "from society's point of view" is natural given that the conflicting objective functions coincide with the centralized objectives when averaged and that the threat point represents substantial equalization of the unemployment-inflation balance.

The nearby neighbors show that the cooperative tenor of the Nash bargain would not change abruptly were the threat point to move substantially in either authority's favor; only the trade-off changes.

3.3 Discussion and Conclusions

These experiments provide several insights into how the monetary-fiscal balance of power affects stabilization policy in the United States:

- The fiscal authority has a greater short-term policy-effectiveness in relation to unemployment and inflation than the monetary authority since the fiscal leverage is more direct (see Figure 3.2). This advantage gives fiscal policy-makers the potential to bring about short-term reductions in unemployment despite active monetary opposition as indicated in the Nash competitive experiments (see Figures 3.12, 3.13). However, the long fiscal lag between recognizing the need for a policy change and its actual implementation limits the fiscal ability to capitalize on this potential. Historically this has contributed to policy-formation which is relatively insensitive to short-term changes in stabilization targets in comparison with monetary decision-making (see "reaction" functions in

Section 2.3 and "reaction" experiments in Figures 3.9, 3.10 and 3.11).

- In the medium-term, monetary and fiscal policies are comparably effective and each authority can fully counterbalance the other's strategies. The fiscal authority "wins" this study's Nash competition because its cost incentive to reduce unemployment is greater than the monetary incentive to lower inflation (see "nominal" in Figure 3.3). However, as the fiscal authority succeeds in reducing unemployment at the expense of increased inflation, the monetary policy-makers are goaded into stronger opposition until a compromise is reached according to which the monetary cost remains lower than the fiscal cost. So it is clear only that they compromise, not who wins.

- The historical sensitivity of monetary policy-formation to short-term changes in stabilization targets may enable the fiscal authority to manipulate monetary policy-makers as is suggested by the monetary "reaction" experiment: C1. The fiscal manipulation potential hinges, however, on the perhaps unrealistic assumption that the monetary authority will not recognize and compensate for the manipulation. Fiscal insensitivity minimizes such a potential for the monetary authority (see experiment C3).

- Realistic decentralized stabilization policies may lead to equilibria which greatly differ from a centralized interpretation of what is desirable to "society." In this experimental setting, the desired centralized policies exhibit cooperative characteristics which move the inflation-unemployment trade-off toward more inflation and less unemployment (see Figure 3.4). At the other extreme, Nash competition leads to counterproductive policies and a compromise "by force." While the two extremes lead to a similar balance between unemployment and inflation, the competition is characterized by tax or deficit dollars spent to counteract tight money and consequently leads to increased and unnecessary economic disruption (see descriptions of experiments E.1 and F.1).

- On the other hand, decentralized optimal policies may closely resemble what "society wants." In this study Nash bargaining strategies are virtually identical to centralized strategies (see Figure 3.15). This finding is partly the result of the chosen cost functions; however, one can conjecture that the character of Nash bargaining and centralized solutions will always be similar as long as fiscal and monetary objectives are seen reflect an "average" of centralized objectives and fiscal and monetary policy-makers are nearly equally effective in pursuing their objectives.

- Historical policy-formation, as reflected by the fiscal and monetary "reaction" functions, leads to strategies which do not closely resemble either pure cooperation or competition (see Figures 3.9, 3.10). The policy-makers choose strategies which are more effective than simply holding to target trajectories (compare with Figures 3.7, 3.8), and less counterproductive than competition but also less effective than cooperation (see experiments F.1 and G.5).

- Finally, even though objectives and views of the world always differ, cooperation between the fiscal and monetary authorities is likely because of the shared costs to conflict. The greater the counterproductivity in competition, the greater the gains to cooperation (compare Figures 3.13 and 3.15).

These insights are very similar to those reported by Pindyck. Given that a reestimation of Pindyck's macroeconomic model is employed, it is not surprising that the same short-term differential in policy-effectiveness enables the fiscal authority to realize a similar short-lived competitive advantage or that comparable medium-term effectiveness leads to a medium-term compromise which leaves neither authority as close to its objectives as it would have been under cooperation (centralization).

Fair's finding that fiscal-policy effects are quite sensitive to behavioral assumptions about the monetary authority is also supported here. The fiscal responses to monetary behavior, however, exhibit different characters in the two studies. Fair reports that the fiscal authority does better when the Fed holds the bill rate constant than when the Fed "reacts" because the fiscal policy-makers choose stronger policies to achieve similar results. This study suggests that it may not pay the fiscal authority to fight as hard when the Fed "reacts" because of the strength of the monetary response (see experiment C.1).

Optimal monetary policies also appear to be sensitive to assumptions about the behavior of the fiscal authority. The Fed does better when the fiscal decision-makers hold spending to a steady target rate of growth than when they "react" but the "reaction" is so subdued that the optimal monetary strategy is nearly identical in both cases (see experiments B.2, C.2).

A stronger case for one authority's policy sensitivity to differing assumptions about the other's can be based on the differential game experiments, the obvious comparison being between Nash bargaining and competition.

This relates to a fundamental divergence between Pindyck's and Fair's approaches. Fair implicitly assumes that one authority is relatively naive in decision-making compared to the other while Pindyck assumes that they are equally sophisticated. This difference enables Pindyck's analysis to lend more insight into characteristics which are peculiar to decentralization. Nash competition illustrates the potential for policy confrontation and compromise by force. Nash bargaining recognizes and exploits the mutual benefits to cooperation. The differential game approach would seem to be more promising.

The relationship between Pindyck's equations for open-loop and closed-loop Nash competition is not well illuminated by this study. Experiments E.1 and F.1 show that a closed-loop equilibrium can improve both players' positions. It has been argued above that the fiscal short-term effectiveness advantage should enhance its closed-loop performance but the results here are inconclusive.

CONCLUSIONS

Summary

This thesis studies the monetary-fiscal balance of power in U.S. economic stabilization policy-formation as a decentralized, linear quadratic, deterministic optimal control problem. Chapter 1 describes the small macroeconomic model analyzed: a reestimated, linearized version of Pindyck's model as presented in (P2). Block structure analysis, simulations and multipliers characterize the model's dynamic properties.

Chapter 2 outlines a series of experiments designed to illustrate how decentralized policies may differ from centralized policies. Changing assumptions which structure monetary-fiscal interaction define the various experiments which are otherwise identical. These assumptions lead to non-game approaches:

A) Joint (centralized) strategy optimization,

B&C) One authority optimizes while the other holds to either an ad hoc exogenous policy sequence or an empirically-based, endogenous policy "reaction" function (a feedback relation),

D) Both authorities follow policy "reaction" functions,

and to dynamic game approaches:

E) Open-loop Nash non-cooperation,

F) Closed-loop Nash non-cooperation, and

G) Nash bargaining.

Chapter 3 presents the results of the experiments and discusses what insights they yield into decentralized stabilization. The dynamic games illustrate the potential for counterproductive policies when monetary and fiscal objectives conflict and the consequent gains to both authorities in bargaining or cooperation. The non-games indicate how much an authority competitively disadvantages itself by choosing "non-optimal" policies when the other chooses "optimally." Comparison of game and non-game approaches suggests greater potential to game studies of decentralized stabilization.

Contributions

- Game and non-game approaches to understanding decentralized economic stabilization as put forth by Pindyck (P3) and Fair (F1) are compared.

- Closed-loop Nash non-cooperative equations derived by Pindyck (P3) are evaluated and compared to open-loop Nash non-cooperation.

- Nash bargaining is introduced to represent the dynamic game cooperative alternative to competition.

- The sensitivity of monetary-policy effects to assumptions about fiscal behavior is studied, complementing Fair's study of fiscal-policy effects.

Further Research

Several avenues of additional research are suggested:

To reinforce belief in the findings of this thesis similar studies should be made of the other models. For the same reason, the sensitivity of the results to the parameters of the models should be examined.

More insight could perhaps be gained from the same set of game and non-game solutions if the cost functions were chosen to better reflect actual stabilization objectives, not just inflation and unemployment, and not diametrically opposed monetary and fiscal objectives. Better understanding of how historical policies relate to optimal strategies might derive from an experimental setting more like the historical setting. Comparison of Riccati K "optimal" feedback coefficients with "reaction" function parameters might also be instructive.

APPENDIX A: Old Version of Pindyck's Model

$$C = \underset{(1.98)}{11.11} + \underset{(1.81)}{.0831}*YD + \underset{(4.11)}{.5047}*\Delta LIQ + \underset{(11.15)}{.8624}*C_{-1}$$

$R^2 = .998$ SER = 3.27 F(3/68) = 1.6E+4 DW = 1.72

$$\Delta INR = \underset{(.98)}{.569} + \underset{(4.86)}{.1198}*\Delta YD + \underset{(4.35)}{.0564}*\Delta YD_{-1} + \underset{(1.72)}{.0287}*\Delta YD_{-2} + \underset{(2.76)}{.0368}*\Delta YD_{-3}$$

$$+ \underset{(3.27)}{.0806}*\Delta YD_{-4} - \underset{(-1.26)}{.5012}*\Delta RL_{-4} - \underset{(2.74)}{.0153}*(INR_{-1} + INR_{-2})$$

$R^2 = .548$ SER = 1.14 F(5/66) = 16.02 DW = 1.92 $\hat{\rho} = .037$

$$IR = \underset{(10.03)}{12.79} + \underset{(10.83)}{.0351}*YD + \underset{(1.65)}{.8354}*(RL_{-2} - RS_{-2}) - \underset{(-3.63)}{1.016}*RS_{-2} - \underset{(-5.36)}{1.090}*RS_{-4}$$

$$- \underset{(-2.68)}{1.694}*DUM1$$

$R^2 = .729$ SER = .887 F(5/66) = 35.52 DW = 1.22 $\hat{\rho} = .674$

$$IIN = \underset{(2.80)}{9.174} + \underset{(3.18)}{.0737}*YD_{-1} + \underset{(4.40)}{.2791}*(YD - YD_{-2}) - \underset{(-3.97)}{.4530}*(C - C_{-2})$$

$$- \underset{(-3.04)}{.3014}*INV_{-1} + \underset{(5.62)}{.5190}*IIN_{-1}$$

$R^2 = .621$ SER = 2.75 F(5/66) = 21.60 DW = 2.11

$$RS = \underset{(-.53)}{-.499} + \underset{(3.86)}{.0069}*YD + \underset{(1.26)}{.0140}*\Delta YD_{-1} - \underset{(-2.80)}{30.51}*RGM + \underset{(3.15)}{57.21}*(RGP_{-1} + RGP_{-2})$$

$R^2 = .431$ SER = .500 F(4/67) = 12.70 DW = 1.54 $\hat{\rho} = .755$

$$RL = \underset{(2.03)}{.317} + \underset{(1.86)}{.1597}*RS + \underset{(1.91)}{.1750}*\Delta RS + \underset{(2.73)}{.0113}*(YD - YD_{-2}) + \underset{(8.55)}{.7771}*RL_{-1}$$

$R^2 = .940$ SER = .348 F(4/67) = 261.8 DW = 1.92

$$RGP = \underset{(-.44)}{-.00055} + \underset{(4.51)}{.1637}*(RGW + RGW_{-1}) + \underset{(2.21)}{4.35E\text{-}5}*(GNP_{-1} - GNPP_{-1})$$

$$+ \underset{(1.47)}{.0470}*\Delta YD_{-3}/YD_{-3} - \underset{(-2.54)}{.0034}*DUM2 + \underset{(6.87)}{.2375}*(RGP_{-2} + RGP_{-3} + RGP_{-4})$$

$R^2 = .684$ SER = .0026 F(5/66) = 28.53 DW = 1.47

$$W = -.275 + .6870{*}P_{-3} + .0016{*}YD - .0084{*}UR_{-2} + .8376{*}W_{-1} - .0142{*}DUM2$$
$$\quad (-3.19) \quad (3.05) \quad (4.52) \quad (-3.32) \quad (13.94) \quad (-1.56)$$

$R^2 = .999$ SER = .015 F(5/66) = 2.35E+4 DW = 1.84

$$UR = 1.266 - .0205{*}\Delta YD - .0152{*}\Delta YD_{-1} - .0066{*}\Delta YD_{-2} - .0187{*}(GNP_{-1} - GNPP_{-1})$$
$$\quad (3.11) \quad (-3.49) \quad (-2.33) \quad (-1.09) \quad (-4.00)$$

$$+ .0972{*}W_{-2} + .6773{*}UR_{-1}$$
$$\quad (1.42) \quad (8.40)$$

$R^2 = .949$ SER = .243 F(6/65) = 201.0 DW = .96

APPENDIX B: Data Series

C - Personal Consumption Expenditures
(In billions of 1958 dollars)

Quarter	1	2	3	4
1956	279.1	279.6	280.5	283.3
1957	285.1	285.2	287.3	288.0
1958	284.7	287.1	291.6	294.4
1959	300.3	304.6	307.0	307.6
1960	310.3	314.4	313.2	313.8
1961	314.3	318.2	319.4	325.6
1962	328.4	332.2	334.6	339.2
1963	341.4	344.2	348.9	351.1
1964	357.3	363.5	369.7	370.4
1965	377.7	380.9	386.7	397.1
1966	401.7	402.5	407.1	408.2
1967	411.2	416.3	418.3	420.6
1968	428.7	433.6	442.5	444.8
1969	449.2	451.1	453.6	457.2
1970	459.8	461.9	465.3	461.3
1971	471.1	476.5	479.0	485.3
1972	493.0	503.1	509.4	520.0
1973	530.5	529.5	532.2	528.9
1974	526.2	526.3	529.4	520.0
1975	522.9	532.1	539.7	547.5
1976	557.7	563.1	568.2	580.2
1977	587.3	590.0	594.2	607.5

G - Government Purchases of Goods & Services
(In billions of 1958 dollars)

1956	84.6	85.8	85.2	86.4
1957	89.3	89.8	90.1	90.4
1958	92.2	94.2	95.5	98.2
1959	96.3	96.2	95.5	95.0
1960	95.0	96.8	97.8	98.5
1961	100.6	101.4	102.4	105.6
1962	107.2	107.6	109.1	109.3
1963	110.0	109.5	111.8	112.3
1964	113.2	114.2	113.6	114.1
1965	113.5	116.3	118.6	121.9
1966	123.9	125.9	131.1	133.9
1967	137.1	138.7	140.4	141.0
1968	143.6	145.9	146.5	146.0
1969	144.6	145.0	143.5	143.1
1970	141.5	139.8	139.9	140.4
1971	139.9	138.6	140.6	140.8
1972	142.6	142.1	141.4	142.1
1973	143.2	141.0	141.3	141.4
1974	143.8	144.6	145.0	145.0
1975	145.6	147.2	148.6	148.9
1976	148.1	148.4	148.5	148.5
1977	147.9	151.6	153.8	155.5

GNP - Gross National Product
(In billions of 1958 dollars)

1956	437.3	437.7	437.9	441.5
1957	443.3	443.7	447.8	442.3
1958	434.2	437.0	448.4	461.4
1959	468.9	481.6	474.0	479.6
1960	489.2	486.4	482.1	478.3
1961	479.8	490.3	497.3	508.5
1962	517.3	523.1	527.1	529.1
1963	533.8	539.3	550.1	553.4
1964	561.1	570.0	575.9	578.1
1965	594.1	601.7	612.2	626.3
1966	638.4	643.8	650.6	654.4
1967	653.8	657.7	666.0	672.7
1968	680.4	692.0	700.6	704.6
1969	711.6	715.0	716.4	712.9
1970	709.3	709.8	714.5	707.8
1971	724.1	732.5	736.1	744.5
1972	760.7	775.1	783.5	799.7
1973	816.2	815.1	816.5	818.1
1974	806.3	804.3	797.6	783.1
1975	763.8	770.3	795.1	801.9
1976	823.6	834.6	843.0	847.8
1977	865.4	880.4	888.4	901.2

GNPP - Potential GNP (Scaled series in Pindyck & Rubinfeld's textbook)
(In billions of 1958 dollars)

1956	413.4	415.1	419.6	421.6
1957	424.4	429.5	435.7	441.9
1958	450.1	455.3	460.4	467.4
1959	474.5	480.9	482.3	485.4
1960	487.4	490.4	494.1	495.5
1961	499.9	507.2	512.0	517.9
1962	524.9	526.8	532.3	539.1
1963	545.7	547.6	554.2	558.2
1964	560.8	568.5	574.2	580.9
1965	592.0	594.7	603.0	612.5
1966	619.9	629.6	641.2	648.2
1967	655.7	662.9	671.9	685.4
1968	698.1	704.3	714.6	728.5
1969	736.9	747.0	755.4	764.6
1970	774.6	784.4	793.9	806.9
1971	820.5	837.2	843.7	861.0
1972	884.7	892.7	898.6	912.0
1973	919.4	929.1	927.6	935.3
1974	946.0	957.0	957.0	966.6
1975	976.2	986.0	995.8	1005.7
1976	1015.8	1026.0	1036.3	1046.6
1977	1057.1	1067.9	1078.6	1089.4

IIN - Inventory Investment: Change in Business Inventories
(In billions of 1958 dollars)

1956	6.39	4.54	4.28	4.45
1957	2.15	2.34	3.23	-2.22
1958	-5.43	-5.12	0.10	4.08
1959	3.94	10.18	0.00	6.32
1960	10.91	4.14	2.30	-2.78
1961	-2.88	1.53	4.85	4.74
1962	7.81	6.66	5.99	3.81
1963	5.37	4.90	6.64	5.13
1964	4.29	5.83	5.43	5.51
1965	9.95	8.02	9.21	6.70
1966	10.03	13.19	11.15	14.87
1967	10.39	5.13	8.58	9.64
1968	4.31	8.44	6.37	5.58
1969	6.76	8.21	8.99	4.63
1970	1.84	3.05	4.17	1.85
1971	5.25	6.62	3.28	2.37
1972	3.14	6.71	7.97	7.03
1973	7.57	9.72	9.54	17.56
1974	8.13	7.45	1.29	3.71
1975	-11.70	-13.16	2.52	-1.83
1976	7.28	9.08	10.55	-0.44
1977	6.60	10.20	10.96	6.18

INV - Level of Business Inventories (1956-1 value is assumed initial condition)
(In billions of 1958 dollars)

1956	111.3	112.5	113.5	114.7
1957	115.2	115.8	116.6	116.0
1958	114.7	113.4	113.4	114.4
1959	115.4	117.8	117.8	119.6
1960	122.3	123.3	123.9	123.2
1961	122.5	122.9	124.1	125.3
1962	127.2	128.9	130.4	131.3
1963	132.7	133.9	135.6	136.8
1964	137.9	139.4	140.7	142.1
1965	144.6	146.6	148.9	150.6
1966	153.1	156.4	159.2	162.9
1967	165.5	166.8	168.9	171.3
1968	172.4	174.5	176.1	177.5
1969	179.2	181.2	183.5	184.6
1970	185.1	185.9	186.9	187.4
1971	188.8	190.3	191.2	191.7
1972	192.5	194.2	196.2	198.0
1973	199.9	202.3	204.7	209.1
1974	211.1	212.9	213.3	214.2
1975	211.3	208.0	208.6	208.2
1976	210.0	212.3	214.9	214.8
1977	216.6	219.0	221.7	223.2

INR - Fixed Nonresidential Investment; gross private domestic investment in nonresidential structures and producers durable equipment
(In billions of 1958 dollars)

1956	45.27	46.03	46.58	46.32
1957	46.43	46.37	47.40	46.24
1958	43.27	41.32	40.44	41.59
1959	42.67	44.06	45.43	45.56
1960	47.10	47.33	46.09	46.02
1961	45.12	46.02	46.31	47.69
1962	48.70	50.26	50.95	50.35
1963	49.85	51.37	52.66	53.91
1964	54.73	56.38	57.97	59.60
1965	63.56	66.22	68.52	71.73
1966	73.96	74.84	75.55	75.13
1967	73.21	72.92	72.55	73.50
1968	75.47	74.81	76.21	78.58
1969	80.41	80.20	81.29	80.58
1970	78.80	78.85	78.21	74.84
1971	76.10	75.61	75.85	77.39
1972	80.01	80.87	82.27	86.71
1973	90.70	92.19	93.55	93.45
1974	94.55	94.45	92.15	87.65
1975	82.30	79.12	78.32	78.52
1976	80.20	81.87	83.63	83.98
1977	87.69	89.18	90.11	91.01

IR - Fixed Residential Investment in Nonfarm Structures
(In billions of 1958 dollars)

1956	21.95	21.81	21.35	21.01
1957	20.41	19.95	19.77	19.84
1958	19.43	19.41	20.78	23.08
1959	25.68	26.58	26.05	25.11
1960	25.97	23.74	22.68	22.74
1961	22.74	23.04	24.34	24.84
1962	25.23	26.32	26.46	26.36
1963	27.32	29.37	30.09	31.09
1964	31.55	30.14	29.18	28.57
1965	29.41	30.24	29.21	28.88
1966	28.84	27.38	25.70	22.36
1967	21.88	24.56	26.05	27.98
1968	28.38	29.25	29.04	29.64
1969	30.58	30.46	28.94	27.30
1970	27.33	26.14	26.94	29.44
1971	31.76	35.18	37.33	38.64
1972	41.90	42.33	42.38	43.95
1973	44.29	42.73	40.00	36.87
1974	33.57	31.54	29.74	26.70
1975	24.73	25.06	26.52	28.80
1976	30.30	32.15	32.16	35.51
1977	35.98	39.43	39.37	41.05

M - Money Supply - Demand Deposits & Currency (M1)
(In billions of 1958 dollars)

1956	144.3	143.5	142.0	141.5
1957	140.1	139.6	138.4	137.5
1958	136.8	138.1	138.6	139.9
1959	140.6	140.8	141.0	139.6
1960	138.0	137.5	138.1	138.2
1961	138.9	139.4	139.6	140.7
1962	140.4	140.5	139.9	139.9
1963	140.6	141.9	142.8	143.3
1964	143.7	144.6	146.2	147.6
1965	147.4	147.8	148.5	150.3
1966	151.2	151.3	150.3	149.1
1967	149.6	151.2	153.2	153.7
1968	153.8	155.0	156.7	157.7
1969	158.6	158.2	156.7	155.6
1970	154.7	154.8	155.4	155.3
1971	155.6	157.3	158.5	158.2
1972	158.9	160.9	162.8	164.7
1973	165.4	165.1	164.3	162.7
1974	161.9	159.6	157.0	154.0
1975	150.3	150.8	150.8	149.5
1976	149.0	150.3	150.2	150.7
1977	150.3	150.9	152.6	153.0

P - Implicit Price Deflator for GNP
(In billions of 1958 dollars)

1956	93.9	94.7	95.8	96.6
1957	97.7	98.1	99.0	99.1
1958	99.5	99.7	100.3	100.6
1959	101.4	102.1	102.5	102.9
1960	103.6	103.8	104.2	104.4
1961	104.3	104.8	105.2	105.4
1962	106.3	106.6	106.9	107.6
1963	108.0	108.1	108.4	109.1
1964	109.5	109.8	110.4	110.7
1965	111.6	112.2	112.9	113.5
1966	114.6	116.0	116.6	117.7
1967	118.4	118.8	120.0	121.4
1968	122.9	124.4	125.5	217.3
1969	128.6	130.3	132.4	134.0
1970	136.0	137.7	138.9	140.8
1971	143.0	145.0	146.2	147.5
1972	149.6	150.6	151.9	153.6
1973	155.8	158.5	161.4	165.1
1974	168.5	173.2	178.0	183.3
1975	188.1	190.7	194.1	197.1
1976	199.1	201.5	203.8	206.5
1977	209.2	212.8	215.3	218.4

RL - Long-term Interest Rate: Market Yield on Long-term U.S. Government Bonds
(Nominal Rate, % per annum, not seasonally adjusted)

1956	2.887	2.990	3.127	3.300
1957	3.273	3.433	3.630	3.533
1958	3.250	3.150	3.570	3.753
1959	3.913	4.060	4.157	4.167
1960	4.223	4.107	3.823	3.907
1961	3.827	3.803	3.973	4.007
1962	4.060	3.890	3.977	3.877
1963	3.910	3.980	4.013	4.103
1964	4.157	4.163	4.143	4.140
1965	4.150	4.143	4.197	4.347
1966	4.557	4.583	4.777	4.697
1967	4.440	4.710	4.933	5.327
1968	5.243	5.303	5.073	5.417
1969	5.883	5.917	6.137	6.530
1970	6.563	6.820	6.650	6.267
1971	5.820	5.883	5.750	5.507
1972	5.650	5.657	5.603	5.607
1973	6.093	6.217	6.587	6.307
1974	6.637	7.047	7.270	6.977
1975	6.673	6.960	7.080	7.223
1976	6.910	6.880	6.780	6.553
1977	7.010	7.100	6.970	7.150

RS - Short-term Interest Rate: Market Yield on 3-month Treasury Bills
(Nominal rate, % per annum, not seasonally adjusted)

1956	2.327	2.567	2.583	3.033
1957	3.100	3.137	3.353	3.303
1958	1.760	0.957	1.680	2.690
1959	2.773	3.000	3.540	4.230
1960	3.873	2.993	2.360	2.307
1961	2.350	2.303	2.303	2.460
1962	2.723	2.713	2.840	2.813
1963	2.907	2.937	3.293	3.497
1964	3.530	3.477	3.497	3.683
1965	3.890	3.873	3.867	4.167
1966	4.610	4.587	5.043	5.210
1967	4.513	3.660	4.300	4.753
1968	5.050	5.520	5.197	5.587
1969	6.093	6.197	7.023	7.353
1970	7.210	6.677	6.330	5.353
1971	3.840	4.250	5.010	4.230
1972	3.437	3.770	4.220	4.863
1973	5.700	6.603	8.323	7.500
1974	7.617	8.153	8.190	7.360
1975	5.750	5.393	6.330	5.627
1976	4.917	5.157	5.150	4.673
1977	4.630	4.840	5.497	6.100

TRANSFER - Federal Government Transfer Payments
(In billions of 1958 dollars)

1956	16.11	16.33	16.57	16.69
1957	16.78	18.36	18.02	19.19
1958	20.12	21.71	22.05	21.59
1959	21.47	21.10	21.45	22.23
1960	21.67	22.41	22.87	23.79
1961	25.38	26.02	25.89	25.38
1962	25.48	25.07	25.44	25.88
1963	26.58	25.90	26.08	26.25
1964	26.65	26.26	26.14	26.32
1965	26.81	26.65	29.12	27.81
1966	28.77	27.66	28.79	30.86
1967	32.33	32.75	33.20	32.64
1968	33.35	35.28	36.00	36.05
1969	36.14	36.97	36.23	36.49
1970	36.67	42.05	41.52	42.72
1971	42.43	45.99	45.92	45.84
1972	45.93	45.38	45.34	50.04
1973	49.66	50.43	50.77	50.58
1974	53.57	55.79	57.07	58.18
1975	61.66	65.79	66.21	66.05
1976	67.10	65.27	67.05	66.76
1977	67.33	65.71	67.06	66.64

UR - Unemployment Rate
(In percentage terms, seasonally adjusted)

1956	4.033	4.200	4.133	4.133
1957	3.933	4.100	4.233	4.933
1958	6.300	7.367	7.333	6.637
1959	5.833	5.100	5.267	5.600
1960	5.133	5.233	5.533	6.267
1961	6.800	7.000	6.767	6.200
1962	5.633	5.533	5.567	5.533
1963	5.767	5.733	5.500	5.567
1964	5.467	5.200	5.000	4.967
1965	4.900	4.667	4.367	4.100
1966	3.867	3.833	3.767	3.700
1967	3.833	3.833	3.800	3.900
1968	3.733	3.567	3.533	3.400
1969	3.400	3.433	3.567	3.567
1970	4.167	4.733	5.167	5.867
1971	5.900	5.900	6.033	5.967
1972	5.767	5.633	5.600	5.333
1973	4.933	4.900	4.800	4.767
1974	5.033	5.167	5.600	6.567
1975	8.233	8.867	8.500	8.300
1976	7.733	7.500	7.733	7.767
1977	7.467	7.100	6.900	6.633

W - Nominal Wage Rate
(Dollars per hour)

1956	1.904	1.932	1.969	2.013
1957	2.043	2.067	2.083	2.118
1958	2.156	2.178	2.219	2.227
1959	2.254	2.258	2.283	2.317
1960	2.374	2.381	2.396	2.414
1961	2.434	2.496	2.527	2.551
1962	2.570	2.606	2.649	2.682
1963	2.704	2.726	2.764	2.800
1964	2.854	2.886	2.937	2.956
1965	2.976	2.988	3.068	3.117
1966	3.161	3.226	3.308	3.365
1967	3.414	3.489	3.545	3.593
1968	3.687	2.753	3.837	3.882
1969	3.934	2.993	4.085	4.157
1970	4.273	4.327	4.420	4.457
1971	4.562	4.610	4.717	4.725
1972	4.809	4.870	4.920	5.025
1973	5.114	5.172	5.245	5.360
1974	5.457	5.584	5.731	5.904
1975	6.105	6.207	6.283	6.381
1976	6.539	6.660	6.798	6.924
1977	7.077	7.133	6.277	7.413

WLTH - Household Net Worth
(In trillions of 1958 dollars)

1956	1.335	1.343	1.351	1.358
1957	1.349	1.363	1.374	1.373
1958	1.371	1.394	1.419	1.460
1959	1.498	1.530	1.556	1.576
1960	1.573	1.575	1.577	1.586
1961	1.619	1.657	1.680	1.712
1962	1.721	1.700	1.673	1.674
1963	1.711	1.758	1.785	1.803
1964	1.841	1.873	1.895	1.928
1965	1.948	1.973	1.988	3.018
1966	2.026	1.989	1.938	1.901
1967	1.936	2.008	2.048	2.056
1968	2.056	2.100	2.153	2.190
1969	2.192	2.178	2.153	2.139
1970	2.123	2.083	2.056	2.074
1971	2.129	2.180	2.185	2.172
1972	2.202	2.274	2.311	2.354
1973	2.401	2.406	2.400	2.387
1974	2.361	2.322	2.254	2.179
1975	2.182	2.251	2.283	2.287
1976	2.341	2.404	2.442	2.464
1977	2.495	2.526	2.557	2.589

YD - Disposable Income
(In billions of 1958 dollars)

1956	385.2	385.5	385.7	388.8
1957	390.5	390.8	394.4	389.6
1958	382.4	384.9	394.9	406.4
1959	413.0	424.1	417.4	422.4
1960	430.9	428.4	424.6	421.3
1961	422.6	431.8	438.0	447.8
1962	455.6	460.7	464.3	466.0
1963	470.2	475.0	484.5	487.4
1964	494.2	502.0	507.3	509.2
1965	523.3	530.0	539.2	551.6
1966	562.3	567.0	573.0	576.4
1967	575.8	579.3	586.5	592.5
1968	599.3	609.5	617.1	620.6
1969	626.7	629.8	631.0	627.9
1970	624.7	625.1	629.3	623.4
1971	637.7	645.1	648.3	655.7
1972	670.0	682.6	690.0	704.4
1973	718.9	717.9	719.2	720.6
1974	710.2	708.4	702.5	689.7
1975	672.8	678.4	700.3	706.3
1976	725.3	735.1	742.5	746.7
1977	762.2	775.4	782.5	793.8

APPENDIX C: State Space Form of the Model, Implicit and Explicit

The RSB-MODEL is put into state space form for the eigenvector-eigenvalue analysis and the various control experiments. Since the model is estimated in implicit form, the implicit state variable representation is presented as well as the explicit representation to assist comparison with the structural relationships.

The method of converting a structural to a state space representation is not unique; an attempt is made here at a minimal realization. The basic method of conversion is explained in Pindyck's thesis (P1, Ch. 5). The order of the realization is minimized by substituting in the YD and GNP identities, eliminating RGW by substituting the RGW equation into the RGP equation, and defining a state equal to GNP(-2) since none of the components of GNP appear lagged more than twice on their own.

TABLE C.1 shows the variable definitions and the vector equations. Note that x(1) refers to the first entry in the state vector, x, at time t; x1(1) refers to that entry at time t-1. Since only the first eight entries of the state vector are represented implicitly, A1 has non-zero entries only in its upper left-hand (8x8) submatrix. Consequently, the implicit to explicit transformation: $(I - A1)^{-1}$ operates on only the first eight rows of the A2, B1, and C1 matrices. TABLES C.2-C.7 report the A1, $(I - A1)^{-1}$, A2, B1, and C1 matrices of the implicit system, and the A, B, and C matrices of the explicit system.

TABLE C.1: State Variable Definitions

States:

x(1) = INV
x(2) = C
x(3) = INR
x(4) = IR
x(5) = IIN
x(6) = RL
x(7) = RGP
x(8) = UR
x(9) = C(-1) = xl(2)
x(10) = INR(-1) = xl(3)
x(11) = IR(-1) = xl(4)
x(12) = IIN(-1) = xl(5)
x(13) = GNP(-2) = xl(9) + xl(10) + xl(11) + xl(12) + xl(24)
x(14) = GNP(-3) = xl(13)
x(15) = GNP(-4) = xl(14)
x(16) = RL(-1) = xl(6)
x(17) = RL(-2) = xl(16)
x(18) = RL(-3) = xl(17)
x(19) = RL(-4) = xl(18)
x(20) = RGP(-1) = xl(7)
x(21) = UR(-1) = xl(8)
x(22) = UR(-2) = xl(21)
x(23) = G = u(1)
x(24) = G(-1) = xl(23)
x(25) = RSB = u(2)
x(26) = RSB(-1) = xl(25)
x(27) = RSB(-2) = xl(26)

Controls:

u(1) = G
u(2) = RSB

Exogenous Inputs:

z(1) = TR
z(2) = ΔWLTH
z(3) = DUM
z(4) = GNPP(-1)
z(5) = 1.0

Implicit System:

$$x_t = A1*x_t + A2*x_{t-1} + B1*u_t + C1*z_t$$

Explicit System:

$$x_t = A*x_{t-1} + B*u_t + C*z_t \qquad \text{where: } A = (I-A1)^{-1}*A2$$
$$B = (I-A1)^{-1}*B1$$
$$C = (I-A1)^{-1}*C1$$

TABLE C.2: Al Matrix

$$
\begin{array}{c} \\ 1 \\ \updownarrow \\ 8 \\ 9 \\ \updownarrow \\ 27 \end{array}
\begin{array}{c} 1 \leftrightarrow 8 \quad 9 \leftrightarrow 27 \\ \left[\begin{array}{c:c} Al_{11} & Al_{12} \\ \hdashline Al_{21} & Al_{22} \end{array}\right] \end{array}
$$

Al_{12}, Al_{21} and Al_{22} are zero matrices.

Al_{11} is presented below.

0.0	0.0	0.0	0.0	.25	0.0	0.0	0.0
0.0	.12348	.12348	.12348	.12348	0.0	0.0	0.0
0.0	.070777	.070777	.070777	.070777	0.0	0.0	0.0
0.0	.01012	.01012	.01012	.01012	0.0	0.0	0.0
0.0	-.23946	.3292	.3292	.3292	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	.0001051	.0001051	.0001051	.0001051	0.0	.10604	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE C.3: $(I - A1)^{-1}$ Matrix

$$\begin{array}{c} \\ 1 \\ \updownarrow \\ 8 \\ 9 \\ \updownarrow \\ 27 \end{array} \overset{\begin{array}{cc} 1 \leftrightarrow 8 & \quad 9 \leftrightarrow 27 \end{array}}{\left[\begin{array}{c:c} (I-A1_{11})^{-1} & 0 \\ \hdashline 0 & I \end{array}\right]}$$

$(I-A1_{11})^{-1}$ is presented below.

1.0	-.090124	.12065	.12065	.37065	0.0	0.0	0.0
0.0	1.09925	.23010	.23010	.23010	0.0	0.0	0.0
0.0	.056889	1.13189	.13189	.13189	0.0	0.0	0.0
0.0	.008134	.018858	1.01886	.018858	0.0	0.0	0.0
0.0	-.36050	.482598	.482598	1.48260	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
0.0	.0000945	.0002191	.0002191	.0002191	0.0	1.11862	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0

<u>TABLE C.4: A2 Matrix</u>

	1 ↔ 9	10 ↔ 18	19 ↔ 27
1 ↕ 8	$A2_{11}$	$A2_{12}$	$A2_{13}$
9 ↕ 18	$A2_{21}$	$A2_{22}$	$A2_{23}$
19 ↕ 27	$A2_{31}$	$A2_{32}$	$A2_{33}$

The nine submatrices are in the following figures.

TABLE C.4.a: $A2_{11}$ Matrix

	1)	2)	3)	4)	5)	6)	7)	8)	9)
1)	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2)	0.0	.78927	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3)	0.0	-.015228	.979462	-.015228	-.015228	0.0	0.0	0.0	-.009169
4)	0.0	0.0	0.0	1.29240	0.0	0.0	0.0	0.0	0.0
5)	-.40114	.1148	.1148	.1148	.1148	0.0	0.0	0.0	.23946
6)	0.0	0.0	0.0	0.0	0.0	.94306	0.0	0.0	0.0
7)	0.0	0.0	0.0	0.0	0.0	0.0	.32983	0.0	-.0001051
8)	0.0	-.03706	-.03706	-.03706	-.03706	0.0	0.0	.93255	.03578

TABLE C.4.b: $A2_{12}$ Matrix

	10)	11)	12)	13)	14)	15)	16)	17)	18)
1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3)	-.014479	-.009169	-.009169	-.00312	.00294	-.0460	0.0	0.0	-1.35401
4)	0.0	-.45175	0.0	0.0	0.0	0.0	.472	0.0	0.0
5)	-.3292	-.3292	.04076	0.0	0.0	0.0	0.0	0.0	0.0
6)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7)	-.0001051	-.0001051	-.0001051	0.0	0.0	0.0	0.0	0.0	0.0
8)	.03578	.03578	.03578	0.0	0.0	0.0	0.0	0.0	0.0

TABLE C.4.c: $A2_{13}$ Matrix

	19)	20)	21)	22)	23)	24)	25)	26)	27)
1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2)	0.0	0.0	0.0	0.0	0.0	0.0	-.18347	-.18347	-.18347
3)	1.35401	0.0	0.0	0.0	-.015228	-.009169	0.0	0.0	0.0
4)	0.0	0.0	0.0	0.0	0.0	0.0	-.38887	-.472	0.0
5)	0.0	0.0	0.0	0.0	.1148	-.3292	0.0	0.0	0.0
6)	0.0	0.0	0.0	0.0	0.0	0.0	-.13063	0.0	0.0
7)	0.0	.32983	0.0	-.00025	0.0	-.0001051	0.0	0.0	0.0
8)	0.0	0.0	0.0	0.0	-.03706	.03578	0.0	0.0	0.0

TABLE C.4.d: $A2_{21}$ Matrix

	1)	2)	3)	4)	5)	6)	7)	8)	9)
9)	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10)	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
11)	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
12)	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
13)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
14)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16)	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
17)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE C.4.e: $A2_{22}$ Matrix

	10)	11)	12)	13)	14)	15)	16)	17)	18)
9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13)	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
14)	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
15)	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
16)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17)	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
18)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0

TABLE C.4.f: $A2_{23}$ Matrix

	19)	20)	21)	22)	23)	24)	25)	26)	27)
9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13)	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
14)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE C.4.g: $A2_{31}$ Matrix

	1)	2)	3)	4)	5)	6)	7)	8)	9)
19)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20)	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
21)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
22)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE C.4.h: $A2_{32}$ Matrix

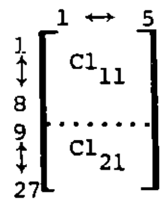
	10)	11)	12)	13)	14)	15)	16)	17)	18)
19)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
20)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE C.4.i: $A2_{33}$ Matrix

	19)	20)	21)	22)	23)	24)	25)	26)	27)
19)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22)	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
23)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24)	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
25)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26)	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
27)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0

TABLE C.5: B1 and C1 matrices

	1)	2)
1)	0.0	0.0
2)	.12348	-.18347
3)	.07077	0.0
4)	.01012	0.0
5)	.3292	0.0
6)	0.0	.17597
7)	.0001051	0.0
8)	0.0	0.0
9)	0.0	0.0
10)	0.0	0.0
11)	0.0	0.0
12)	0.0	0.0
13)	0.0	0.0
14)	0.0	0.0
15)	0.0	0.0
16)	0.0	0.0
17)	0.0	0.0
18)	0.0	0.0
19)	0.0	0.0
20)	0.0	0.0
21)	0.0	0.0
22)	0.0	0.0
23)	1.0	0.0
24)	0.0	0.0
25)	0.0	1.0
26)	0.0	0.0
27)	0.0	0.0



$C1_{21}$ is a zero matrix.

$C1_{11}$ is presented below.

	1)	2)	3)	4)	5)
1)	0.0	0.0	0.0	0.0	0.0
2)	.33285	44.1008	0.0	0.0	1.77276
3)	0.0	0.0	0.0	0.0	0.0
4)	0.0	0.0	0.0	0.0	-.33033
5)	0.0	0.0	0.0	0.0	-4.10794
6)	0.0	0.0	0.0	0.0	.12535
7)	0.0	0.0	.00763	0.0	.00210
8)	0.0	0.0	0.0	.00128	.50222

TABLE C.6: A Matrix

	1 ↔ 9	10 ↔ 18	19 ↔ 27
1 ↕ 8	A_{11}	A_{12}	A_{13}
9 ↕ 18	A_{21}	A_{22}	A_{23}
19 ↕ 27	A_{31}	A_{32}	A_{33}

$A_{21} = A2_{21}$

$A_{22} = A2_{22}$

$A_{23} = A2_{23}$

$A_{31} = A2_{31}$

$A_{32} = A2_{32}$

$A_{33} = A2_{33}$

A_{11}, A_{12}, A_{13} are presented in the following figures.

TABLE C.6.a: A_{11} Matrix

	1)	2)	3)	4)	5)	6)	7)	8)	9)
1)	.85132	-.03042	.160722	.196641	.040713	0.0	0.0	0.0	.087649
2)	-.09230	.890517	.251787	.320290	.022911	0.0	0.0	0.0	.052989
3)	-.05291	.042805	1.12378	.168358	-.002096	0.0	0.0	0.0	.021204
4)	-.007565	.008298	.020636	1.31865	.001878	0.0	0.0	0.0	.00434
5)	-.59473	-.12168	.642889	.786563	.162853	0.0	0.0	0.0	.35060
6)	0.0	0.0	0.0	0.0	0.0	.94306	0.0	0.0	0.0
7)	-.000088	.0000964	.0002397	.0003050	.0000218	0.0	.368954	0.0	-.000067
8)	0.0	-.03706	-.03706	-.03706	-.03706	0.0	0.0	.932550	.03578

TABLE C.6.b: A_{12} Matrix

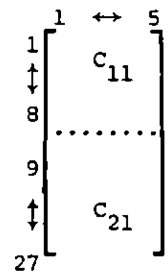
	10)	11)	12)	13)	14)	15)	16)	17)	18)
1)	-.12376	-.17763	.014001	-.000376	.0003547	-.00555	.056947	0.0	-.16336
2)	-.079079	-.18180	.007269	-.000718	.000676	-.01058	.108606	0.0	-.31155
3)	-.059806	-.11338	-.00500	-.00353	.00333	-.05207	.06225	0.0	-1.53259
4)	-.00648	-.46665	.000596	-.000059	.000055	-.000867	.48090	0.0	-.02553
5)	-.49506	-.71051	.05601	-.00151	.00142	-.02220	.22779	0.0	-.65344
6)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7)	-.000193	-.000291	-.000111	-.0000007	.0000006	-.0000101	.0001034	0.0	-.000297
8)	.03578	.03578	.03578	0.0	0.0	0.0	0.0	0.0	0.0

TABLE C.6.c: A_{13} Matrix

	19)	20)	21)	22)	23)	24)	25)	26)	27)
1)	.16336	0.0	0.0	0.0	.04071	-.12312	-.03038	-.04041	.01654
2)	.31155	0.0	0.0	0.0	.02291	-.07786	-.29116	-.31029	-.20168
3)	1.53259	0.0	0.0	0.0	-.00210	-.05380	-.06173	-.07269	-.01048
4)	.02553	0.0	0.0	0.0	.001878	-.00638	-.39770	-.48239	-.00149
5)	.65344	0.0	0.0	0.0	.16285	-.49250	-.12153	-.16165	.006614
6)	0.0	0.0	0.0	0.0	0.0	0.0	-.13063	0.0	0.0
7)	.000297	.36795	0.0	-.000280	.0000218	-.000192	-.000103	-.000121	-.000017
8)	0.0	0.0	0.0	0.0	-.03706	.03578	0.0	0.0	0.0

<u>TABLE C.7: B and C matrices</u>

	1)	2)
1)	.12065	.016535
2)	.23010	-.20168
3)	.13188	-.01044
4)	.01886	-.00149
5)	.48259	.06614
6)	0.0	.17597
7)	.000219	-.000017
8)	0.0	0.0
9)	0.0	0.0
10)	0.0	0.0
11)	0.0	0.0
12)	0.0	0.0
13)	0.0	0.0
14)	0.0	0.0
15)	0.0	0.0
16)	0.0	0.0
17)	0.0	0.0
18)	0.0	0.0
19)	0.0	0.0
20)	0.0	0.0
21)	0.0	0.0
22)	0.0	0.0
23)	1.0	0.0
24)	0.0	0.0
25)	0.0	1.0
26)	0.0	0.0
27)	0.0	0.0



C_{21} is identical to Cl_{21}.

C_{11} is presented below.

	1)	2)	3)	4)	5)
1)	-.03000	-3.9745	0.0	0.0	-1.7222
2)	.36589	48.478	0.0	0.0	.92747
3)	.018935	2.5088	0.0	0.0	-.48451
4)	.002707	.35873	0.0	0.0	-.3996
5)	-.11999	-15.898	0.0	0.0	-6.889
6)	0.0	0.0	0.0	0.0	.12535
7)	.0000314	.004167	.008535	0.0	.001544
8)	0.0	0.0	0.0	.00128	.50222

APPENDIX D: Eigenvector-Eigenvalue Analysis of RSB-MODEL

In this appendix eigenvector-eigenvalue analysis is performed on the RSB-MODEL to identify its characteristic modes.

The basic idea is simple. By definition, the n eigenvalues, λ_i, i=1,...,n, and their associated nx1 eigenvectors, z_i, of the nxn real matrix A satisfy the equation:

(D.1) $$Az_i = \lambda_i z_i$$

where the λ_i and the z_i are complex-valued and where it is assumed for simplicity that the eigenvalues are distinct. Since A is real, its eigenvalues and eigenvectors are composed of simple real numbers or of paired complex conjugates. Since A's eigenvalues are distinct, it possesses n linearly independent eigenvectors which span its domain.

Eigenvalues and eigenvectors bear naturally on the unforced response of a discrete-time system in its state-space representation (see Appendix C for the state-space form of the RSB-MODEL). For the moment, assuming that states can be complex valued, a state vector $x_{z_i}(t)$ which can at time t be expressed as as a real scalar multiple of z_i satisfies eq (D.1); that is, for α_i a real scalar:

(D.2) $$x_{z_i}(t) = \alpha_i z_i$$

implies that:

(D.3) $$x_{z_i}(t+1) = \alpha_i \lambda_i z_i$$

In the case of real eigenvalues and eigenvectors, interpretation of eq (D.2) and eq (D.3) is direct: given that the state satisfies eq (D.2) at time t_0, the time-path of $x_{z_i}(t)$ can be expressed as a function of the real scalars α_i and λ_i, and the real vector z_i for $t>t_0$:

(D.4) $$x_{z_i}(t) = \lambda_i^{(t-t_0)} \alpha_i z_i$$

In this sense, λ_i and z_i parameterize a "characteristic" first-order mode of response of the dynamic system.

In the complex-valued case, an indirect route may be followed to arrive at a similar interpretation. (Obviously, for applications such as this one, the concept of complex-valued states is not appealing.) It is useful to consider the complex eigenvalues and eigenvectors in their conjugate pairs:

(D.5) $$A(z_j : \bar{z}_j) \begin{bmatrix} \lambda_j & 0 \\ 0 & \bar{\lambda}_j \end{bmatrix}$$

It can be shown from eq (D.5) that $(z_j : \bar{z}_j)$ satisfies a second-degree polynomial in A:

(D.6) $$(A^2 - 2\mathrm{Re}(\lambda_j)A + ||\lambda_j||^2 I)(z_j : \bar{z}_j) = 0$$

Therefore any state which at time t can be expressed as a linear combination of z_j and $\bar{z}_j$ over the field of complex scalars also satisfies eq (D.6). Since any state is, in fact, a real vector, these complex scalars must be conjugates and it is equivalent to express the state as a linear combination of $\mathrm{Re}(z_j)$ and $\mathrm{Im}(z_j)$ over the field of real scalars:

(D.7) $$x_{z_j}(t) = \alpha_{1j}\mathrm{Re}(z_j) + \alpha_{2j}\mathrm{Im}(z_j)$$

Since z_j and $\bar{z}_j$ satisfy eq (D.6)'s linear relation, their linear combinations $\mathrm{Re}(z_j)$ and $\mathrm{Im}(z_j)$ must also do so, with the result that:

(D.8) $$x_{z_j}(t+2) = (2\mathrm{Re}(\lambda_j)A - ||\lambda_j||^2)(\alpha_{1j}\mathrm{Re}(z_j) + \alpha_{2j}\mathrm{Im}(z_j))$$

Therefore, given that $x_{z_j}(t_0)$ satisfies eq (D.7), $x_{z_j}(t)$ can be expressed in terms of A, λ_j, z_j, α_{1j} and α_{2j} for $t \geq t_0$:

$$\text{(D.9)} \qquad x_{z_j}(t) = ||\lambda_j||^{(t-t_0)} \left\{ \frac{(A - \text{Re}(\lambda_j)I)}{\text{Im}(\lambda_j)} \sin((t-t_0)(\tan^{-1} \frac{\text{Im}(\lambda_j)}{\text{Re}(\lambda_j)})) + I\cos((t-t_0)(\tan^{-1} \frac{\text{Im}(\lambda_j)}{\text{Re}(\lambda_j)})) \right\} (\alpha_{1j}\text{Re}(z_j) + \alpha_{2j}\text{Im}(z_j))$$

That the matrix A plays a part in this representation demonstrates that the vector $x_{z_j}(t)$ rotates in the plan spanned by $\text{Re}(z_j)$ and $\text{Im}(z_j)$ as it is scaled by $||\lambda_j||$ and the sin and cos terms. Eq (D.9) shows how $(\lambda_j, \bar{\lambda}_j)$ and $(z_j, \bar{z}_j)$ parameterize a "characteristic" second-order mode of response of the dynamic system.

The assumption that A's eigenvalues are distinct allows any $x(t_0)$ to be expressed as a real linear combination of the z_i's and $(\text{Re}(z_j), \text{Im}(z_j))$'s:

$$\text{(D.10)} \qquad x(t_0) = \sum_{i=1}^{n1} \alpha_i z_i + \sum_{j=1}^{n2} (\alpha_{1j}\text{Re}(z_j) + \alpha_{2j}\text{Im}(z_j))$$

where n1 and n2 are the numbers of real, single and complex-conjugate, paired eigenvalues, respectively, and n1+n2 = n. Thus, the unforced response of any state is a linear combination of characteristic first- and second-order modes.

If A is allowed multiple eigenvalues, it may possess less than n linearly independent eigenvectors; thus, a subspace of A's domain may lie orthogonal to its eigenvectors. It happens that the RSB-MODEL's A matrix has a zero eigenvalue of multiplicity 12 and a null space only of rank 4. Consequently there is an 8-dimensional subspace of A's domain which maps into its range but which cannot be expressed as a linear combination of its eigenvectors.

It can be shown (Cel, p. 24) that vectors in A's domain which are orthogonal to its eigenvectors satisfy:

$$\text{(D.11)} \qquad (A - \lambda_i I)^{k_{i1}} w_{k_{i1}} = 0$$

$$(A - \lambda_i I)^{(k_{i1}-1)} w_{k_{i1}} \neq 0$$

where $k_{il} = 2,\ldots,m_{il}$, m_{il} is the order of the lth Jordan block associated with λ_i, and $w_{k_{il}}$ is called "a generalized eigenvector of order k associated with λ_i." Eq (D.11) implies that after $k_{il}-1$ periods, $w_{k_{il}}$ has been mapped onto the eigenvector associated with λ_i's lth Jordan block since $(A - \lambda_i I)(A - \lambda_i I)^{k_{il}-1} w_{k_{il}} = 0$. Thus, the vectors in the RSB-MODEL A matrix's domain which are orthogonal to its eigenvectors are mapped into its null space within $\max_{l}(m_{il}-1)$ quarters.

The total number of generalized eigenvectors defined by eq (D.11) is n minus the number of eigenvectors, and the set of generalized eigenvectors is mutually linearly independent; consequently, the union of the eigenvectors with the generalized eigenvectors spans the domain of A. Thus, in the case of multiple eigenvalues with a deficiency of eigenvectors, the general $x(t_0)$ has some component orthogonal to A's eigenvectors which lies in the space spanned by its generalized eigenvectors and whose time-path takes it into the space spanned by the eigenvectors within $\max_{l}(m_{il}-1)$ periods.

This sets up the mathematical stage for application to the RSB-MODEL; before proceeding, a state-space representation of the model is required. The transformation from the structural to a state-space representation is presented in Appendix C. Since GNP, YD and RGW are eliminated by substituting their expressions wherever they appear in the other relationships, only the first 8 of the 27 states correspond to the original structural variables; these are INV, C, INR, IR, IIN, RL, RGP and UR. Of the 19 remaining states, 14 are identities for lagged structural variables to enable expressing the behavioral equations in terms of first-order lags; the last 5 deal with lagged controls, representing the lag structures on G and RSB as endogenous to the model. Consequently, present period G and RSB are the controlled inputs. TR, ΔWLTH, DUM, GNPP(-1) and 1.0 are uncontrolled drivers.

The state-space realization has a structure which allows easy identification of several of the eigenvalues. Each of the last 5 states introduces a zero eigenvalue since each is either independent of the other states or a lagged value of an independent state.

$$(D.12)\quad \begin{bmatrix} x(23) \\ x(24) \\ x(25) \\ x(26) \\ x(27) \end{bmatrix} = \begin{bmatrix} 0.0 & 0.0 & 0.0 & 0.0 & 0.0 \\ 1.0 & 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 1.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 1.0 & 0.0 \end{bmatrix} * \begin{bmatrix} xl(23) \\ xl(24) \\ xl(25) \\ xl(26) \\ xl(27) \end{bmatrix}$$

In Figure 1.3's block diagram, the interest rate block (RL) and the nominal block (UR, RGW and RGP) also appear relatively uncoupled with the rest. Referring to eq (1.2.11) one confirms that RL's endogenous dynamics derive from its dependence on RL_{-1} alone. Thus, the submatrix of states associated with RL can be isolated from the state-space A matrix:

$$(D.13)\quad \begin{bmatrix} y(6) \\ y(16) \\ y(17) \\ y(18) \\ y(19) \end{bmatrix} = \begin{bmatrix} .94306 & 0.0 & 0.0 & 0.0 & 0.0 \\ 1.0 & 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 1.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 1.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 1.0 & 0.0 \end{bmatrix} \begin{bmatrix} yl(6) \\ yl(16) \\ yl(17) \\ yl(18) \\ yl(19) \end{bmatrix}$$

The submatrix is lower-diagonal so its eigenvalues lie on the diagonal: (.94306, 0.0, 0.0, 0.0, 0.0).

The lack of feedback from the nominal to the real variables mentioned above allows a similar isolation of the nominal block of states (remembering that RGW has been eliminated from the system):

$$
(\text{D.14}) \quad
\begin{bmatrix} y(7) \\ y(8) \\ y(20) \\ \hline y(21) \\ y(22) \end{bmatrix}
=
\left[\begin{array}{ccc|cc}
.36895 & 0.0 & .36895 & 0.0 & -.00028 \\
0.0 & .93255 & 0.0 & 0.0 & 0.0 \\
1.0 & 0.0 & 0.0 & 0.0 & 0.0 \\
\hline
0.0 & 1.0 & 0.0 & 0.0 & 0.0 \\
0.0 & 0.0 & 0.0 & 1.0 & 0.0
\end{array}\right]
\begin{bmatrix} y1(7) \\ y1(8) \\ y1(20) \\ \hline y1(21) \\ y1(22) \end{bmatrix}
$$

The characteristic equation for this submatrix is:

$$
(\text{D.15}) \quad \psi(s) = s^2(s - .93244)(s^2 - .36895s - .36895) = 0
$$

Its roots (the eigenvalues) are (0.0, 0.0, .93255, -.45033, .81928).

A 12th zero eigenvalue can be predicted due to the GNP identity introduced via the lagged-GNP states: y(13), y(14) and y(15).

As pointed out above, there are only 4 linearly independent eigenvectors associated with the zero eigenvalues. A convenient way to show this relies on the observation that the zero-eigenvectors of $(I-A1)^{-1}A2 = A$ must also be zero-eigenvectors of A2 which is much more sparse than A. One can see that only the 9th, 10th, 12th, 15th, 19th, 20th, 22nd and 24th entries of A2's zero-eigenvectors can be nonzero. Furthermore, only rows 3, 5, 7, and 8 of A2 supply independent information concerning these entries; this can be distilled into the following 4 conditions:

$$
(\text{D.16}) \quad
\begin{array}{ll}
\text{Condition 1:} & z_{24} = -(z_9 + z_{10} + z_{12}) \\
\text{Condition 2:} & z_{10} = -8.6629z_{15} + 254.992z_{19} \\
\text{Condition 3:} & z_{12} = -1.53709z_9 \\
\text{Condition 4:} & z_{22} = 1319.32z_{20}
\end{array}
$$

Only 4 degrees of freedom remain.

So, what kinds of initial conditions map to zero in one quarter? The above

4 conditions lend to simple explanation in conjunction with Figure 1.2's block diagram. In the simplest case, z_9, z_{10}, z_{12}, z_{15}, z_{19}, and z_{24} are all zero: the interest rate and real blocks of the economy are at rest; UR_{-2} and RGP_{-1} alone are nonzero. In the next period, these two variables provide impetus only to RGP (remember that RGW has been removed to conserve states). It is easy to see that due to Condition 4 the effects of these two states on RGP cancel each other exactly. Thus, at the end of the first period, every state is at rest.

A slightly more complicated case results when all the states are zero except z_{10}, z_{15}, z_{19}, and z_{24}. Here, the nominal block is at rest while INR_{-1}, GNP_{-4}, RL_{-4} and G_{-1} are nonzero. Condition 1 ensures that GNP_{-1} is zero so that there is no next-period impetus to C, IIN, INV, IR or to the nominal block. In the interest rate block only RL_{-4} is nonzero, and thereby RL_{-5} in the next period; this is ignored since RL_{-5} is not a state. So the only question is: What happens to INR? A brief calculation shows that Condition 2 ensures that INR also will receive no net motivation.

Similar arguments hold when Condition 1 and 3 or 2 and 3 operate jointly.

The process of identifying the zero eigenvalues and zero-eigenvectors has isolated where the associated Jordan blocks come from: 1) a 5th-order block associated with the input identities, 2) a 4th-order block associated with the lagged-RL identities, 3) a 2nd-order block associated with the lagged-UR identities, and 4) a 1st-order block associated with the GNP identity. Thus, there are (4+3+1) = 8 generalized eigenvectors to add to the 19 eigenvectors, their union spanning the 27th-order domain of A. Moreover, the generalized eigenvectors are mapped to zero within $\max_i(m_{i1}) = 5$ quarters.

The eigenvectors associated with the 4 nonzero eigenvalues may be only partially specified by the subsystems that were isolated; while these blocks of variables exhibit independent internal responses, they may feed into the other blocks. For example, looking at Figure 1.2, when the RL block decays according to its .94306 eigenvalue, the real and the nominal blocks are driven; to preserve the eigenvector-eigenvalue relationship, these two blocks must decay in the same manner as RL. Thus, the eigenvector must appropriately preconfigure these two blocks in addition to the RL block. Rather than compute the entirety of this eigenvector, the entries associated with the RL block alone are specified: (y(6), y(16), y(17), y(18), y(19)) must appear in the configuration $((.94306)^4, (.94306)^3, (.94306)^2, .94306, 1.0)$ to complement the .94306 eigenvalue.

On the other hand, the nominal block does not drive any other blocks, so its eigenvectors can be completely determined: (y(7), y(8), y(20), y(21), y(22)) must appear as (-.001917, 1.0, -.002056, 1.07233, 1.14989) for the .93255 eigenvalue, as (-.45033, 0.0, 1.0, 0.0, 0.0) for the -.45033 eigenvalue and as (.81928, 0.0, 1.0, 0.0, 0.0) for .81928.

This is more or less the extent to which analysis can be carried by hand, since the states in the real block are highly interdependent. So, call on the computer! The entire system is fed into the computation in order that a check on the results can be made through the above preliminary analysis. With hindsight, a better numerical procedure would have initially "deflated" the matrix down to a 15x15 system by removing the 12 zero eigenvalues.* In the first place, the lower-order system would have been less sensitive to the relatively large errors introduced by the single-precision parameter

* This can be done via Singular-Value Decomposition

estimation method. But more importantly, the multiplicity of the zero eigenvalue in the 27x27 matrix severely ill-conditions the computation of its eigenvectors. Precisely when in the computations any eigenvector-eigenvalue algorithm will break down on being faced with such a matrix requires in-depth analysis of the algorithm. Failing such analysis, one does not know which, if any, of the eigenvectors are accurate. Consequently the results of the computations must be closely scrutinized.

The computer algorithm employed is an EISPACK subroutine RG which performs a double precision QR factorization on a real, general matrix. Input-output is handled by an LIDS subroutine EIGVEC.

Table D.1 lists the 27 eigenvalues and the unforced time response of states along their associated eigenvectors. The eigenvalues look basically as expected. Only 9 of the predicted 12 "hard-zeros" appear, but doubtless the "zero + noise" in eigenvalues 15 through 17 is meant to be interpreted as "zero."

The eigenvectors are listed in Table D.2. Certain confidence-inspiring features are immediately obvious. First, all of the precalculated eigenvectors are present (note that they are scaled). Second, zeros are scattered around in a logical systematic manner. Entries z_6 and z_{16}-z_{19} are zero in all except vectors 18-22, that is, those associated with the RL eigenvalues. This is not surprising since the interest rate block of states is independent of the other two blocks. Likewise, the control identities are implicated in only the last 5 vectors.

The very large numbers in the 19th through 21st and 24th through 27th eigenvectors look worrisome. However, these 7 eigenvectors correspond to zero eigenvalues whose deficiency of eigenvectors is expected to ill-condition the problem. The "blown-up" eigenvectors are the algorithm's solution to the lack of true eigenvectors. The first eigenvector in each block of zeros is OK in that it satisfies Conditions 1-4. When the algorithm searches for independent eigenvectors for the block's remaining zeros, it retains the previous eigenvector's configuration for the dominant nonzero entries and proceeds to find an eigenvector relationship between the remaining entries based on background computational noise. (Numbers blow up as powers of -8.77D13.) This seems somehow well-behaved given that the problem is ill-posed. Thus, given the encouragement of the previous two paragraphs, it seems reasonable to tentatively accept the accuracy of the eigenvectors associated with the nonzero eigenvalues and henceforth ignore the zero eigenvalues.

TABLE D.1 Eigenvalues:				Time Response, (unforced):
1) 2)	-.4485	±	.1863j	$x_t = (.4857)^t((-5.368x_1-2.407x_0)\sin(.3937t) + x_0\cos(.3937t))$
3) 4)	-.0151	±	.5788j	$x_t = (.5788)^t((-1.728x_1-.0261x_0)\sin(1.545t) + x_0\cos(1.545t))$
5)	-.45033			$x_t = (-.4503)^t x_0$
6) 7)	.5588	±	.2185j	$x_t = (.6)^t((4.577x_1-2.557x_0)\sin(.3727t) + x_0\cos(.3727t))$
8) 9)	.6614	±	.1862j	$x_t = (.687)^t((5.371x_1-3.552x_0)\sin(.2815t) + x_0\cos(.2815t))$
10) 11)	.9715	±	.0333j	$x_t = (.972)^t((30.06x_1-29.20x_0)\sin(.0342t) + x_0\cos(.2815t))$
12)	.8908			$x_t = (.8908)^t x_0$
13)	.93255			$x_t = (.93255)^t x_0$
14)	.81928			$x_t = (.8193)^t x_0$
15) 16)	(5.D-18	±	8.D-11j)	All of the remaining eigenvalues except the 22nd imply instantaneous decay:
17)	(-1.D-16)			x_{t+1} independent of x_t for all t.
18)	0.0			
19)	0.0			
20)	0.0			
21)	0.0			
22)	.94306			$x_t = (.94306)^t x_0$
23)	0.0			
24)	0.0			
25)	0.0			
26)	0.0			
27)	0.0			

TABLE D.2.a Eigenvectors:

(1,2)	Re	Im	(3,4)	Re	Im	5	Re
1)	-.00147	-.0161		.01689	-.00200		-
2)	.00352	-.00739		.01652	.00056		-
3)	.0711	.0676		.03074	.07878		-
4)	.00007	-.00031		.00074	-.00067		-
5)	.0339	-.1918		.08437	.10828		-
6)	0	0		0	0		0
7)	-.00004	-.00003		.00005	.00004		-.4302
8)	.0118	-.0062		-.01217	.00882		-
9)	-.0125	.0113		.00022	-.02854		-
10)	-.0819	-.1847		.1346	-.05661		-
11)	-.00039	.00054		-.00120	-.00124		-
12)	-.2160	.3379		.1832	-.1505		-
13)	.7214	-.0682		-.4234	-.5364		-
14)	-1.4258	-.4402		-.90723	.7551		-
15)	2.3638	1.9633		1.3446	1.5326		-
16)	0	0		0	0		0
17)	0	0		0	0		0
18)	0	0		0	0		0
19)	0	0		0	0		0
20)	.00005	.00009		.00006	-.00008		.9552
21)	-.0274	.0025		.01578	.02063		-
22)	.0542	.0169		.03490	-.02817		-
23)	0	0		0	0		0
24)	0	0		0	0		0
25)	0	0		0	0		0
26)	0	0		0	0		0
27)	0	0		0	0		0

TABLE D.2.b Eigenvectors:

	(6.7) Re	(6.7) Im	(8,9) Re	(8,9) Im
1)	-.05814	-.09100	-1.8946	-.39823
2)	-.06365	-.03454	-.83925	.71657
3)	-.02801	-.23753	-1.4557	-.7901
4)	-.00767	.02824	-2.4595	-.30541
5)	.3493	.05987	3.6667	-2.3502
6)	0	0	0	0
7)	.00005	-.00002	-.00001	-.00056
8)	-.01154	.01688	.09719	.14163
9)	-.1198	-.01498	-.89314	1.3349
10)	-.1876	-.3517	-2.351	-.53279
11)	.00524	.04849	-3.5661	.54214
12)	.5786	-.11909	4.2100	-4.7385
13)	.16368	-.84649	-4.9815	-3.7297
14)	-.2597	-1.4133	-8.4497	-3.2605
15)	-1.26079	-2.03605	-13.1233	-1.2354
16)	0	0	0	0
17)	0	0	0	0
18)	0	0	0	0
19)	0	0	0	0
20)	.00007	-.00006	-.00024	-.00078
21)	-.00767	.03320	.19201	.16008
22)	.00825	.05618	.33213	.14854
23)	0	0	0	0
24)	0	0	0	0
25)	0	0	0	0
26)	0	0	0	0
27)	0	0	0	0

TABLE D.2.c Eigenvectors:

(10,11)	Re	Im	12 Re	13 Re
1)	-3.9738	1.5729	3.9945	-
2)	-8.0067	1.9713	4.0094	-
3)	-4.0346	-.18300	1.3338	-
4)	-.8515	.1560	.31613	-
5)	.22608	-.73683	-1.9589	-
6)	0	0	0	0
7)	-.00018	-.00066	-.00004	-.00199
8)	.27214	.16893	-.27528	1.0406
9)	-8.1627	2.3088	4.5010	-
10)	-4.1546	-.04610	1.4974	-
11)	-.86999	.19036	.35489	-
12)	.2065	-.7655	-2.1991	-
13)	-13.287	2.192	4.6634	-
14)	-13.584	2.722	5.2352	-
15)	-13.871	3.277	5.8770	-
16)	0	0	0	0
17)	0	0	0	0
18)	0	0	0	0
19)	0	0	0	0
20)	-.0002	-.0007	-.00004	-.00213
21)	.2857	.1641	-.3090	1.1159
22)	.2996	.1587	-.3469	1.1966
23)	0	0	0	0
24)	0	0	0	0
25)	0	0	0	0
26)	0	0	0	0
27)	0	0	0	0

TABLE D.2.d Eigenvectors:

14	Re	(15,16) Re	Im	17 Re
1)	-	-	-	-
2)	-	-	-	-
3)	-	-	-	-
4)	-	-	-	-
5)	-	-	-	-
6)	0	0	0	0
7)	-.6453	-	-.00007	0
8)	-	-	-	0
9)	-	-	-.27036	1.2446
10)	-	-	-.14521	.6685
11)	-	-	-	0
12)	-	-	.41556	-1.9131
13)	-	-	-	-
14)	-	-	-	-
15)	-	-	.01676	-.07717
16)	0	0	0	0
17)	0	0	0	0
18)	0	0	0	0
19)	0	0	0	0
20)	-.78764	-9.145D6	55.343	2.5258
21)	-	-	-.956797	-
22)	-	-1.21D10	7.301D4	3332.34
23)	0	0	0	0
24)	0	0	0	0
25)	0	0	0	0
26)	0	0	0	0
27)	0	0	0	0

TABLE D.2.e Eigenvectors:

18	Re	19 Re	20 Re	21 Re
1)	-	-.19478	1.92D13	-1.75D27
2)	-	.21875	-1.21D13	6.19D26
3)	-	1.3676	-1.06D14	9.92D27
4)	-	-.18077	1.57D13	-1.34D27
5)	-	-1.54	1.24D14	-1.11D28
6)	0	0	0	0
7)	-	.5345	-4.95D13	4.09D27
8)	-	.003906	-2.20D12	0
9)	-3.0971	2.72D14	-2.38D28	2.09D42
10)	-1.6634	1.46D14	-1.28D28	1.12D42
11)	-	.25826	-2.52D13	2.58D27
12)	4.7605	-4.18D14	3.66D28	-3.22D42
13)	-	-2.348	1.93D14	-1.64D28
14)	-	-5.022	4.32D14	-3.86D28
15)	29.63	-2.60D15	2.28D29	-2.00D43
16)	0	0	0	1.0
17)	0	0	1.0	-8.77D13
18)	0	1.0	-8.77D13	7.70D27
19)	1.0	-8.77D13	7.70D27	-6.75D41
20)	-2.2	1.93D14	-1.70D28	1.49D42
21)	-	.2811	-2.46D13	2.12D27
22)	-2905.84	2.55D17	-2.24D31	1.96D45
23)	0	0	0	0
24)	0	0	0	0
25)	0	0	0	0
26)	0	0	0	0
27)	0	0	0	0

TABLE D.2.f Eigenvectors:

22	Re	23	Re	24	Re
1)	-11.359		-		-1.124
2)	-18.202		-		-11.340
3)	-10.670		-		-36.107
4)	2.090		-		-3.046
5)	2.743		-		-3.050
6)	1.0		0		0
7)	.0053		-		13.818
8)	-2.014		-		4.625
9)	-19.301		.00483		-9.74D13
10)	-11.315		-.99741		3.54D13
11)	2.216		-		-4.213
12)	2.909		-.00742		1.50D14
13)	-27.030		-		-.07313
14)	-28.662		-		-.61687
15)	-30.392		.11514		-4.09D12
16)	1.060		0		0
17)	1.124		0		0
18)	1.192		0		0
19)	1.264		0		0
20)	.00559		-.49425		4.64D15
21)	-2.135		-		6.0603
22)	-2.264		-652.070		6.12D18
23)	0		0		1.0
24)	0		1.0		-8.77D13
25)	0		0		0
26)	0		0		0
27)	0		0		0

TABLE D.2.g Eigenvectors

25	Re	26	Re	27	Re
1)	1.257		-9.49D13		1.83D40
2)	-6.125		6.51D14		-2.04D40
3)	-29.964		2.65D15		-1.27D41
4)	-3.346		2.75D15		1.66D40
5)	5.944		-5.38D14		1.45D41
6)	0		0		.138517
7)	11.942		-1.09D15		-4.98D40
8)	3.5		-3.28D14		-3.40D38
9)	2.01D15		-1.76D29		-2.54D55
10)	1.08D15		-9.46D28		-1.37D55
11)	-4.605		3.85D14		-2.52D40
12)	-3.09D15		2.71D29		3.91D55
13)	1.4278		-1.21D14		2.10D41
14)	-2.335		1.49D14		4.65D41
15)	-1.25D14		1.09D28		2.43D56
16)	0		0		-1.22D13
17)	0		0		0
18)	0		0		-9.36D40
19)	0		0		8.21D54
20)	4.08D15		-3.58D29		-1.81D55
21)	5.4786		-4.80D14		-2.64D40
22)	5.38D18		-4.72D32		-2.39D58
23)	0		0		0
24)	0		0		0
25)	0		0		1.0
26)	0		1.0		-8.77D13
27)	1.0		-8.77D13		7.70D27

APPENDIX E: Two Short Simulations and Forecast:

Short "Control Period" Simulation: 1968-4 to 1973-4

The control period simulation is dominated by the phenomena of overreaction to G and RSB in the RSB-MODEL and smoothing of RS in the M-MODEL. Table E.1 shows that except for RL, obviously, and perhaps RGW, the M-MODEL performs substantially the better of the two. Referring to Figures E.1 and E.2 the reason is clear: since RS is smoothed, when the M-MODEL overreacts to G, historical behavior is reproduced quite closely. Since RS is not smoothed in the RSB-MODEL, historical trends are exaggerated.

Short "Volatile" Simulation: 1972-1 to 1976-1

The same factors which produce a close correspondence in the M-MODEL to the historical over the control period, favor the RSB-MODEL in volatile simulation. Since G does not pick up the fiscal stimulus of the deficit in 1975, the characteristic overreaction to inputs can only act through RS. The 1972-1 to 1976-1 behavior of the endogenous variables is thus reproduced by the RSB-MODEL more or less by chance, while the markedly smoothed RS in the M-MODEL leaves it with almost no information on which to base a prediction of recession. Table E.2 and Figures E.3 and E.4 illustrate the simulation results.

Forecast: 1976-1 to 1977-4

The historical trajectories in the 1976-1 to 1977-4 forecast are very smooth. The M-MODEL predicts better apparently because RS and RL are simulated too high and steady over the two years, yielding INR and IR predictions which are not bloated as badly as in the RSB-MODEL. This overoptimism may be due in part to the unmodeled lowering of production possibilities following the 1974 supply shocks as well as to the over-responsiveness to G and RS. These results are presented in Table E.3 and Figures E.5 and E.6.

TABLE E.1: Results of Short Ex Post Simulation (control period)

	1968-4 to 1973-4		1968-4 to 1973-4	
	M-MODEL		RSB-MODEL	
Variable	RMS error	RMS % error	RMS error	RMS % error
C	4.70	0.93	16.65	3.32
INR	3.45	3.80	8.45	10.16
IR	4.11	11.41	5.62	15.47
IIN	3.25	76.77	4.14	91.03
INV	1.24	0.62	6.15	3.14
RS	1.44	23.29	NA	NA
RL	0.71	10.99	0.35	5.56
RGP	5.8E-3	36.65	7.2E-3	49.58
RGW	5.6E-3	70.05	5.9E-3	54.93
UR	0.47	9.71	0.76	15.23
GNP	11.49	1.44	31.83	4.17

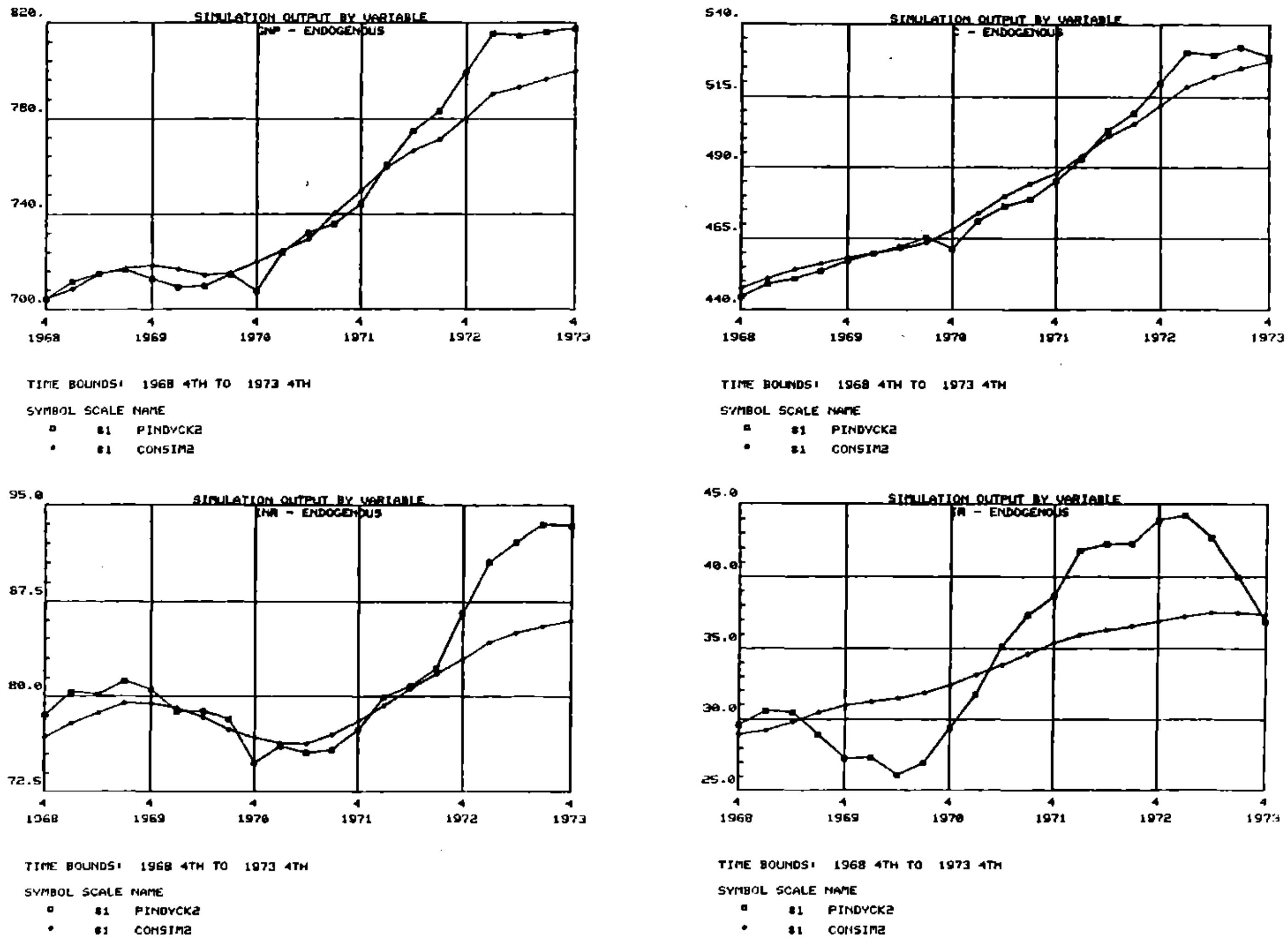


FIGURE E.1.a Results of Short Ex Post Simulation (control period) - M-MODEL

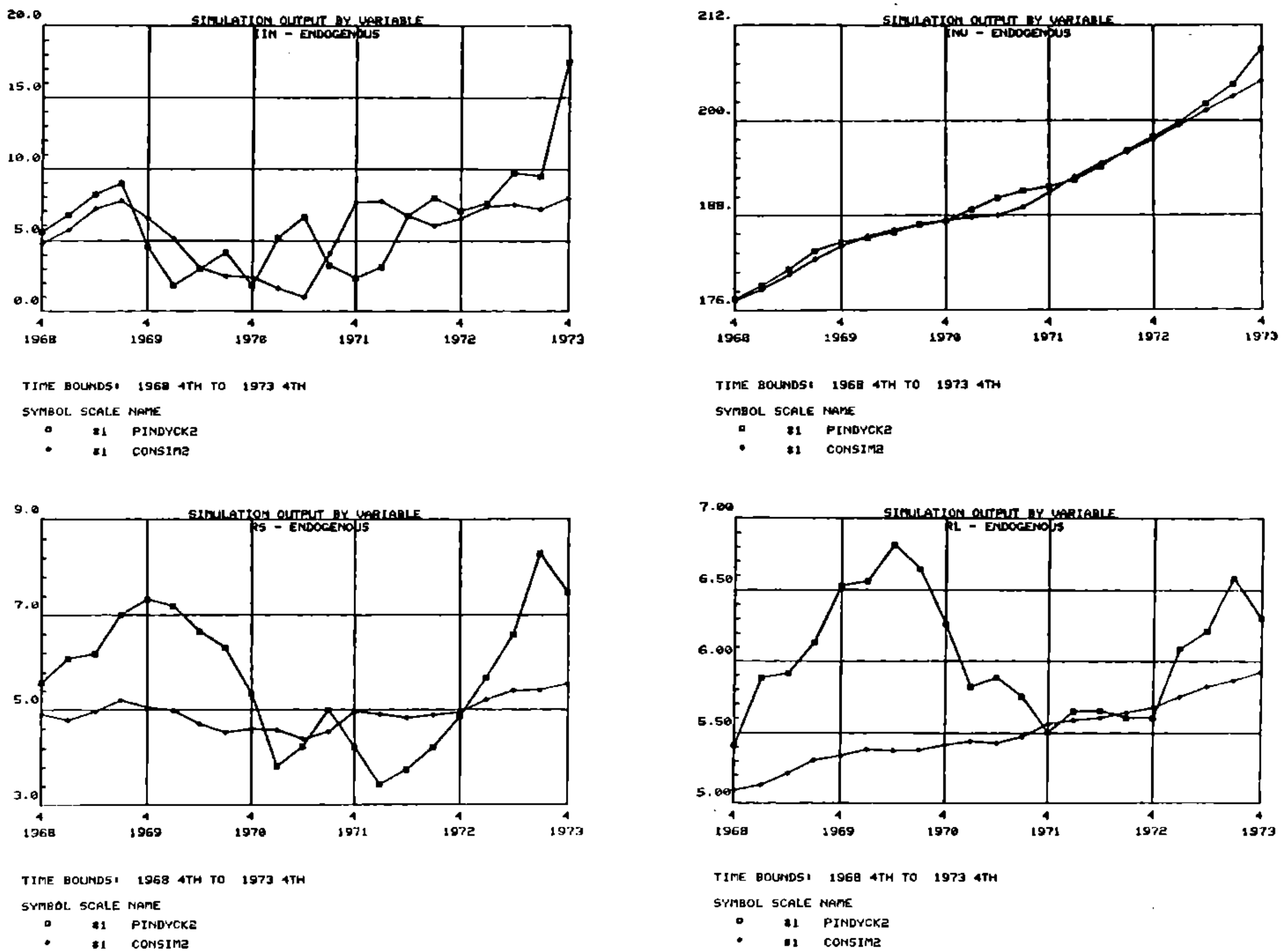


FIGURE E.1.b Results of Short Ex Post Simulation (control period) - M-MODEL

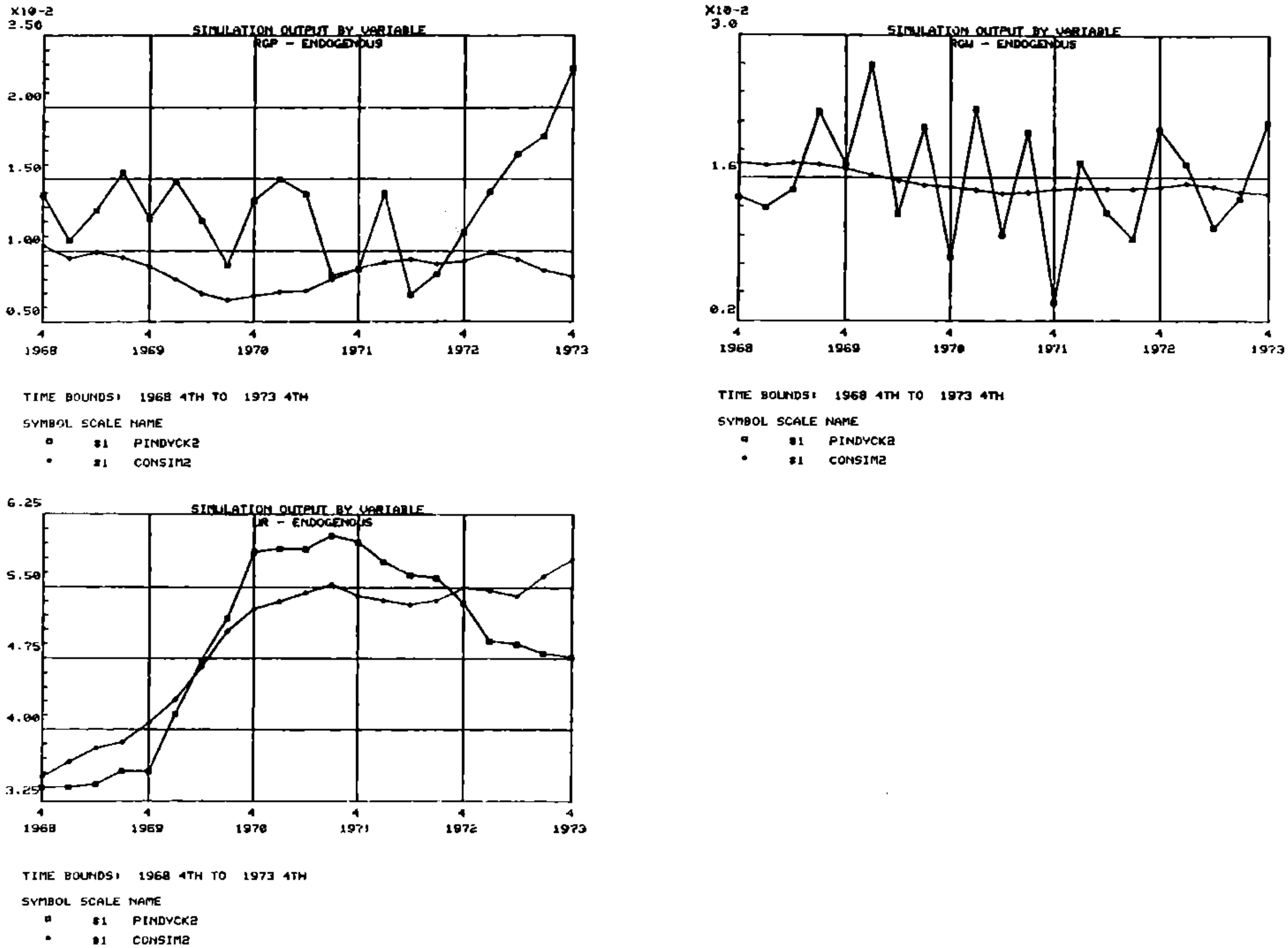


FIGURE E.1.c Results of Short Ex Post Simulation (control period) - M-MODEL

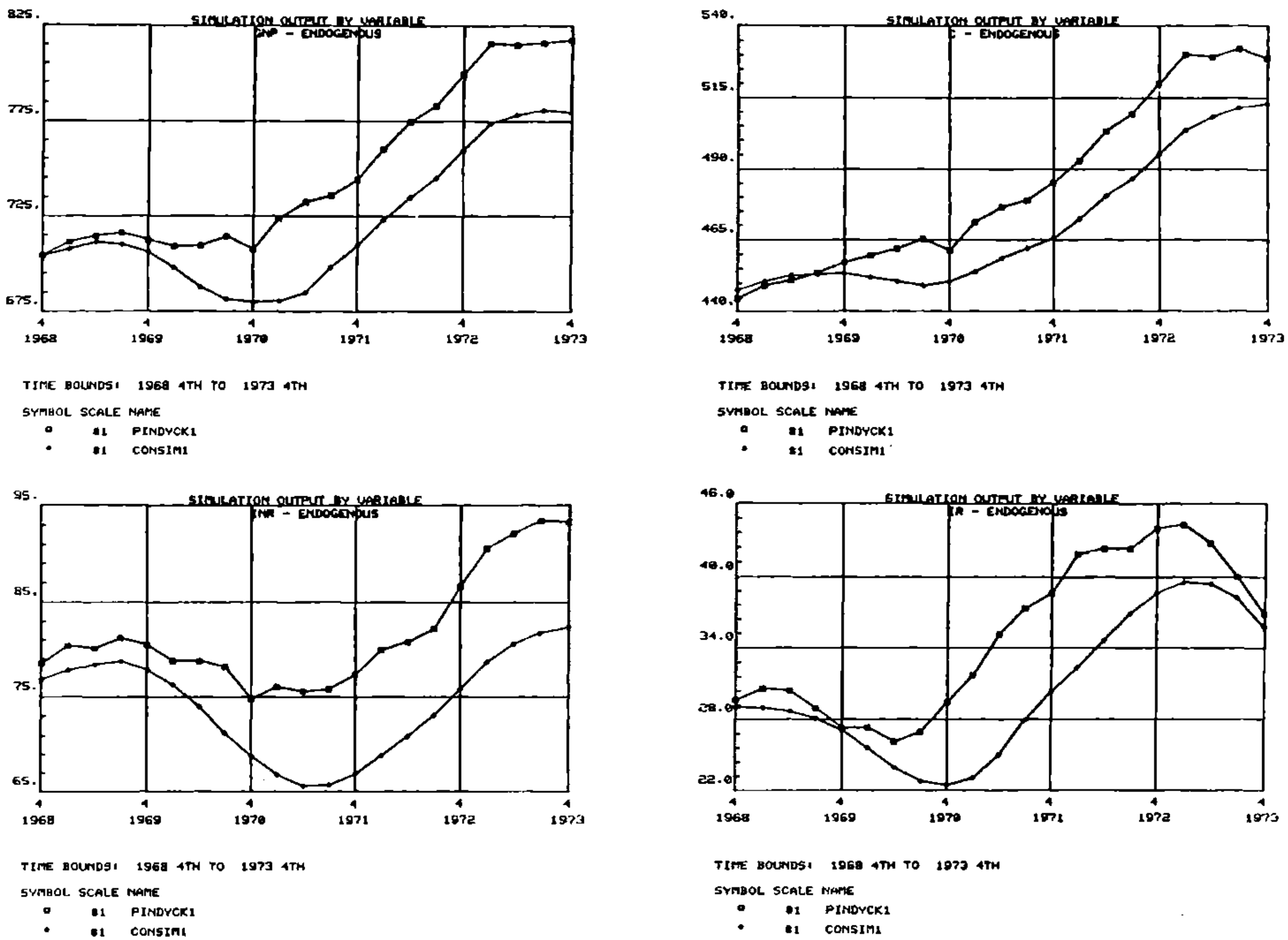
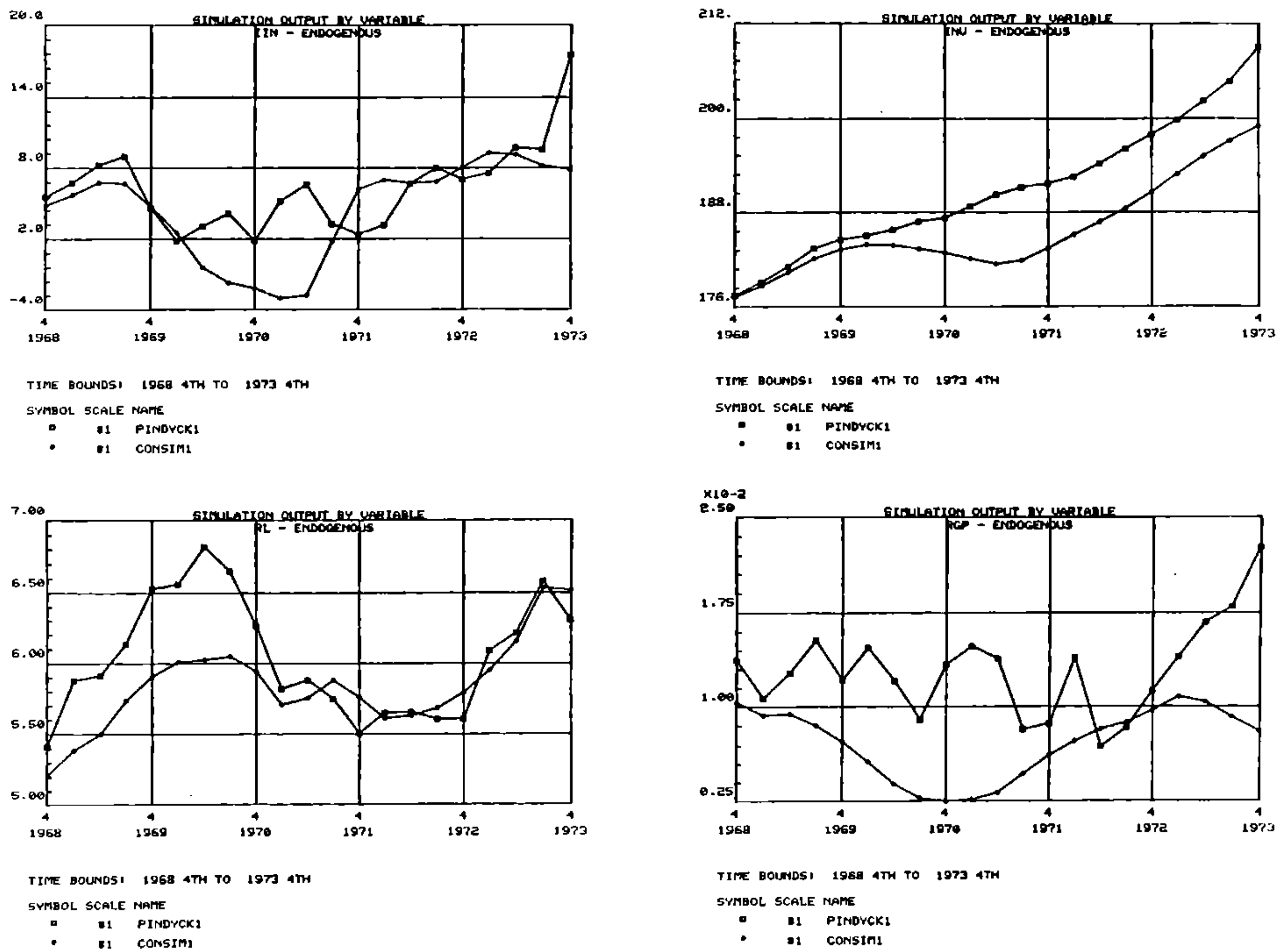
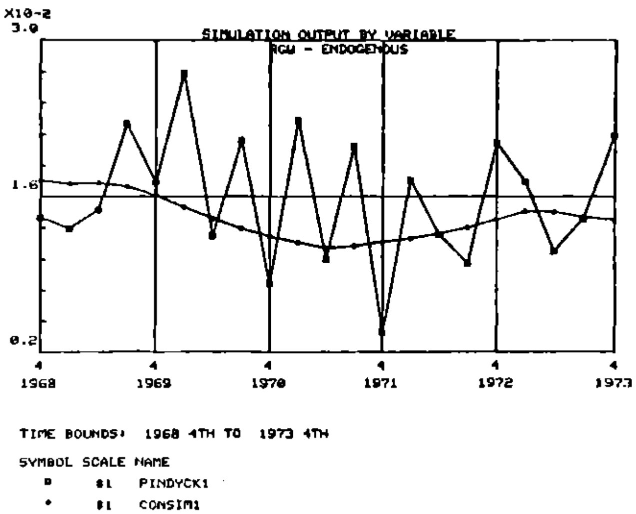
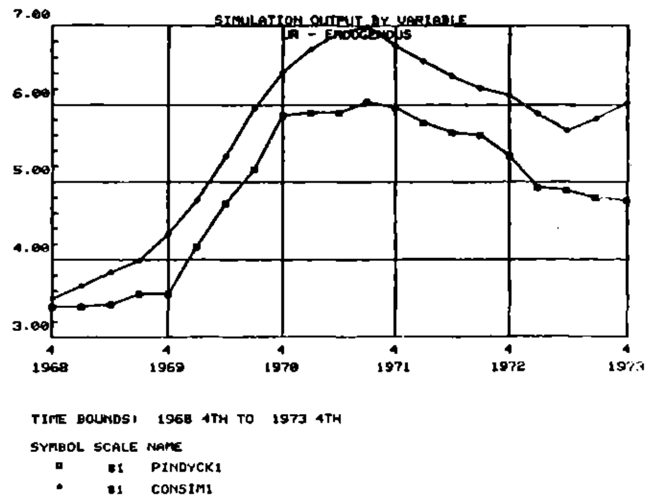


FIGURE E.2.a Results of Short Ex Post Simulation (control period) - RSB-MODEL



<u>FIGURE E.2.b</u> Results of Short Ex Post Simulation (control period) - RSB-MODEL





<u>FIGURE E.2.c</u> Results of Short Ex Post Simulation (control period) - RSB-MODEL

TABLE E.2: Results of Short Ex Post Simulation

	1972-1 to 1976-1		1972-1 to 1976-1	
	M-MODEL		RSB-MODEL	
Variable	RMS error	RMS % error	RMS error	RMS % error
C	10.29	1.94	4.02	0.77
INR	5.10	6.02	2.83	3.07
IR	5.81	20.30	1.71	4.98
IIN	5.94	140.00	4.68	94.09
INV	3.28	1.57	1.74	0.83
RS	1.58	26.54	NA	NA
RL	0.48	7.01	0.32	4.78
RGP	5.7E-3	33.56	6.0E-3	32.44
RGW	5.2E-3	26.87	5.6E-3	27.00
UR	0.93	14.48	0.58	10.60
GNP	23.34	2.98	7.73	0.98

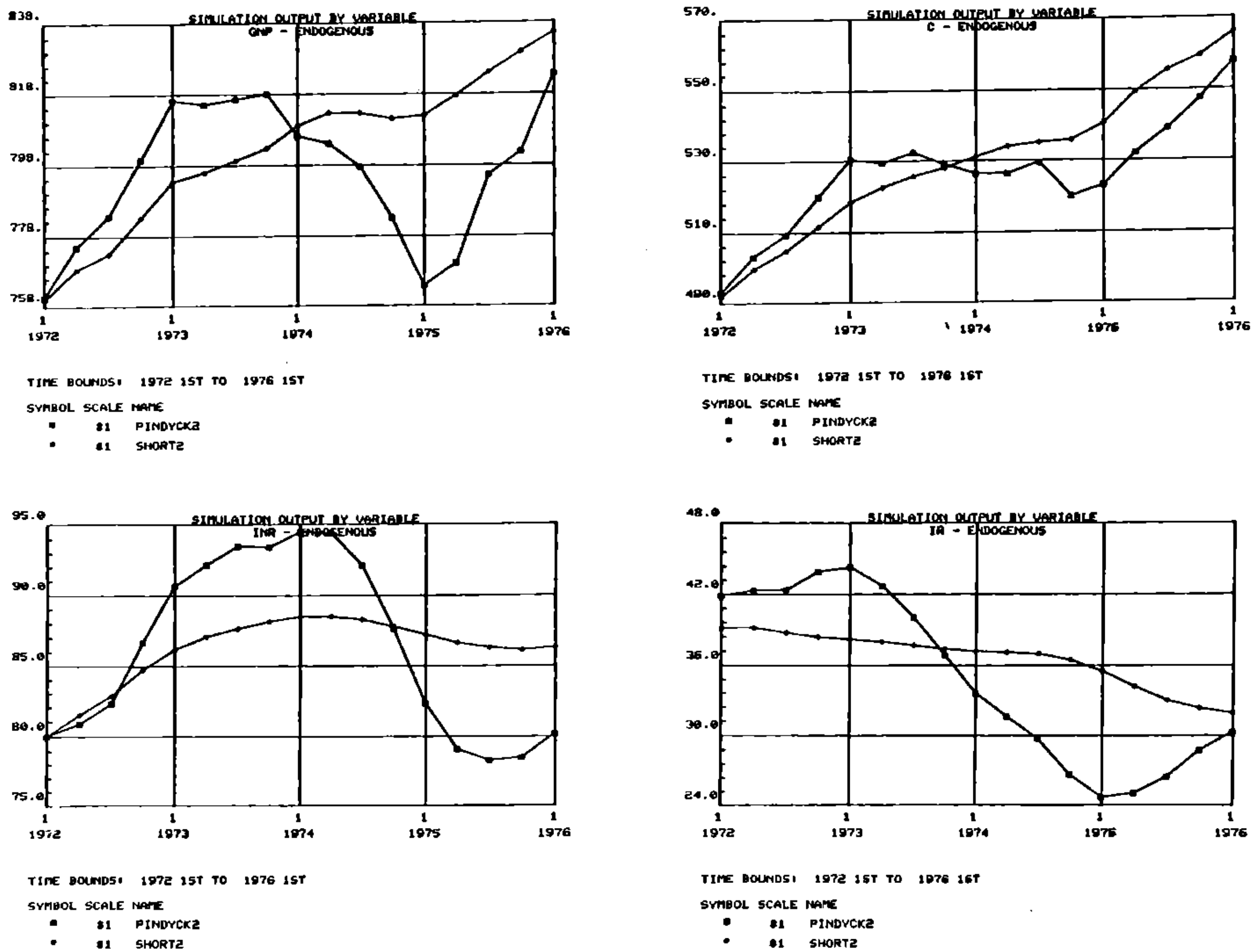


FIGURE E.3.a Results of Short Ex Post Simulation - M-MODEL

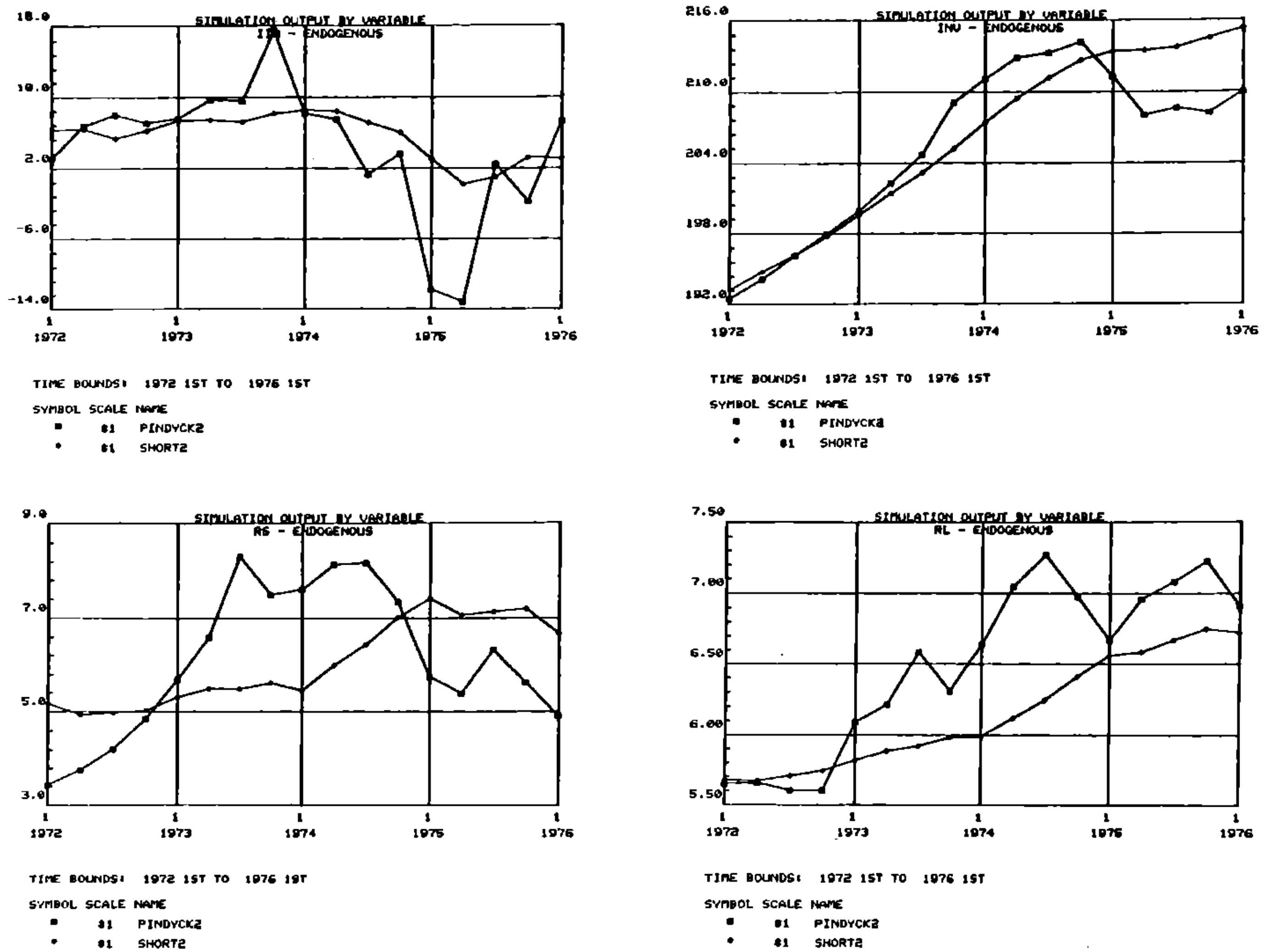
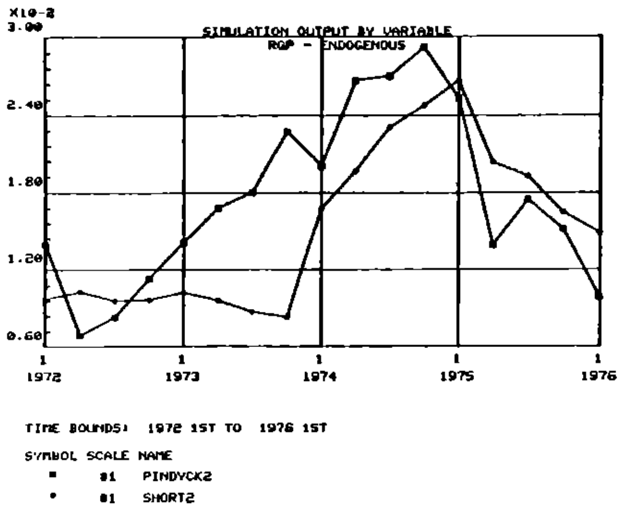
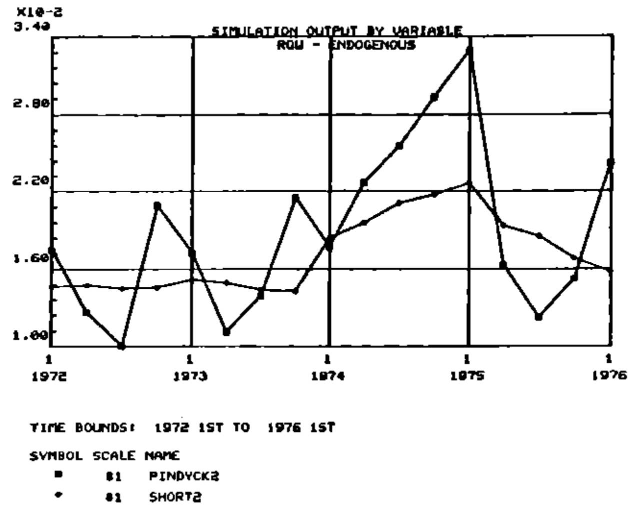
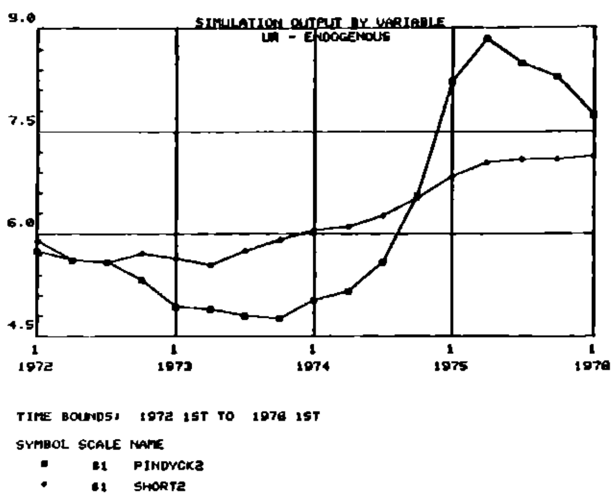


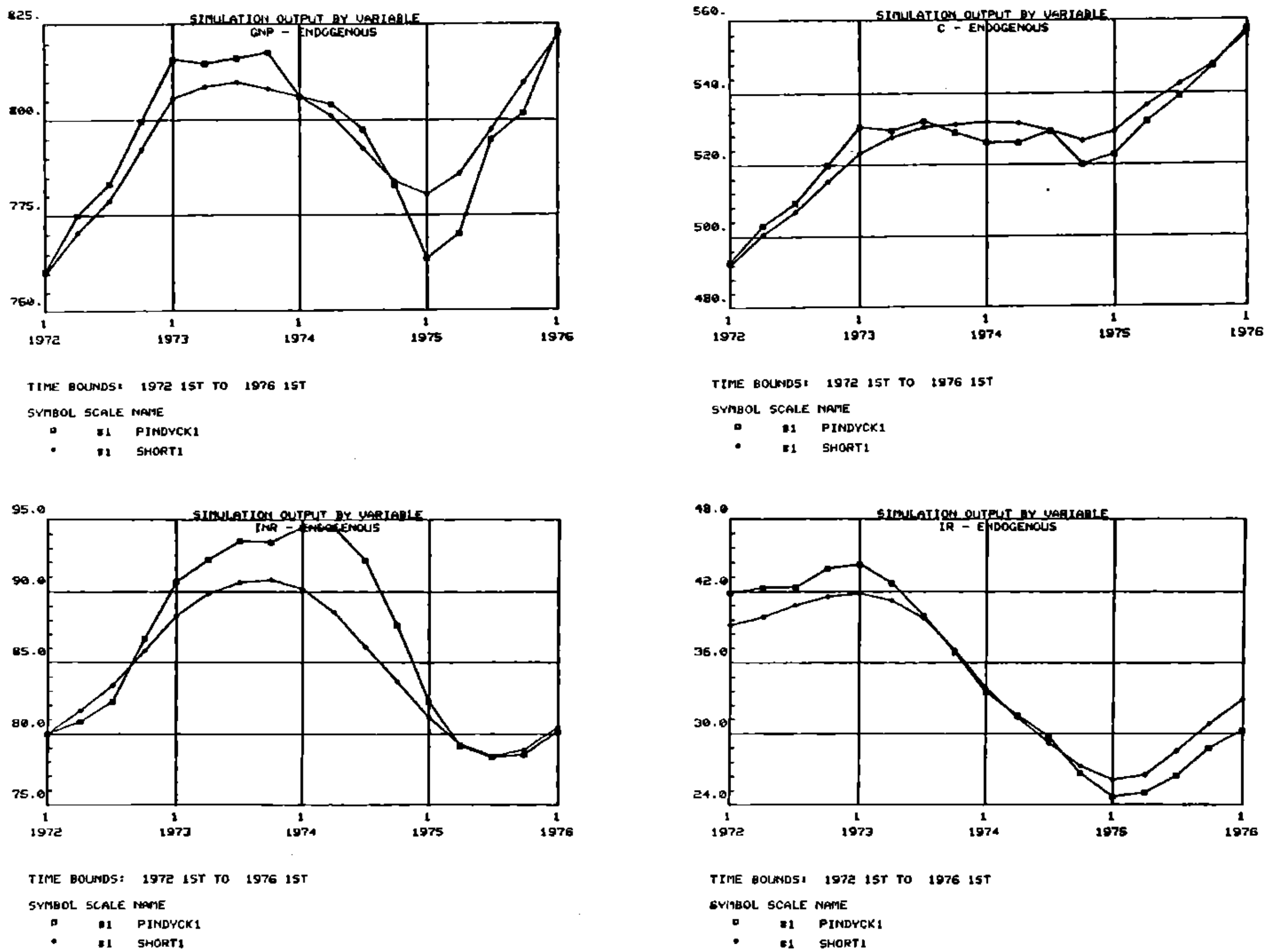
FIGURE E.3.b Results of Short Ex Post Simulation - M-MODEL







<u>FIGURE E.3.c</u> Results of Short Ex Post Simulation - M-MODEL



<u>FIGURE E.4.a</u> Results of Short Ex Post Simulation - RSB-MODEL

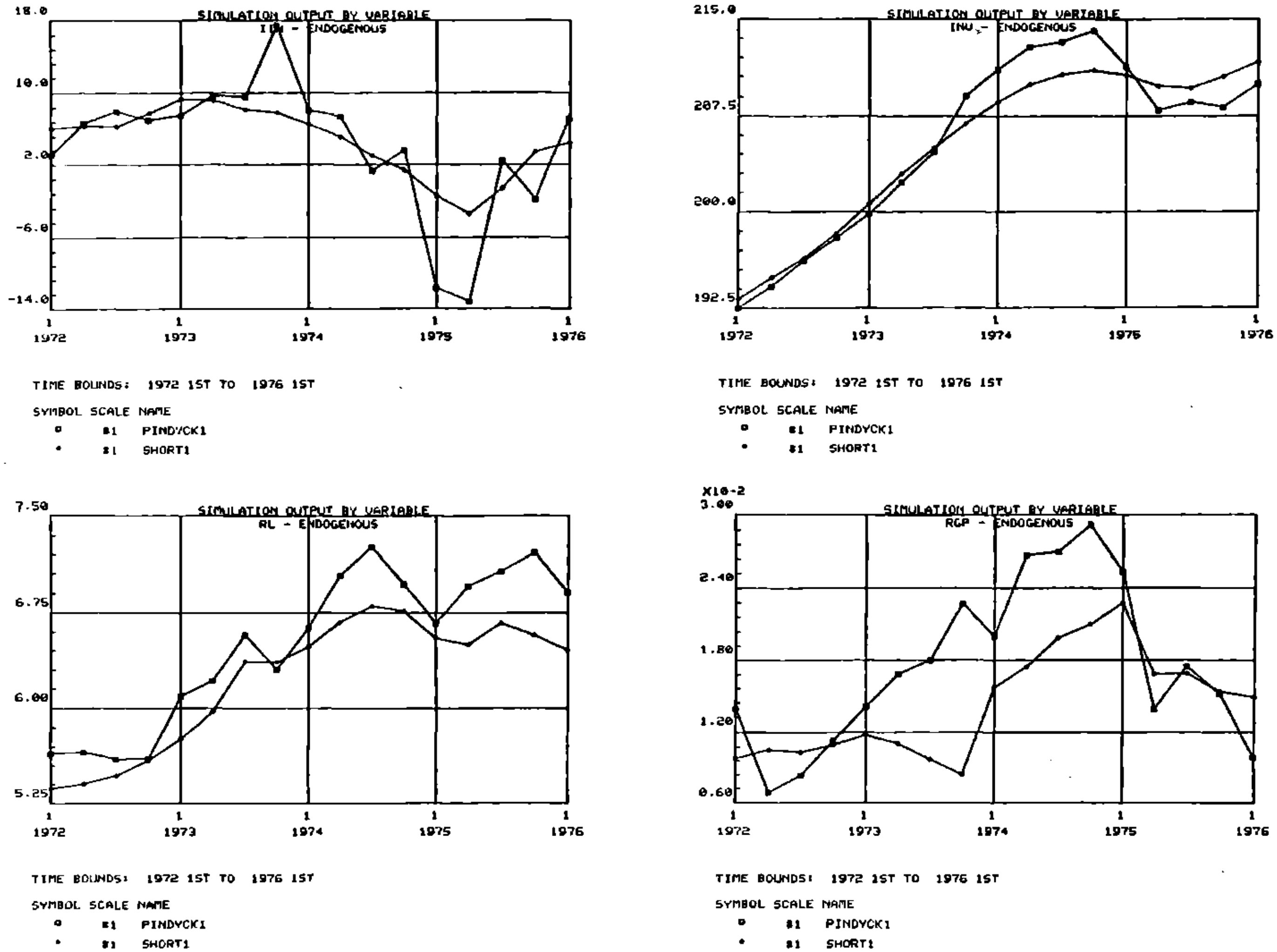
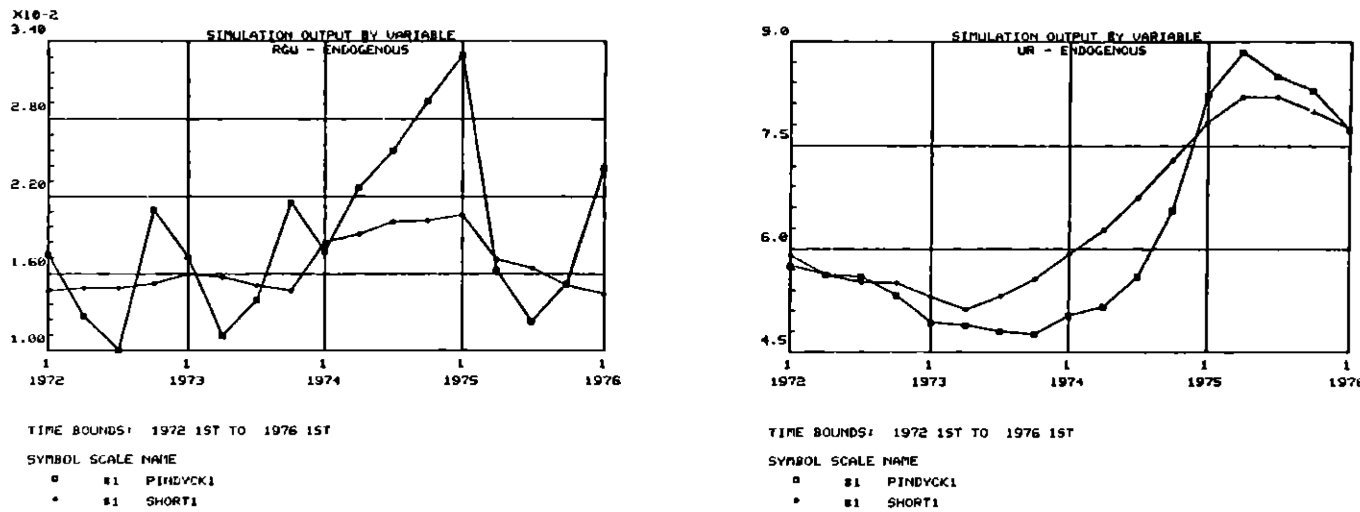


FIGURE E.4.b Results of Short Ex Post Simulation - RSB-MODEL



<u>FIGURE E.4.c</u> Results of Short Ex Post Simulation - RSB-MODEL

TABLE E.3: Results of Ex Post Forecast

	1976-1 to 1977-4		1976-1 to 1977-4	
	M-MODEL		RSB-MODEL	
Variable	RMS error	RMS % error	RMS error	RMS % error
C	2.84	0.48	8.63	1.04
INR	4.83	5.43	7.72	8.62
IR	2.13	6.32	6.00	16.04
IIN	5.90	1017.0	7.63	1123.5
INV	3.68	1.67	5.30	2.39
RS	1.34	27.62	NA	NA
RL	0.43	6.38	0.22	3.18
RGP	2.9E-3	25.19	3.6E-3	31.13
RGW	6.2E-3	40.87	6.0E-3	43.72
UR	0.46	6.12	0.82	11.65
GNP	7.90	0.91	28.43	3.22

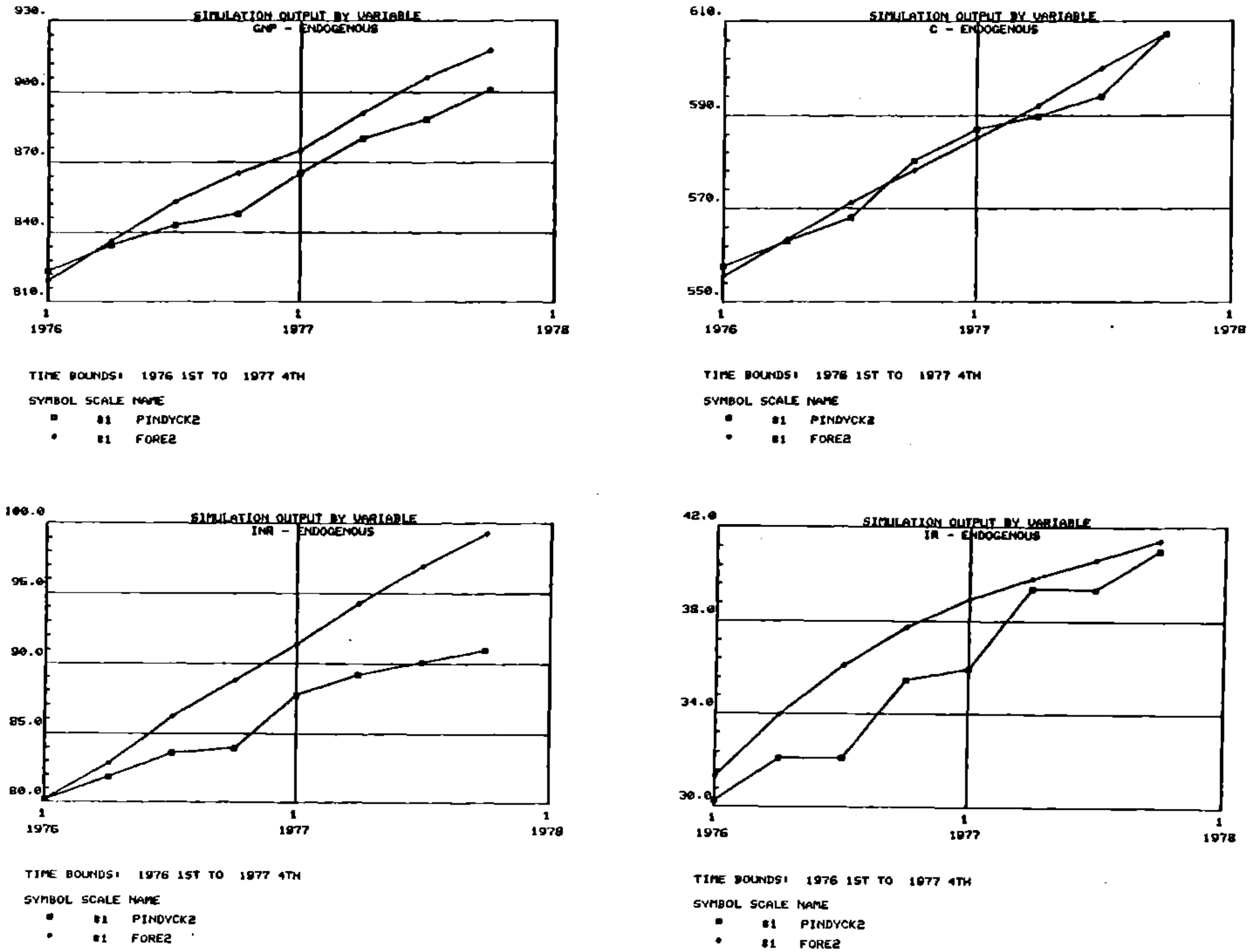


FIGURE E.5.a Results of Ex Post Forecast - M-MODEL

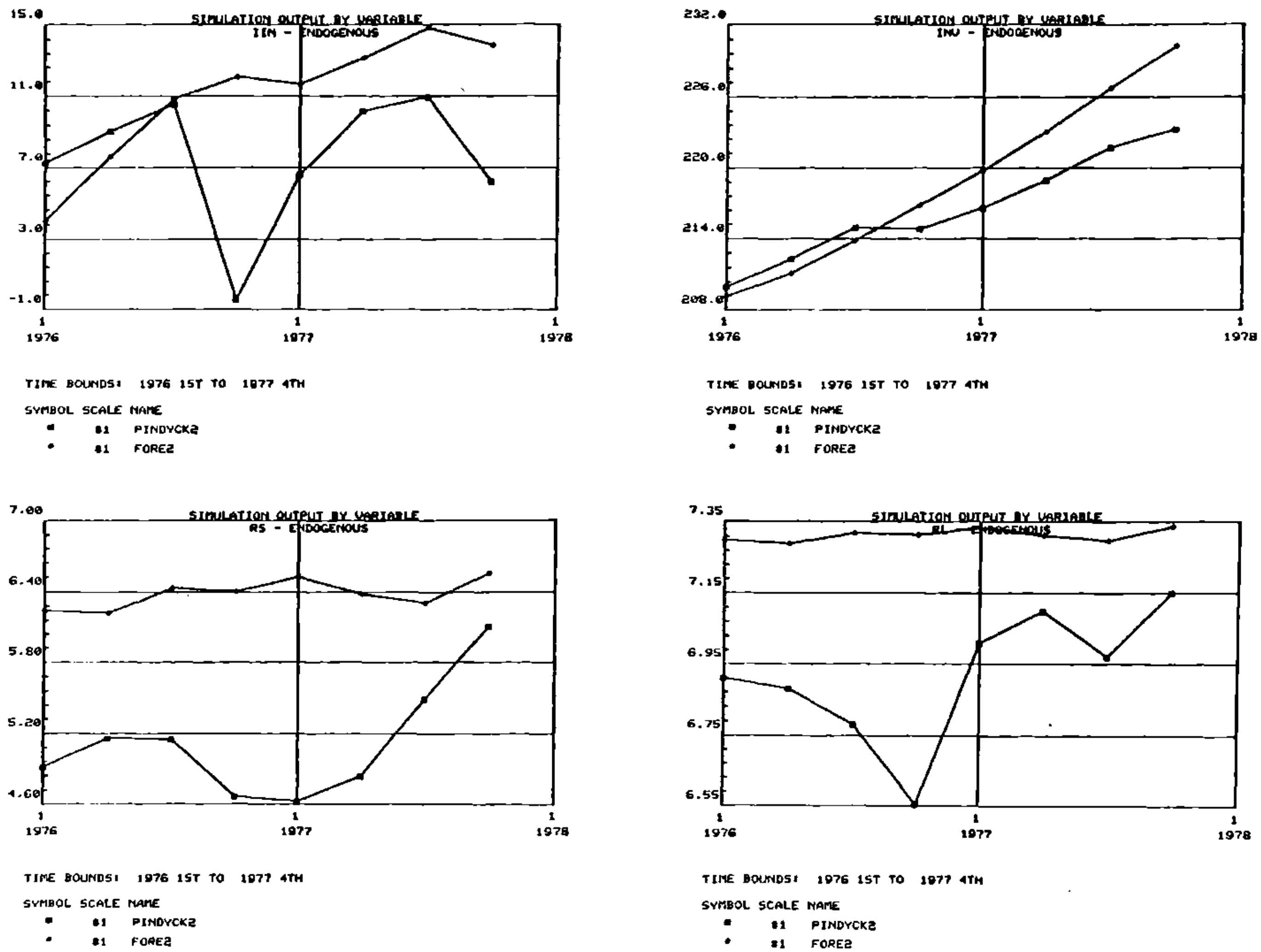
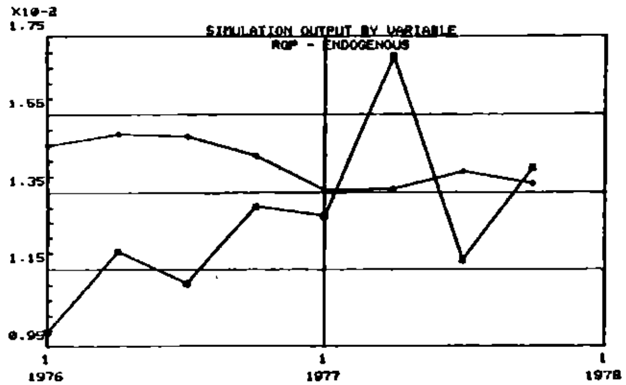
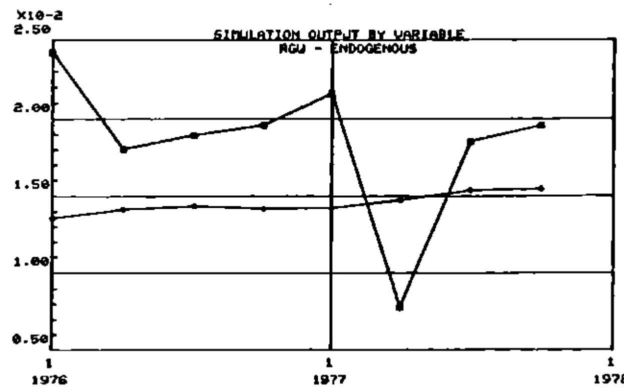


FIGURE E.5.b Results of Ex Post Forecast - M-MODEL



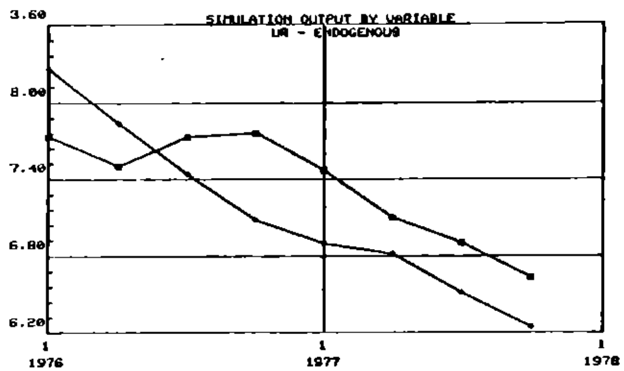
TIME BOUNDS: 1976 1ST TO 1977 4TH

SYMBOL SCALE NAME
■ #1 PINDYCK2
• #1 FORE2



TIME BOUNDS: 1976 1ST TO 1977 4TH

SYMBOL SCALE NAME
■ #1 PINDYCK2
• #1 FORE2



TIME BOUNDS: 1976 1ST TO 1977 4TH

SYMBOL SCALE NAME
■ #1 PINDYCK2
• #1 FORE2

FIGURE E.5.c Results of Ex Post Forecast - M-MODEL

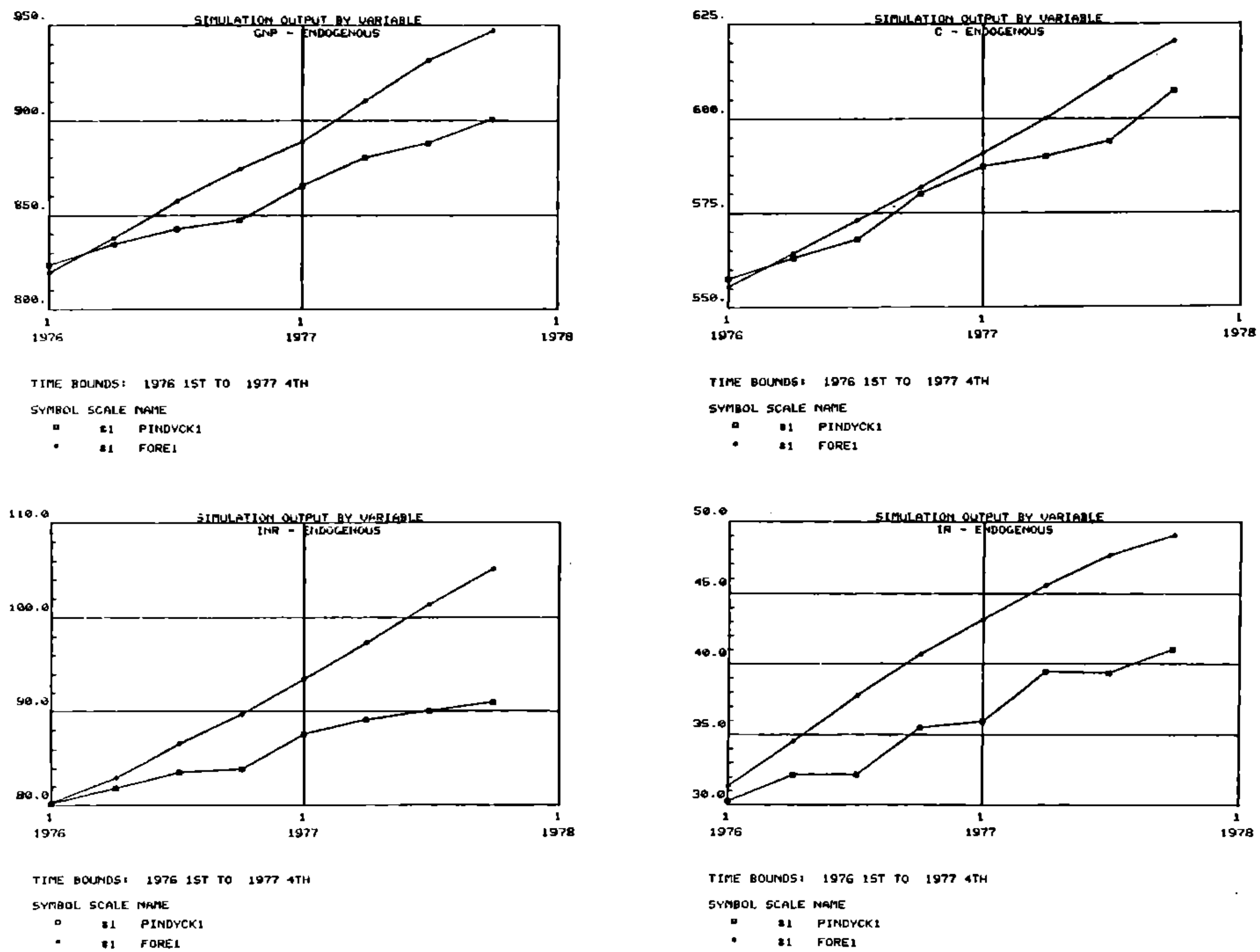


FIGURE E.6.a Results of Ex Post Forecast - RSB-MODEL

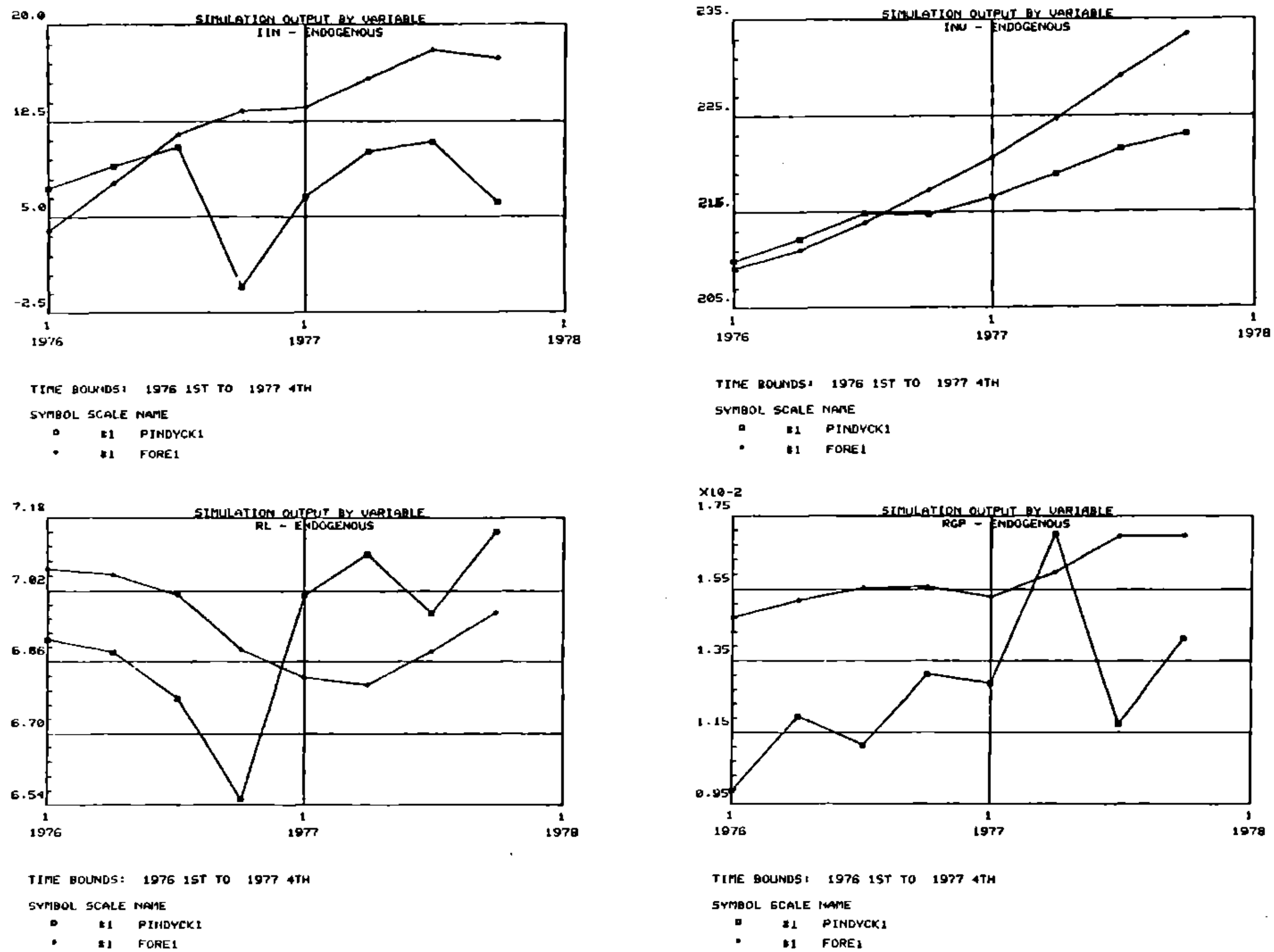
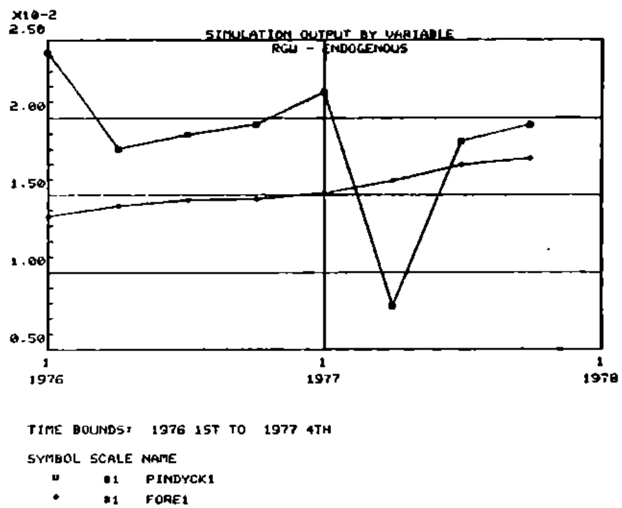


FIGURE E.6.b Results of Ex Post Forecast - RSB-MODEL



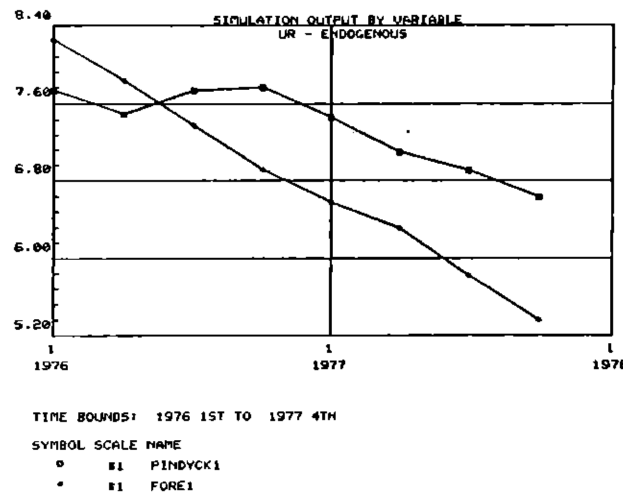


FIGURE E.6.c Results of Ex Post Forecast - RSB-MODEL

APPENDIX F: State-Space Form of "Reaction" Functions

The transformation from the structural to the state-space form of the "reaction" functions is analogous to that presented in Appendix C for the RSB-MODEL. The exact form required is given in Section 2.2, equation (2.2.31):

$$\tilde{u}_{it} = D_{i1}x_{t+1} + D_{i2}x_t + E_{ii}u_{it} + E_{ij}\tilde{u}_{jt} + F_i z_t \tag{F.1}$$

$$(i,j) = (1,2) \text{ or } (2,1)$$

where D_{i1}, D_{i2}, E_{i1}, E_{i2} and F_i are $r_i$xn, $r_i$xn, r_ixr_1, r_ixr_2 and $r_i$xs matrices, respectively. (Remember that u_{it} and z_t refer to controls and exogenous inputs at time t+1 due to time relabeling.)

Fiscal "Reaction"

Equation (2.3.5) can be rewritten to coincide with the form of (F.1):

$$\begin{aligned} G = & -0.0669\ (C+INR+IR+IIN) - 52.72RGP \\ & +0.0669\ (C_{-1}+INR_{-1}+IR_{-1}+IIN_{-1}) + 0.442UR_{-1} \\ & +1.0669G_{-1} - 0.0669G - 1.148 \end{aligned} \tag{F.2}$$

Table F.1 shows the D_{11}, D_{12}, E_{11}, E_{12} and F_1 matrices

Monetary "Reaction"

Equation (2.3.2) can be rewritten to coincide with the form of (F.1):

$$\begin{aligned} RSB = & \ 0.0235\ (C+INR+IR+IIN) - 0.161UR \\ & -0.0123\ (C_{-1}+INR_{-1}+IR_{-1}+IIN_{-1}+G_{-1}) + 29.53RGP_{-1} \\ & +0.872RSB_{-1} - 0.0112\ (C_{-2}+INR_{-2}+IR_{-2}+IIN_{-2}+G_{-2}) + 0.988 \end{aligned} \tag{F.3}$$

TABLE F.1: Fiscal "Reaction" Function Matrices:

	D_{11}:	D_{12}:
1)	0	0
2)	-0.0669	0.0669
3)	-0.0669	0.0669
4)	-0.0669	0.0669
5)	-0.0669	0.0669
6)	0	0
7)	-52.72	0
8)	0	0.442
9)	0	0
10)	0	0
11)	0	0
12)	0	0
13)	0	0
14)	0	0
15)	0	0
16)	0	0
17)	0	0
18)	0	0
19)	0	0
20)	0	0
21)	0	0
22)	0	0
23)	0	1.0669
24)	0	0
25)	0	0
26)	0	0
27)	0	0

$E_{11}(1,1) = -0.0669$

$E_{12}(1,1) = 0$

	F_1:
1)	0
2)	0
3)	0
4)	0
5)	-1.148

Table F.2 shows the D_{21}, D_{22}, E_{21}, E_{22} and F_2 matrices.

TABLE F.2: Monetary "Reaction" Function Matrices:

	D_{21}:	D_{22}:
1)	0	0
2)	0.0235	-0.0123
3)	0.0235	-0.0123
4)	0.0235	-0.0123
5)	0.0235	-0.0123
6)	0	0
7)	0	29.53
8)	-0.161	0
9)	0	-0.0112
10)	0	-0.0112
11)	0	-0.0112
12)	0	-0.0112
13)	0	0
14)	0	0
15)	0	0
16)	0	0
17)	0	0
18)	0	0
19)	0	0
20)	0	0
21)	0	0
22)	0	0
23)	0	-0.0123
24)	0	-0.0112
25)	0	0.872
26)	0	0
27)	0	0

$E_{21}(1,1) = 0.0235$

$E_{22}(1,1) = 0$

	F_2:
1)	0
2)	0
3)	0
4)	0
5)	0.988

APPENDIX G: Tables of Experimental Trajectories

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GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
0.13950D+03	0.13950D+03	0.0
0.13967D+03	0.13967D+03	0.0
0.13984D+03	0.13984D+03	0.0
0.14000D+03	0.14000D+03	0.0
0.14017D+03	0.14017D+03	0.0
0.14034D+03	0.14034D+03	0.0
0.14051D+03	0.14051D+03	0.0
0.14068D+03	0.14068D+03	0.0
0.14084D+03	0.14084D+03	0.0
0.14101D+03	0.14101D+03	0.0
0.14118D+03	0.14118D+03	0.0
0.14135D+03	0.14135D+03	0.0
0.14152D+03	0.14152D+03	0.0
0.14169D+03	0.14169D+03	0.0
0.14186D+03	0.14186D+03	0.0
0.14203D+03	0.14203D+03	0.0
0.14220D+03	0.14220D+03	0.0
[illegible]	0.14237D+03	0.0
[illegible]	[illegible]	0.0
[illegible]	[illegible]	0.0

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0

[illegible] GROWTH OF PRICES (PERCENT) [illegible] STATE VARIABLE [illegible]

OPTIMAL	[illegible]	DEVIATION	TARGET	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE G.1.a: Nominal Trajectories

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.35680D+01	0.20000D+01	0.15680D+01	0.20000D+01	0.15680D+01
0.38154D+01	0.20000D+01	0.18154D+01	0.20000D+01	0.18154D+01
0.40336D+01	0.20000D+01	0.20336D+01	0.20000D+01	0.20336D+01
0.43385D+01	0.20000D+01	0.23386D+01	0.20000D+01	0.23386D+01
0.46318D+01	0.20000D+01	0.26318D+01	0.20000D+01	0.26318D+01
0.49379D+01	0.20000D+01	0.29379D+01	0.20000D+01	0.29379D+01
0.52217D+01	0.20000D+01	0.32219D+01	0.20000D+01	0.32219D+01
0.54889D+01	0.20000D+01	0.34889D+01	0.20000D+01	0.34889D+01
0.56720D+01	0.20000D+01	0.36720D+01	0.20000D+01	0.36720D+01
0.57831D+01	0.20000D+01	0.37831D+01	0.20000D+01	0.37831D+01
0.58141D+01	0.20000D+01	0.38141D+01	0.20000D+01	0.38141D+01
0.58552D+01	0.20000D+01	0.38552D+01	0.20000D+01	0.38552D+01
0.59196D+01	0.20000D+01	0.39196D+01	0.20000D+01	0.39196D+01
[illegible]	0.20000D+01	0.39379D+01	0.20000D+01	0.39379D+01
[illegible]	0.20000D+01	0.40202D+01	0.20000D+01	0.40202D+01
[illegible]	0.20000D+01	0.40665D+01	0.20000D+01	0.40665D+01
[illegible]	0.20000D+01	0.40536D+01	0.20000D+01	0.40536D+01
[illegible]	0.20000D+01	0.40557D+01	0.20000D+01	0.40557D+01
[illegible]	0.20000D+01	0.40857D+01	0.20000D+01	0.40857D+01

[illegible]	[illegible]	NON RES. INV	RES. INV	INVENT. INV	INTEREST	GNP
[illegible]	[illegible]	0.29693D+02	0.29472D+02	[illegible]	[illegible]	0.70515D+03
[illegible]	[illegible]	[illegible]	0.27129D+02	[illegible]	[illegible]	0.70663D+03
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[illegible]	[illegible]	0.76232D+02	0.29213D+02	0.19550D 01	[illegible]	[illegible]
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[illegible]	[illegible]	0.76907D+02	0.31256D+02	0.41772D+01	[illegible]	[illegible]
[illegible]	[illegible]	0.79957D+02	0.31771D+02	0.50760D+01	[illegible]	[illegible]
[illegible]	0.49875D+03	[illegible]	[illegible]	0.55025D+01	0.62517D+01	[illegible]
[illegible]	[illegible]	[illegible]	0.32679D+02	0.56830D+01	[illegible]	[illegible]
[illegible]	[illegible]	0.83530D+02	0.33451D+02	0.71022D+01	0.63052D+01	[illegible]
0.19926D+03	0.51214D+03	0.84460D+02	0.34014D+02	0.81007D+01	0.53305D+01	0.78143D+03

TABLE G.1.b: Nominal Trajectories

GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
[illegible]	0.13950D+0[illegible]	[illegible]D+00
[illegible]49D+03	[illegible]	[illegible]4830D+00
[illegible]	0.13984D+0[illegible]	[illegible]D+01
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[illegible]	[illegible]	[illegible]50D+01
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[illegible]	[illegible]	[illegible]D+01
[illegible]	[illegible]	[illegible]D-01
[illegible]	[illegible]	[illegible]D+01

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.51565D+01	0.57000D+01	[illegible]D+00
0.50727D+01	0.57000D+01	[illegible]D+00
0.50131D+01	0.57000D+01	[illegible]D+00
0.49821D+01	0.57000D+01	[illegible]D+00
0.4[illegible]D+01	0.57000D+01	[illegible]D+00
0.50123D+01	0.57000D+01	[illegible]D+00
0.50683D+01	0.57000D+01	[illegible]D+00
0.51391D+01	0.57000D+01	[illegible]D+00
0.52138D+01	0.57000D+01	[illegible]D+00
0.52862D+01	0.57000D+01	[illegible]D+00
0.53574D+01	0.57000D+01	[illegible]D+00
0.54310D+01	0.57000D+01	[illegible]D+00
0.55116D+01	0.57000D+01	[illegible]D+00
0.55904D+01	0.57000D+01	[illegible]D+00
0.56770D+01	0.57000D+01	[illegible]D-01
0.5757[illegible]D+01	[illegible]D+01	[illegible]D-01
[illegible]D+01	[illegible]D+01	[illegible]D-01
[illegible]D+01	[illegible]D+01	[illegible]D-01
[illegible]D+01	[illegible]D+01	[illegible]D-01
[illegible]D+01	[illegible]	[illegible]

[illegible]

OPTIMAL	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]D+01	[illegible]D+01	[illegible]D+01	[illegible]D+01	[illegible]D+01

TABLE G.2.a: Experiment A1

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.35442D+01	0.20000D+01	0.15442D+01	0.20000D+01	0.15442D+01
0.37256D+01	0.20000D+01	0.17256D+01	0.20000D+01	0.17256D+01
0.37879D+01	0.20000D+01	0.17879D+01	0.20000D+01	0.17879D+01
0.39301D+01	0.20000D+01	0.19301D+01	0.20000D+01	0.19301D+01
0.40409D+01	0.20000D+01	0.20409D+01	0.20000D+01	0.20409D+01
0.41702D+01	0.20000D+01	0.21702D+01	0.20000D+01	0.21702D+01
0.42869D+01	0.20000D+01	0.22869D+01	0.20000D+01	0.22869D+01
0.44048D+01	0.20000D+01	0.24048D+01	0.20000D+01	0.24048D+01
0.44852D+01	0.20000D+01	0.24852D+01	0.20000D+01	0.24852D+01
0.45508D+01	0.20000D+01	0.25508D+01	0.20000D+01	0.25508D+01
0.45844D+01	0.20000D+01	0.25844D+01	0.20000D+01	0.25844D+01
0.46334D+01	0.20000D+01	0.26334D+01	0.20000D+01	0.26334D+01
0.47012D+01	0.20000D+01	0.27012D+01	0.20000D+01	0.27012D+01
0.47985D+01	0.20000D+01	0.27985D+01	0.20000D+01	0.27985D+01
0.48698D+01	0.20000D+01	0.28698D+01	0.20000D+01	0.28698D+01
0.49707D+01	0.20000D+01	0.29707D+01	0.20000D+01	0.29707D+01
0.50506D+01	0.20000D+01	0.30506D+01	0.20000D+01	0.30506D+01
0.51060D+01	0.20000D+01	0.31060D+01	0.20000D+01	0.31060D+01
0.53255D+01	0.20000D+01	0.33255D+01	0.20000D+01	0.33255D+01

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	GNP
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.54335D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.54970D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.55048D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.57521D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.58219D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.60818D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.20682D+03	0.53112D+03	0.91715D+02	0.35689D+02	0.46537D+01	0.62215D+01	0.80104D+03

TABLE G.2.b: Experiment A.1

GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
0.14881D+03	0.13950D+03	0.93091D+01
0.14902D+03	0.13967D+03	0.93547D+01
0.14965D+03	0.13984D+03	0.98105D+01
0.14990D+03	0.14000D+03	0.98974D+01
0.15003D+03	0.14017D+03	0.98571D+01
0.15028D+03	0.14034D+03	0.99436D+01
0.15056D+03	0.14051D+03	0.10051D+02
0.15073D+03	0.14068D+03	0.10050D+02
0.15070D+03	0.14084D+03	0.98545D+01
0.15050D+03	0.14101D+03	0.94851D+01
0.15013D+03	0.14118D+03	0.89487D+01
0.14982D+03	0.14135D+03	0.84715D+01
0.14965D+03	0.14152D+03	0.81267D+01
0.14963D+03	0.14169D+03	0.79387D+01
0.14943D+03	0.14186D+03	0.75734D+01
0.14910D+03	0.14203D+03	0.70663D+01
0.14867D+03	0.14220D+03	0.64635D+01
0.14965D+03	0.14237D+03	0.72833D+01
0.14846D+03	0.14254D+03	0.59177D+01
0.14272D+03	0.14272D+03	0.0

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.43636D+01	0.57000D+01	-0.13364D+01
0.43589D+01	0.57000D+01	-0.13411D+01
0.43636D+01	0.57000D+01	-0.13364D+01
0.43770D+01	0.57000D+01	-0.13230D+01
0.44011D+01	0.57000D+01	-0.12989D+01
0.44379D+01	0.57000D+01	-0.12621D+01
0.44875D+01	0.57000D+01	-0.12125D+01
0.45433D+01	0.57000D+01	-0.11567D+01
0.46050D+01	0.57000D+01	-0.10950D+01
0.46703D+01	0.57000D+01	-0.10297D+01
0.47430D+01	0.57000D+01	-0.95703D+00
0.48278D+01	0.57000D+01	-0.87221D+00
0.49298D+01	0.57000D+01	-0.77022D+00
0.50458D+01	0.57000D+01	-0.65422D+00
0.51878D+01	0.57000D+01	-0.51219D+00
0.53559D+01	0.57000D+01	-0.34408D+00
0.55098D+01	0.57000D+01	-0.19024D+00
0.56370D+01	0.57000D+01	-0.62976D-01
0.56922D+01	0.57000D+01	0.78079D-02
0.57000D+01	0.57000D+01	0.0

RATE OF GROWTH OF PRICES (PERCENT, 4.D2*(ACTUAL STATE VARIABLE))

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.53082D+01	0.20000D+01	0.33082D+01	0.20000D+01	0.33082D+01
0.61459D+01	0.20000D+01	0.41459D+01	0.20000D+01	0.41459D+01
0.54881D+01	0.20000D+01	0.34881D+01	0.20000D+01	0.34881D+01
0.54486D+01	0.20000D+01	0.34486D+01	0.20000D+01	0.34486D+01
0.53908D+01	0.20000D+01	0.33908D+01	0.20000D+01	0.33908D+01
0.53359D+01	0.20000D+01	0.33359D+01	0.20000D+01	0.33359D+01
0.51923D+01	0.20000D+01	0.31923D+01	0.20000D+01	0.31923D+01
0.50946D+01	0.20000D+01	0.30946D+01	0.20000D+01	0.30946D+01
0.50775D+01	0.20000D+01	0.30775D+01	0.20000D+01	0.30775D+01
0.51382D+01	0.20000D+01	0.31382D+01	0.20000D+01	0.31382D+01
0.52550D+01	0.20000D+01	0.32550D+01	0.20000D+01	0.32550D+01
0.53366D+01	0.20000D+01	0.33366D+01	0.20000D+01	0.33366D+01
[illegible]	0.20000D+01	0.33337D+01	0.20000D+01	0.33337D+01
0.53321D+01	0.20000D+01	0.33321D+01	0.20000D+01	0.33321D+01
0.53321D+01	0.20000D+01	0.33321D+01	0.20000D+01	0.33321D+01
0.52529D+01	0.20000D+01	0.32529D+01	0.20000D+01	0.32529D+01
[illegible]	0.20000D+01	0.31797D+01	0.20000D+01	0.31797D+01
0.52163D+01	0.20000D+01	0.32163D+01	0.20000D+01	0.32163D+01
0.50424D+01	0.20000D+01	0.30424D+01	0.20000D+01	0.30424D+01
0.42100D+01	0.20000D+01	0.22100D+01	0.20000D+01	0.22100D+01

TABLE G.3.a: Experiment A.2

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.29178D+01	0.20000D+01	0.91781D+00	0.20000D+01	0.91781D+00
0.28923D+01	0.20000D+01	0.89226D+00	0.20000D+01	0.89226D+00
0.30139D+01	0.20000D+01	0.10139D+01	0.20000D+01	0.10139D+01
0.30587D+01	0.20000D+01	0.10587D+01	0.20000D+01	0.10587D+01
0.30711D+01	0.20000D+01	0.10711D+01	0.20000D+01	0.10711D+01
0.31337D+01	0.20000D+01	0.11337D+01	0.20000D+01	0.11337D+01
0.32167D+01	0.20000D+01	0.12167D+01	0.20000D+01	0.12167D+01
0.32922D+01	0.20000D+01	0.12922D+01	0.20000D+01	0.12922D+01
0.33188D+01	0.20000D+01	0.13188D+01	0.20000D+01	0.13188D+01
0.33162D+01	0.20000D+01	0.13162D+01	0.20000D+01	0.13162D+01
0.32716D+01	0.20000D+01	0.12716D+01	0.20000D+01	0.12716D+01
0.32577D+01	0.20000D+01	0.12577D+01	0.20000D+01	0.12577D+01
0.32798D+01	0.20000D+01	0.12798D+01	0.20000D+01	0.12798D+01
0.33190D+01	0.20000D+01	0.13190D+01	0.20000D+01	0.13190D+01
0.33575D+01	0.20000D+01	0.13575D+01	0.20000D+01	0.13575D+01
0.34500D+01	0.20000D+01	0.14500D+01	0.20000D+01	0.14500D+01
0.35170D+01	0.20000D+01	0.15170D+01	0.20000D+01	0.15170D+01
0.35296D+01	0.20000D+01	0.15296D+01	0.20000D+01	0.15296D+01
0.37144D+01	0.20000D+01	0.17144D+01	0.20000D+01	0.17144D+01

[illegible]	[illegible]	GOV. RES. INV	RES. INV	NONRES. INV	INTEREST	GNP
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.31477D+02	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	0.86225D+02	[illegible]	0.90591D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.35727D+02	0.91035D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.36762D+02	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.37568D+02	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	0.51629D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	0.98008D+02	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.40114D+02	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.40510D+02	0.86923D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.40594D+02	0.85436D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.40663D+02	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	0.10545D+03	0.40533D+02	[illegible]	[illegible]	[illegible]
0.21997D+03	[illegible]	0.10524D+03	0.40516D+02	0.84752D+01	0.50212D+01	0.85781D+03

TABLE G.3.b: Experiment A.2

GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
[illegible]	0.13950D+03	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	0.13984D+03	[illegible]
[illegible]	0.14000D+03	[illegible]
[illegible]	0.14017D+03	-0.40165D+01
[illegible]	[illegible]	[illegible]
[illegible]	0.14051D+03	0.19350D+01
[illegible]	0.14068D+03	-0.11891D+01
[illegible]	0.14084D+03	-0.83293D+00
[illegible]	0.14101D+03	-0.10601D+01
[illegible]	0.14118D+03	0.15996D+01
[illegible]	0.14135D+03	[illegible]
[illegible]	0.14152D+03	0.21066D+01
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.62630D+01	0.57000D+01	0.56301D+00
0.61358D+01	0.57000D+01	0.43580D+00
0.60268D+01	0.57000D+01	0.32680D+00
0.59554D+01	0.57000D+01	0.25541D+00
0.59198D+01	0.57000D+01	0.21980D+00
0.59157D+01	0.57000D+01	0.21572D+00
0.59367D+01	0.57000D+01	0.23674D+00
0.59720D+01	0.57000D+01	0.27203D+00
0.60096D+01	0.57000D+01	0.30964D+00
0.60419D+01	0.57000D+01	0.34188D+00
0.60656D+01	0.57000D+01	0.36562D+00
0.60817D+01	0.57000D+01	0.38159D+00
0.60873D+01	0.57000D+01	0.38727D+00
0.60779D+01	0.57000D+01	0.37789D+00
0.60514D+01	0.57000D+01	0.35139D+00
0.59901D+01	0.57000D+01	0.29006D+00
0.59026D+01	0.57000D+01	0.20264D+00
0.58100D+01	0.57000D+01	0.11001D+00
[illegible]	0.57000D+01	[illegible]
0.57041D+01	0.57000D+01	[illegible]

RATE OF GROWTH OF PRICES (PERCENT, STRUCTURAL STATE VARIABLE))

OPTIMAL	TARGET 1	DEVIATION 1	TARGET 2	DEVIATION 2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	0.20000D+01	[illegible]	0.20000D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.20000D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	0.20000D+01	[illegible]	[illegible]	[illegible]
[illegible]	0.20000D+01	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.20000D+01	[illegible]
[illegible]	[illegible]	[illegible]	0.20000D+01	[illegible]
[illegible]	[illegible]	[illegible]	0.20000D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE G.4.a: Experiment A.3

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.42224D+01	0.20000D+01	0.22224D+01	0.20000D+01	0.22224D+01
0.45996D+01	0.20000D+01	0.25996D+01	0.20000D+01	0.25996D+01
0.47352D+01	0.20000D+01	0.27352D+01	0.20000D+01	0.27352D+01
0.50722D+01	0.20000D+01	0.30722D+01	0.20000D+01	0.30722D+01
0.53458D+01	0.20000D+01	0.33458D+01	0.20000D+01	0.33458D+01
0.56279D+01	0.20000D+01	0.36279D+01	0.20000D+01	0.36279D+01
0.58652D+01	0.20000D+01	0.38652D+01	0.20000D+01	0.38652D+01
0.60986D+01	0.20000D+01	0.40986D+01	0.20000D+01	0.40986D+01
0.62713D+01	0.20000D+01	0.42713D+01	0.20000D+01	0.42713D+01
0.64104D+01	0.20000D+01	0.44104D+01	0.20000D+01	0.44104D+01
0.64981D+01	0.20000D+01	0.44981D+01	0.20000D+01	0.44981D+01
[illegible]	0.20000D+01	0.45880D+01	0.20000D+01	0.45880D+01
0.66831D+01	0.20000D+01	0.46831D+01	0.20000D+01	0.46831D+01
0.67924D+01	0.20000D+01	0.47924D+01	0.20000D+01	0.47924D+01
0.68687D+01	0.20000D+01	0.48687D+01	0.20000D+01	0.48687D+01
[illegible]	0.20000D+01	0.49536D+01	0.20000D+01	0.49536D+01
[illegible]	0.20000D+01	0.49782D+01	0.20000D+01	0.49782D+01
[illegible]	0.20000D+01	0.50121D+01	0.20000D+01	0.50121D+01
[illegible]	0.20000D+01	0.51368D+01	0.20000D+01	0.51368D+01

[illegible]	[illegible]	NON-RES. INV	RES. INV	INVENT. INV	INTEREST	GNP
[illegible]	[illegible]	[illegible]	0.29500D+02	0.26259D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.28509D+02	-0.11119D+00	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.27545D+02	0.45229D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.26271D+02	0.42774D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.26311D+02	0.41121D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.26135D+02	0.35132D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.26164D+02	0.27519D+01	[illegible]	0.68591D+03
[illegible]	[illegible]	0.71939D+02	0.26308D+02	0.19458D+01	[illegible]	0.68622D+03
[illegible]	[illegible]	[illegible]	0.26504D+02	0.50420D+00	[illegible]	0.68818D+03
[illegible]	[illegible]	0.70955D+02	0.26722D+02	-0.31160D+00	[illegible]	[illegible]
[illegible]	[illegible]	0.70956D+02	[illegible]	0.10930D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	0.60335D+00	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	0.29443D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	0.31413D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.26134D+02	0.31114D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.71962D+03
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	0.49554D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.31011D+02	0.68343D+01	[illegible]	0.74536D+03

TABLE G.4.b: Experiment A.3

GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
0.15035D+03	0.13950D+03	0.10852D+02
0.15091D+03	0.13957D+03	0.11141D+02
0.15195D+03	0.13984D+03	0.12112D+02
0.15270D+03	0.14000D+03	0.12700D+02
0.15335D+03	0.14017D+03	0.13155D+02
0.15328D+03	0.14034D+03	0.13638D+02
0.15455D+03	0.14051D+03	0.14040D+02
0.15492D+03	0.14068D+03	0.14239D+02
0.15560D+03	0.14085D+03	0.14151D+02
0.15482D+03	0.14101D+03	0.13809D+02
0.15394D+03	0.14118D+03	0.1327[illegible]D+02
0.15398D+03	0.14135D+03	0.12630D+02
0.15463D+03	0.14152D+03	0.1212[illegible]D+02
0.15375D+03	0.14169D+03	0.11[illegible]57D+02
0.15298D+03	0.14186D+03	0.11121D+02
0.15228D+03	0.142[illegible]	0.10250D+02
0.15145D+03	0.14220D+03	0.[illegible]2500D+01
0.15240D+03	0.1425[illegible]D+03	0.1003[illegible]D+02
0.1500[illegible]D+03	0.142[illegible]D+03	0.78719D+01
0.1427[illegible]D+03	0.14271D+03	0.0

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0
0.57000D+01	0.57000D+01	0.0

RATE OF GROWTH OF PRICES (PERCENT) [illegible]

OPTIMAL	TARGET 1	DEVIATION 1	TARGET 2	DEVIATION 2
[illegible]	[illegible]	0.[illegible]4410D+01	[illegible]	[illegible]
0.2[illegible]D+01	[illegible]	0.4325[illegible]D+01	[illegible]	[illegible]
[illegible]	0.[illegible]0000D+01	0.34896D+01	0.20000D+01	[illegible]
[illegible]	[illegible]	0.32733D+01	[illegible]	[illegible]
[illegible]	[illegible]	0.30[illegible]D+01	[illegible]	[illegible]
[illegible]	[illegible]	0.2372[illegible]D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	0.2[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.20000D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE G.5.a: Experiment B.1

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.28186D+01	0.20000D+01	0.81860D+00	0.20000D+01	0.81860D+00
0.27925D+01	0.20000D+01	0.79259D+00	0.20000D+01	0.79259D+00
0.30079D+01	0.20000D+01	0.10079D+01	0.20000D+01	0.10079D+01
0.31517D+01	0.20000D+01	0.11517D+01	0.20000D+01	[illegible]
0.32787D+01	0.20000D+01	0.12787D+01	0.20000D+01	0.12787D+01
0.34443D+01	0.20000D+01	0.14443D+01	0.20000D+01	[illegible]
0.36161D+01	0.20000D+01	0.16161D+01	0.20000D+01	[illegible]
0.37682D+01	0.20000D+01	0.17682D+01	0.20000D+01	[illegible]
0.38570D+01	0.20000D+01	0.18570D+01	0.20000D+01	[illegible]
0.39040D+01	0.20000D+01	0.19040D+01	0.20000D+01	[illegible]
0.38979D+01	0.20000D+01	0.18979D+01	0.20000D+01	[illegible]
0.39135D+01	0.20000D+01	0.19135D+01	0.20000D+01	[illegible]
0.39556D+01	0.20000D+01	0.19556D+01	0.20000D+01	[illegible]
0.40028D+01	0.20000D+01	0.20028D+01	0.20000D+01	[illegible]
0.40424D+01	0.20000D+01	0.20424D+01	0.20000D+01	[illegible]
0.41296D+01	0.20000D+01	0.21296D+01	0.20000D+01	[illegible]
0.41776D+01	0.20000D+01	0.21776D+01	0.20000D+01	0.21776D+01
0.41514D+01	0.20000D+01	0.21514D+01	0.20000D+01	[illegible]
0.42856D+01	0.20000D+01	0.22856D+01	0.20000D+01	[illegible]

INVENTORIES	CONSUMPTION	NON-RES. INV	RES. INV	INVENT. INV	INTEREST	GNP
[illegible]	[illegible]	[illegible]	0.29683D+02	0.12681D+02	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	0.13930D+02	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.56301D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.56755D+01	[illegible]
[illegible]	[illegible]	[illegible]	0.30328D+02	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.30688D+02	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.60038D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.60855D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.63057D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.63305D+01	[illegible]

TABLE G.5.b: Experiment B.1

GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
0.13950D+03	0.13950D+03	0.0
0.13967D+03	0.13967D+03	0.0
0.13984D+03	0.13984D+03	0.0
0.14000D+03	0.14000D+03	0.0
0.14017D+03	0.14017D+03	0.0
0.14034D+03	0.14034D+03	0.0
0.14051D+03	0.14051D+03	0.0
0.14068D+03	0.14068D+03	0.0
0.14084D+03	0.14084D+03	0.0
0.14101D+03	0.14101D+03	0.0
0.14118D+03	0.14118D+03	0.0
0.14135D+03	0.14135D+03	0.0
0.14152D+03	0.14152D+03	0.0
0.141[illegible]D+03	0.14169D+03	0.0
0.14185D+03	0.14185D+03	0.0
0.14203D+03	0.14203D+03	0.0
0.14220D+03	0.14220D+03	0.0
0.14237D+03	0.14237D+03	0.0
0.14254D+03	0.14254D+03	0.0
0.14272D+03	0.14272D+03	0.0

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.66132D+01	0.57000D+01	0.91320D+00
0.63851D+01	0.57000D+01	0.68851D+00
0.62104D+01	0.57000D+01	0.51037D+00
0.60940D+01	0.57000D+01	0.39399D+00
0.60346D+01	0.57000D+01	0.33402D+00
0.60249D+01	0.57000D+01	0.32490D+00
0.60556D+01	0.57000D+01	0.35556D+00
0.61069D+01	0.57000D+01	0.40692D+00
0.61591D+01	0.57000D+01	0.45910D+00
0.62008D+01	0.57000D+01	0.50080D+00
0.62301D+01	0.57000D+01	0.53011D+00
0.62497D+01	0.57000D+01	0.54967D+00
0.62564D+01	0.57000D+01	0.55639D+00
0.62467D+01	0.57000D+01	0.54667D+00
0.62134D+01	0.57000D+01	0.51340D+00
0.61292D+01	0.57000D+01	0.42925D+00
0.60036D+01	0.57000D+01	0.30368D+00
0.58637D+01	0.57000D+01	0.16374D+00
0.57506D+01	0.57000D+01	0.50591D-01
0.57059D+01	0.57000D+01	0.59324D-02

RATE OF GROWTH OF PRICES (PERCENT) 4.02% (ACTUAL STATE VARIABLE)

OPTIMAL	TARGET 1	DEVIATION 1	TARGET 2	DEVIATION 2
0.44750D+01	0.20000D+01	0.24750D+01	0.20000D+01	0.24750D+01
0.45502D+01	0.20000D+01	0.25502D+01	0.20000D+01	[illegible]
0.39[illegible]D+01	0.20000D+01	0.19[illegible]D+01	0.20000D+01	[illegible]
[illegible]	0.20000D+01	0.15[illegible]D+01	0.20000D+01	[illegible]
[illegible]	0.20000D+01	0.10[illegible]D+01	0.20000D+01	[illegible]
[illegible]	[illegible]	[illegible]	0.20000D+01	[illegible]
[illegible]	[illegible]	[illegible]	0.20000D+01	[illegible]
0.222[illegible]D+01	0.20000D+01	[illegible]	0.20000D+01	[illegible]
0.212[illegible]D+01	[illegible]	[illegible]	0.20000D+01	[illegible]
0.21[illegible]D+01	[illegible]	[illegible]	[illegible]	[illegible]
0.23013D+01	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	0.20000D+01	[illegible]	0.20000D+01	[illegible]
[illegible]	0.20000D+01	[illegible]D+00	0.20000D+01	[illegible]
[illegible]	0.20000D+01	[illegible]D+00	0.20000D+01	0.43[illegible]
[illegible]	0.20000D+01	0.56[illegible]D+00	0.20000D+01	0.56961D+00
[illegible]	[illegible]	[illegible]D+00	0.20000D+01	0.65[illegible]D+00
[illegible]	0.20000D+01	[illegible]D+00	0.20000D+01	[illegible]D+00
[illegible]	0.20000D+01	[illegible]	0.20000D+01	0.8[illegible]D+00
[illegible]	0.20000D+01	[illegible]D+00	0.20000D+01	[illegible]D+00
[illegible]	0.20000D+01	0.1[illegible]D+01	0.20000D+01	0.10[illegible]D+01

TABLE G.6.a: Experiment B.2

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.35730D+01	0.20000D+01	0.15730D+01	0.20000D+01	0.15730D+01
0.38549D+01	0.20000D+01	0.18549D+01	0.20000D+01	0.18549D+01
0.41485D+01	0.20000D+01	0.21485D+01	0.20000D+01	0.21485D+01
0.45326D+01	0.20000D+01	0.25326D+01	0.20000D+01	0.25326D+01
0.48991D+01	0.20000D+01	0.28991D+01	0.20000D+01	0.28991D+01
0.52510D+01	0.20000D+01	0.32510D+01	0.20000D+01	0.32510D+01
0.55614D+01	0.20000D+01	0.35614D+01	0.20000D+01	0.35614D+01
0.58510D+01	0.20000D+01	0.38510D+01	0.20000D+01	[illegible]
0.60555D+01	0.20000D+01	0.40555D+01	0.20000D+01	[illegible]
0.61907D+01	0.20000D+01	0.41907D+01	0.20000D+01	0.41907D+01
0.62502D+01	0.20000D+01	0.42502D+01	0.20000D+01	[illegible]
0.63245D+01	0.20000D+01	0.43245D+01	0.20000D+01	[illegible]
[illegible]	0.20000D+01	0.44244D+01	0.20000D+01	[illegible]
[illegible]	0.20000D+01	0.45582D+01	0.20000D+01	0.45582D+01
[illegible]	0.20000D+01	[illegible]	0.20000D+01	[illegible]
[illegible]	0.20000D+01	0.46603D+01	0.20000D+01	[illegible]
[illegible]	0.20000D+01	[illegible]	0.20000D+01	[illegible]
[illegible]	0.20000D+01	[illegible]	[illegible]	[illegible]
[illegible]	0.20000D+01	[illegible]	0.20000D+01	[illegible]

[illegible]	[illegible]	[illegible]	RES. INV	GOV'T. INV	INTEREST	GNP
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.57159D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.62111D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.63253D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	0.45219D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.19852D+03	0.39927D+03	0.29114D+02	0.31443D+02	0.73459D+01	0.65057D+01	0.78049D+03

TABLE G.6.b: Experiment B.2

GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
0.14097D+03	0.13950D+03	0.14729D+01
0.14166D+03	0.13967D+03	0.19880D+01
0.14255D+03	0.13984D+03	0.27136D+01
0.14372D+03	0.14000D+03	0.37148D+01
0.14491D+03	0.14017D+03	0.47412D+01
0.14612D+03	0.14034D+03	0.57806D+01
0.14722D+03	0.14051D+03	0.67083D+01
0.14815D+03	0.14068D+03	0.74691D+01
0.14877D+03	0.14084D+03	0.79317D+01
0.14916D+03	0.14101D+03	0.81483D+01
0.14938D+03	0.14118D+03	0.81975D+01
0.14972D+03	0.14135D+03	0.83654D+01
0.15030D+03	0.14152D+03	0.87729D+01
0.15120D+03	0.14169D+03	0.95122D+01
0.15191D+03	0.14186D+03	0.10053D+02
0.15231D+03	0.14203D+03	0.10274D+02
0.15235D+03	0.14220D+03	0.10146D+02
0.15410D+03	0.14237D+03	0.11731D+02
0.15196D+03	0.14254D+03	0.94199D+01
0.14272D+03	0.14272D+03	0.0

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.60805D+01	0.57000D+01	0.38051D+00
0.62538D+01	0.57000D+01	0.55383D+00
0.63058D+01	0.57000D+01	0.60576D+00
0.62259D+01	0.57000D+01	0.52589D+00
0.60807D+01	0.57000D+01	0.38068D+00
0.58865D+01	0.57000D+01	0.18653D+00
0.56822D+01	0.57000D+01	-0.17828D-01
0.54912D+01	0.57000D+01	-0.20883D+00
0.53654D+01	0.57000D+01	-0.33456D+00
0.53315D+01	0.57000D+01	-0.36851D+00
0.54033D+01	0.57000D+01	-0.29667D+00
0.55304D+01	0.57000D+01	-0.16957D+00
0.56747D+01	0.57000D+01	0.25319D-01
0.58399D+01	0.57000D+01	0.13990D+00
0.60186D+01	0.57000D+01	0.31863D+00
0.61570D+01	0.57000D+01	0.45704D+00
0.62725D+01	0.57000D+01	0.57246D+00
0.64318D+01	0.57000D+01	0.73179D+00
0.64504D+01	0.57000D+01	0.75036D+00
0.59350D+01	0.57000D+01	0.23504D+00

RATE OF GROWTH OF PRICES (PERCENT, 4.D2*(ACTUAL STATE VARIABLE))

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION 2
0.46096D+01	0.20000D+01	0.26096D+01	0.20000D+01	0.26096D+01
0.48888D+01	0.20000D+01	0.28888D+01	0.20000D+01	0.28888D+01
0.43245D+01	0.20000D+01	0.23245D+01	0.20000D+01	0.23245D+01
0.40920D+01	0.20000D+01	0.20920D+01	0.20000D+01	0.20920D+01
0.37294D+01	0.20000D+01	0.17294D+01	0.20000D+01	0.17294D+01
0.34952D+01	0.20000D+01	0.14952D+01	0.20000D+01	0.14952D+01
0.32946D+01	0.20000D+01	0.12946D+01	0.20000D+01	0.12946D+01
0.32007D+01	0.20000D+01	0.12007D+01	0.20000D+01	0.12007D+01
0.32383D+01	0.20000D+01	0.12383D+01	0.20000D+01	0.12383D+01
0.34235D+01	0.20000D+01	0.14235D+01	0.20000D+01	0.14235D+01
0.37111D+01	0.20000D+01	0.17111D+01	0.20000D+01	0.17111D+01
0.39865D+01	0.20000D+01	0.19865D+01	0.20000D+01	0.19865D+01
0.41826D+01	0.20000D+01	0.21826D+01	0.20000D+01	0.21826D+01
0.43824D+01	0.20000D+01	0.23824D+01	0.20000D+01	0.23824D+01
0.45694D+01	0.20000D+01	0.25694D+01	0.20000D+01	0.25694D+01
0.46373D+01	0.20000D+01	0.26373D+01	0.20000D+01	0.26373D+01
0.46709D+01	0.20000D+01	0.26709D+01	0.20000D+01	0.26709D+01
0.48338D+01	0.20000D+01	0.28338D+01	0.20000D+01	0.28338D+01
0.46706D+01	0.20000D+01	0.26706D+01	0.20000D+01	0.26706D+01
0.35102D+01	0.20000D+01	0.15102D+01	0.20000D+01	0.15102D+01

TABLE G.7.a: Experiment C.1

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.34684D+01	0.20000D+01	0.14684D+01	0.20000D+01	0.14684D+01
0.36616D+01	0.20000D+01	0.16616D+01	0.20000D+01	0.16616D+01
0.38699D+01	0.20000D+01	0.18699D+01	0.20000D+01	0.18699D+01
0.41414D+01	0.20000D+01	0.21414D+01	0.20000D+01	0.21414D+01
0.43955D+01	0.20000D+01	0.23955D+01	0.20000D+01	0.23955D+01
0.46486D+01	0.20000D+01	0.26486D+01	0.20000D+01	0.26486D+01
0.48578D+01	0.20000D+01	0.28578D+01	0.20000D+01	0.28578D+01
0.50248D+01	0.20000D+01	0.30248D+01	0.20000D+01	0.30248D+01
0.50938D+01	0.20000D+01	0.30938D+01	0.20000D+01	0.30938D+01
0.50835D+01	0.20000D+01	0.30835D+01	0.20000D+01	0.30835D+01
0.49900D+01	0.20000D+01	0.29900D+01	0.20000D+01	0.29900D+01
0.48987D+01	0.20000D+01	0.28987D+01	0.20000D+01	0.28987D+01
0.48246D+01	0.20000D+01	0.28246D+01	0.20000D+01	0.28246D+01
0.47510D+01	0.20000D+01	0.27510D+01	0.20000D+01	0.27510D+01
0.46763D+01	0.20000D+01	0.26763D+01	0.20000D+01	0.26763D+01
0.46695D+01	0.20000D+01	0.26695D+01	0.20000D+01	0.26695D+01
0.46535D+01	0.20000D+01	0.26535D+01	0.20000D+01	0.26535D+01
0.45586D+01	0.20000D+01	0.25586D+01	0.20000D+01	0.25586D+01
0.47325D+01	0.20000D+01	0.27325D+01	0.20000D+01	0.27325D+01

INVENTORIES	CONSUMPTION	NON RES. INV	RES. INV	INVENT. INV	INTEREST	GNP
0.17947D+03	0.44960D+03	0.79883D+02	0.29506D+02	0.78901D+01	0.55590D+01	0.70784D+03
0.18128D+03	0.45219D+03	0.80664D+02	0.29109D+02	0.72464D+01	0.56740D+01	0.71087D+03
0.18304D+03	0.45397D+03	0.81328D+02	0.28503D+02	0.70354D+01	0.57690D+01	0.71338D+03
0.18471D+03	0.45466D+03	0.81104D+02	0.27856D+02	0.66531D+01	0.58477D+01	0.71407D+03
0.18616D+03	0.45587D+03	0.80990D+02	0.27354D+02	0.57954D+01	0.58873D+01	0.71492D+03
0.18742D+03	0.45692D+03	0.80478D+02	0.27135D+02	0.50316D+01	0.59190D+01	0.71571D+03
0.18846D+03	0.45886D+03	0.80011D+02	0.27267D+02	0.41742D+01	0.59383D+01	0.71753D+03
0.18935D+03	0.46129D+03	0.79614D+02	0.27741D+02	0.35764D+01	0.59495D+01	0.72037D+03
0.19002D+03	0.46637D+03	0.79551D+02	0.28538D+02	0.26649D+01	0.59629D+01	0.72596D+03
0.19053D+03	0.47303D+03	0.79912D+02	0.29575D+02	0.20433D+01	0.59861D+01	0.73373D+03
0.19113D+03	0.48060D+03	0.80816D+02	0.30740D+02	0.25873D+01	0.60249D+01	0.74412D+03
0.19242D+03	0.48500D+03	0.82135D+02	0.31881D+02	0.49598D+01	0.60746D+01	0.75149D+03
0.19431D+03	0.49029D+03	0.83772D+02	0.32868D+02	0.75756D+01	0.61302D+01	0.76491D+03
0.19636D+03	0.49703D+03	0.85645D+02	0.33647D+02	0.81759D+01	0.61928D+01	0.77570D+03
0.19828D+03	0.50523D+03	0.87627D+02	0.34211D+02	0.75773D+01	0.62618D+01	0.78666D+03
0.20034D+03	0.51115D+03	0.89470D+02	0.34564D+02	0.82599D+01	0.63278D+01	0.79575D+03
0.20238D+03	0.51976D+03	0.91237D+02	0.34754D+02	0.81446D+01	0.63924D+01	0.80525D+03
0.20454D+03	0.52612D+03	0.93091D+02	0.34800D+02	0.83356D+01	0.64562D+01	0.81683D+03
0.20680D+03	0.53076D+03	0.94461D+02	0.34911D+02	0.90886D+01	0.65182D+01	0.82114D+03
0.20776D+03	0.54252D+03	0.94212D+02	0.34720D+02	0.38631D+01	0.64742D+01	0.80803D+03

TABLE G.7.b: Experiment C.1

GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
0.13878D+03	0.13950D+03	0.71530D+00
0.13861D+03	0.13967D+03	-0.10592D+01
0.13851D+03	0.13984D+03	0.13294D+01
0.13872D+03	0.14000D+03	-0.12852D+01
0.13907D+03	0.14017D+03	-0.11000D+01
0.13960D+03	0.14034D+03	-0.73571D+00
0.14025D+03	0.14051D+03	-0.26230D+00
0.14101D+03	0.14068D+03	0.33181D+00
0.14175D+03	0.14084D+03	0.90446D+00
0.14247D+03	0.14101D+03	0.14522D+01
0.14309D+03	0.14118D+03	0.19091D+01
0.14377D+03	0.14135D+03	0.24167D+01
0.14447D+03	0.14152D+03	0.29481D+01
0.14516D+03	0.14169D+03	0.34642D+01
0.14580D+03	0.14186D+03	0.39342D+01
0.14647D+03	0.14203D+03	0.44373D+01
0.14701D+03	0.14220D+03	0.48077D+01
0.14754D+03	0.14237D+03	0.51696D+01
0.14805D+03	0.14254D+03	0.55034D+01
0.14851D+03	0.14271D+03	0.58202D+01

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.60641D+01	0.57000D+01	0.36406D+00
0.59386D+01	0.57000D+01	0.23859D+00
0.58522D+01	0.57000D+01	0.15219D+00
0.58098D+01	0.57000D+01	0.10977D+00
0.58120D+01	0.57000D+01	0.11199D+00
0.58561D+01	0.57000D+01	0.15612D+00
0.59337D+01	0.57000D+01	0.23374D+00
0.60290D+01	0.57000D+01	0.32905D+00
0.61251D+01	0.57000D+01	0.42511D+00
0.62118D+01	0.57000D+01	0.51162D+00
0.62855D+01	0.57000D+01	0.58546D+00
0.63452D+01	0.57000D+01	0.64517D+00
0.63839D+01	0.57000D+01	0.68389D+00
0.63968D+01	0.57000D+01	0.69679D+00
0.63746D+01	0.57000D+01	0.67456D+00
0.62772D+01	0.57000D+01	0.57716D+00
0.61165D+01	0.57000D+01	0.41647D+00
0.59290D+01	0.57000D+01	0.22900D+00
0.57717D+01	0.57000D+01	0.71745D-01
0.57085D+01	0.57000D+01	0.84804D-02

RATE OF GROWTH OF PRICES (PERCENT, 3.0=ACTUAL STATE VARIABLE))

OPTIMAL	TARGET 1	DEVIATION 1	TARGET 2	DEVIATION 2
0.34129D+01	0.20000D+01	0.14129D+01	0.20000D+01	0.14129D+01
0.31830D+01	0.20000D+01	0.11830D+01	0.20000D+01	0.11830D+01
0.38731D+01	0.20000D+01	0.18731D+01	0.20000D+01	0.18731D+01
0.35883D+01	0.20000D+01	0.15883D+01	0.20000D+01	0.15883D+01
0.31701D+01	0.20000D+01	0.11701D+01	0.20000D+01	0.11701D+01
0.29044D+01	0.20000D+01	0.90439D+00	0.20000D+01	0.90439D+00
0.25685D+01	0.20000D+01	0.56850D+00	0.20000D+01	0.56850D+00
0.25117D+01	0.20000D+01	0.51170D+00	0.20000D+01	0.51170D+00
0.24553D+01	0.20000D+01	0.45530D+00	0.20000D+01	0.45530D+00
0.25303D+01	0.20000D+01	0.53034D+00	0.20000D+01	0.53034D+00
0.25906D+01	0.20000D+01	0.59064D+00	0.20000D+01	0.59064D+00
0.28793D+01	0.20000D+01	0.87932D+00	0.20000D+01	0.87932D+00
0.28888D+01	0.20000D+01	0.88880D+00	0.20000D+01	0.88880D+00
0.29513D+01	0.20000D+01	0.95135D+00	0.20000D+01	0.95135D+00
0.30556D+01	0.20000D+01	0.10556D+01	0.20000D+01	0.10556D+01
0.31146D+01	0.20000D+01	0.11146D+01	0.20000D+01	0.11146D+01
0.32991D+01	0.20000D+01	0.12991D+01	0.20000D+01	0.12991D+01
0.34588D+01	0.20000D+01	0.14588D+01	0.20000D+01	0.14588D+01
0.35525D+01	0.20000D+01	0.15525D+01	0.20000D+01	0.15525D+01
0.36573D+01	0.20000D+01	0.16573D+01	0.20000D+01	0.16573D+01

TABLE G.8.a: Experiment C.2

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.36194D+01	0.20000D+01	0.16194D+01	0.20000D+01	0.16194D+01
0.39208D+01	0.20000D+01	0.19208D+01	0.20000D+01	0.19208D+01
0.41896D+01	0.20000D+01	0.21896D+01	0.20000D+01	0.21896D+01
0.45299D+01	0.20000D+01	0.25299D+01	0.20000D+01	0.25299D+01
0.48428D+01	0.20000D+01	0.28428D+01	0.20000D+01	0.28428D+01
0.51453D+01	0.20000D+01	0.31453D+01	0.20000D+01	0.31453D+01
0.54078D+01	0.20000D+01	0.34078D+01	0.20000D+01	0.34078D+01
0.56462D+01	0.20000D+01	0.36462D+01	0.20000D+01	0.36462D+01
0.58044D+01	0.20000D+01	0.38044D+01	0.20000D+01	0.38044D+01
0.58994D+01	0.20000D+01	0.38994D+01	0.20000D+01	0.38994D+01
0.59264D+01	0.20000D+01	0.39264D+01	0.20000D+01	0.39264D+01
0.59666D+01	0.20000D+01	0.39666D+01	0.20000D+01	0.39666D+01
0.60294D+01	0.20000D+01	0.40294D+01	0.20000D+01	0.40294D+01
0.60974D+01	0.20000D+01	0.40974D+01	0.20000D+01	0.40974D+01
0.61298D+01	0.20000D+01	0.41298D+01	0.20000D+01	0.41298D+01
0.61668D+01	0.20000D+01	0.41668D+01	0.20000D+01	0.41668D+01
0.61388D+01	0.20000D+01	0.41388D+01	0.20000D+01	0.41388D+01
0.61097D+01	0.20000D+01	0.41097D+01	0.20000D+01	0.41097D+01
0.60834D+01	0.20000D+01	0.40834D+01	0.20000D+01	0.40834D+01

INVENTORIES	CONSUMPTION	NON-RES. INV	RES. INV	INVENT. INV	INTEREST	GNP
0.17921D+03	0.44910D+03	[illegible]	0.29465D+02	[illegible]	0.55561D+01	0.20372D+03
0.18051D+03	0.45078D+03	[illegible]	0.28990D+02	[illegible]	0.56129D+01	0.20394D+03
0.18180D+03	0.45205D+03	0.30114D+02	0.28405D+02	[illegible]	0.56725D+01	0.20440D+03
0.18307D+03	[illegible]	[illegible]	0.27971D+02	[illegible]	0.57374D+01	[illegible]
0.18209D+03	[illegible]	[illegible]	0.27748D+02	[illegible]	0.57999D+01	[illegible]
0.18425D+03	[illegible]	[illegible]	[illegible]	[illegible]	0.58663D+01	[illegible]
0.18565D+03	0.45349D+03	[illegible]	[illegible]	[illegible]	0.59368D+01	[illegible]
0.18612D+03	0.45463D+03	[illegible]	[illegible]	[illegible]	0.60099D+01	0.20146D+03
0.18648D+03	[illegible]	[illegible]	[illegible]	[illegible]	0.60833D+01	[illegible]
0.18655D+03	[illegible]	[illegible]	[illegible]	[illegible]	0.61552D+01	[illegible]
0.18659D+03	[illegible]	[illegible]	[illegible]	[illegible]	0.62247D+01	0.21508D+03
0.10723D+03	0.47154D+03	[illegible]	[illegible]	[illegible]	0.62911D+01	[illegible]
0.18849D+03	[illegible]	[illegible]	[illegible]	[illegible]	0.63527D+01	0.22203D+03
0.18970D+03	[illegible]	[illegible]	[illegible]	[illegible]	0.64081D+01	[illegible]
0.19073D+03	[illegible]	[illegible]	[illegible]	[illegible]	0.64547D+01	[illegible]
0.19199D+03	[illegible]	[illegible]	[illegible]	[illegible]	0.64844D+01	[illegible]
0.19332D+03	[illegible]	[illegible]	[illegible]	[illegible]	0.64926D+01	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.64966D+01	[illegible]
0.19662D+03	[illegible]	[illegible]	[illegible]	[illegible]	0.64953D+01	[illegible]
0.19886D+03	0.50921D+03	[illegible]	[illegible]	[illegible]	0.64994D+01	[illegible]

TABLE G.8.b: Experiment C.2

GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
0.13878D+03	0.13950D+03	-0.71605D+00
0.13861D+03	0.13967D+03	-0.10589D+01
0.13851D+03	0.13984D+03	-0.13218D+01
0.13875D+03	0.14000D+03	-0.12546D+01
0.13914D+03	0.14017D+03	-0.10278D+01
0.13974D+03	0.14034D+03	-0.60251D+00
0.14045D+03	0.14051D+03	-0.55409D-01
0.14129D+03	0.14068D+03	0.61697D+00
0.14211D+03	0.14084D+03	0.12655D+01
0.14289D+03	0.14101D+03	0.18799D+01
0.14357D+03	0.14118D+03	0.23892D+01
0.14428D+03	0.14135D+03	0.29319D+01
0.14500D+03	0.14152D+03	0.34803D+01
0.14569D+03	0.14169D+03	0.39973D+01
0.14632D+03	0.14186D+03	0.44564D+01
0.14698D+03	0.14203D+03	0.49437D+01
0.14751D+03	0.14220D+03	0.53060D+01
0.14806D+03	0.14237D+03	0.56837D+01
0.14862D+03	0.14254D+03	0.60741D+01
0.14922D+03	0.14272D+03	0.65007D+01

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.60583D+01	0.57000D+01	0.35830D+00
0.60516D+01	0.57000D+01	0.35156D+00
0.60465D+01	0.57000D+01	0.34652D+00
0.60554D+01	0.57000D+01	0.35539D+00
0.60716D+01	0.57000D+01	0.37164D+00
0.60967D+01	0.57000D+01	0.39668D+00
0.61273D+01	0.57000D+01	0.42734D+00
0.61636D+01	0.57000D+01	0.46359D+00
0.61993D+01	0.57000D+01	0.49931D+00
0.62339D+01	0.57000D+01	0.53387D+00
0.62641D+01	0.57000D+01	0.56412D+00
0.62955D+01	0.57000D+01	0.59546D+00
0.63268D+01	0.57000D+01	0.62680D+00
0.63568D+01	0.57000D+01	0.65683D+00
0.63845D+01	0.57000D+01	0.68452D+00
0.64133D+01	0.57000D+01	0.71328D+00
0.64369D+01	0.57000D+01	0.73691D+00
0.64611D+01	0.57000D+01	0.76106D+00
0.64855D+01	0.57000D+01	0.78550D+00
0.65114D+01	0.57000D+01	0.81138D+00

RATE OF GROWTH OF PRICES (PERCENT, 4.D2*(ACTUAL STATE VARIABLE))

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.44179D+01	0.20000D+01	0.24179D+01	0.20000D+01	0.24179D+01
0.44825D+01	0.20000D+01	0.24825D+01	0.20000D+01	0.24825D+01
0.38673D+01	0.20000D+01	0.18673D+01	0.20000D+01	0.18673D+01
0.35652D+01	0.20000D+01	0.15652D+01	0.20000D+01	0.15652D+01
0.31184D+01	0.20000D+01	0.11184D+01	0.20000D+01	0.11184D+01
0.28182D+01	0.20000D+01	0.81822D+00	0.20000D+01	0.81822D+00
0.25508D+01	0.20000D+01	0.55082D+00	0.20000D+01	0.55082D+00
0.23734D+01	0.20000D+01	0.37341D+00	0.20000D+01	0.37341D+00
0.23130D+01	0.20000D+01	0.31299D+00	0.20000D+01	0.31299D+00
0.23964D+01	0.20000D+01	0.39641D+00	0.20000D+01	0.39641D+00
0.25790D+01	0.20000D+01	0.57903D+00	0.20000D+01	0.57903D+00
0.27488D+01	0.20000D+01	0.74884D+00	0.20000D+01	0.74884D+00
0.28436D+01	0.20000D+01	0.84361D+00	0.20000D+01	0.84361D+00
0.29438D+01	0.20000D+01	0.94385D+00	0.20000D+01	0.94385D+00
0.30758D+01	0.20000D+01	0.10758D+01	0.20000D+01	0.10758D+01
0.31846D+01	0.20000D+01	0.11846D+01	0.20000D+01	0.11846D+01
0.33309D+01	0.20000D+01	0.13309D+01	0.20000D+01	0.13309D+01
0.34799D+01	0.20000D+01	0.14799D+01	0.20000D+01	0.14799D+01
0.35438D+01	0.20000D+01	0.15438D+01	0.20000D+01	0.15438D+01
0.35609D+01	0.20000D+01	0.15609D+01	0.20000D+01	0.15609D+01

TABLE G.9.a: Experiment D.1

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.36194D+01	0.20000D+01	0.16194D+01	0.20000D+01	0.16194D+01
0.39212D+01	0.20000D+01	0.19212D+01	0.20000D+01	0.19212D+01
0.41940D+01	0.20000D+01	0.21940D+01	0.20000D+01	0.21940D+01
0.45464D+01	0.20000D+01	0.25464D+01	0.20000D+01	0.25464D+01
0.48789D+01	0.20000D+01	0.28789D+01	0.20000D+01	0.28789D+01
0.52062D+01	0.20000D+01	0.32062D+01	0.20000D+01	0.32062D+01
0.54931D+01	0.20000D+01	0.34931D+01	0.20000D+01	0.34931D+01
0.57504D+01	0.20000D+01	0.37504D+01	0.20000D+01	0.37504D+01
0.59193D+01	0.20000D+01	0.39193D+01	0.20000D+01	0.39193D+01
0.60154D+01	0.20000D+01	0.40154D+01	0.20000D+01	0.40154D+01
0.60343D+01	0.20000D+01	0.40343D+01	0.20000D+01	0.40343D+01
0.60591D+01	0.20000D+01	0.40591D+01	0.20000D+01	0.40591D+01
0.61016D+01	0.20000D+01	0.41016D+01	0.20000D+01	0.41016D+01
0.61474D+01	0.20000D+01	0.41474D+01	0.20000D+01	0.41474D+01
0.61588D+01	0.20000D+01	0.41588D+01	0.20000D+01	0.41588D+01
0.61798D+01	0.20000D+01	0.41798D+01	0.20000D+01	0.41798D+01
0.61456D+01	0.20000D+01	0.41456D+01	0.20000D+01	0.41456D+01
0.61260D+01	0.20000D+01	0.41260D+01	0.20000D+01	0.41260D+01
0.61295D+01	0.20000D+01	0.41295D+01	0.20000D+01	0.41295D+01

INVENTORIES	CONSUMPTION	NON-RES. INV	RES. INV	INVENT. INV	INTEREST	GNP
0.17921D+03	0.44910D+03	0.79594D+02	0.29465D+02	0.68222D+01	0.55551D+01	0.70377D+03
0.18051D+03	0.45096D+03	0.79934D+02	0.28992D+02	0.52367D+01	0.56376D+01	0.70373D+03
0.18185D+03	0.45196D+03	0.80105D+02	0.28365D+02	0.53355D+01	0.57154D+01	0.70428D+03
0.18306D+03	0.45177D+03	0.79289D+02	0.27794D+02	0.48524D+01	0.57911D+01	0.70245D+03
0.18405D+03	0.45197D+03	0.78475D+02	0.27358D+02	0.39563D+01	0.58641D+01	0.70091D+03
0.18486D+03	0.45186D+03	0.77402D+02	0.27063D+02	0.32284D+01	0.59352D+01	0.69929D+03
0.18547D+03	0.45244D+03	0.76343D+02	0.26887D+02	0.24453D+01	0.60044D+01	0.69857D+03
0.18592D+03	0.45328D+03	0.75291D+02	0.26803D+02	0.18074D+01	0.60721D+01	0.69847D+03
0.18612D+03	0.45654D+03	0.74506D+02	0.26800D+02	0.78467D+00	0.61374D+01	0.70074D+03
0.18612D+03	0.46121D+03	0.74076D+02	0.26879D+02	0.67294D-02	0.62005D+01	0.70506D+03
0.18620D+03	0.46667D+03	0.74111D+02	0.27051D+02	0.31900D+00	0.62607D+01	0.71172D+03
0.18680D+03	0.46970D+03	0.74492D+02	0.27303D+02	0.23952D+01	0.63191D+01	0.71818D+03
0.18797D+03	0.47203D+03	0.75159D+02	0.27619D+02	0.46813D+01	0.63756D+01	0.72449D+03
0.18920D+03	0.47661D+03	0.76033D+02	0.27981D+02	0.49173D+01	0.64301D+01	0.73123D+03
0.19027D+03	0.48279D+03	0.77083D+02	0.28383D+02	0.42843D+01	0.64824D+01	0.73886D+03
0.19157D+03	0.48699D+03	0.78156D+02	0.28815D+02	0.52207D+01	0.65332D+01	0.74615D+03
0.19299D+03	0.49326D+03	0.79374D+02	0.29282D+02	0.56838D+01	0.65815D+01	0.75511D+03
0.19446D+03	0.49928D+03	0.80691D+02	0.29778D+02	0.58692D+01	0.66282D+01	0.76367D+03
0.19630D+03	0.50338D+03	0.82042D+02	0.30292D+02	0.73644D+01	0.66734D+01	0.77170D+03
0.19842D+03	0.50718D+03	0.83341D+02	0.30808D+02	0.84644D+01	0.67173D+01	0.77901D+03

TABLE G.9.b: Experiment D.1

GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
0.15253D+03	0.13950D+03	0.13033D+02
0.15337D+03	0.13967D+03	0.13706D+02
0.15530D+03	0.13984D+03	0.15461D+02
0.15678D+03	0.14000D+03	0.16782D+02
0.15809D+03	0.14017D+03	0.17918D+02
0.15922D+03	0.14034D+03	0.18883D+02
0.16012D+03	0.14051D+03	0.19608D+02
0.16069D+03	0.14068D+03	0.20014D+02
0.16088D+03	0.14084D+03	0.20031D+02
0.16073D+03	0.14101D+03	0.19719D+02
0.16028D+03	0.14118D+03	0.19096D+02
0.15975D+03	0.14135D+03	0.18397D+02
0.15926D+03	0.14152D+03	0.17736D+02
0.15891D+03	0.14169D+03	0.17222D+02
0.15815D+03	0.14186D+03	0.16286D+02
0.15701D+03	0.14203D+03	0.14975D+02
0.15571D+03	0.14220D+03	0.13504D+02
0.15669D+03	0.14237D+03	0.14320D+02
0.15358D+03	0.14254D+03	0.11038D+02
0.14272D+03	0.14272D+03	0.0

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.79635D+01	0.57000D+01	0.22635D+01
0.77106D+01	0.57000D+01	0.20106D+01
0.75212D+01	0.57000D+01	0.18212D+01
0.73848D+01	0.57000D+01	0.16848D+01
0.72962D+01	0.57000D+01	0.15962D+01
0.72515D+01	0.57000D+01	0.15515D+01
0.72382D+01	0.57000D+01	0.15382D+01
0.72363D+01	0.57000D+01	0.15363D+01
0.72291D+01	0.57000D+01	0.15291D+01
0.72066D+01	0.57000D+01	0.15066D+01
0.71618D+01	0.57000D+01	0.14618D+01
0.70907D+01	0.57000D+01	0.13907D+01
0.69958D+01	0.57000D+01	0.12958D+01
0.68738D+01	0.57000D+01	0.11738D+01
0.66988D+01	0.57000D+01	0.99885D+00
0.64559D+01	0.57000D+01	0.75587D+00
0.61708D+01	0.57000D+01	0.47076D+00
0.59103D+01	0.57000D+01	0.21028D+00
0.57542D+01	0.57000D+01	0.54206D-01
0.57056D+01	0.57000D+01	0.56014D-02

RATE OF GROWTH OF PRICES (PERCENT, 4.D2*(ACTUAL STATE VARIABLE))

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.56095D+01	0.20000D+01	0.36095D+01	0.20000D+01	0.36095D+01
0.65563D+01	0.20000D+01	0.45563D+01	0.20000D+01	0.45563D+01
0.54465D+01	0.20000D+01	0.34465D+01	0.20000D+01	0.34465D+01
0.49656D+01	0.20000D+01	0.29656D+01	0.20000D+01	0.29656D+01
0.45475D+01	0.20000D+01	0.25475D+0	0.20000D+01	0.25475D+01
0.41984D+01	0.20000D+01	0.21984D+01	0.20000D+01	0.21984D+01
0.38767D+01	0.20000D+01	0.18767D+01	0.20000D+01	0.18767D+01
0.36503D+01	0.20000D+01	0.16503D+01	0.20000D+01	0.16503D+01
0.35485D+01	0.20000D+01	0.15485D+01	0.20000D+01	0.15485D+01
0.35584D+01	0.20000D+01	0.15584D+01	0.20000D+01	0.15584D+01
0.36458D+01	0.20000D+01	0.16458D+01	0.20000D+01	0.16458D+01
0.37124D+01	0.20000D+01	0.17124D+01	0.20000D+01	0.17124D+01
0.37110D+01	0.20000D+01	0.17110D+01	0.20000D+01	0.17110D+01
0.37407D+01	0.20000D+01	0.17407D+01	0.20000D+01	0.17407D+01
0.37886D+01	0.20000D+01	0.17886D+01	0.20000D+01	0.17886D+01
0.37616D+01	0.20000D+01	0.17616D+01	0.20000D+01	0.17616D+01
0.37774D+01	0.20000D+01	0.17774D+01	0.20000D+01	0.17774D+01
0.40413D+01	0.20000D+01	0.20413D+01	0.20000D+01	0.20413D+01
0.40372D+01	0.20000D+01	0.20372D+01	0.20000D+01	0.20372D+01
0.29692D+01	0.20000D+01	0.96925D+00	0.20000D+01	0.96925D+00

TABLE G.10.a: Experiment E.1

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.26803D+01	0.20000D+01	0.68031D+00	0.20000D+01	0.68031D+00
0.26643D+01	0.20000D+01	0.66428D+00	0.20000D+01	0.66428D+00
0.30311D+01	0.20000D+01	0.10311D+01	0.20000D+01	0.10311D+01
0.33243D+01	0.20000D+01	0.13243D+01	0.20000D+01	0.13243D+01
0.36112D+01	0.20000D+01	0.16112D+01	0.20000D+01	0.16112D+01
0.39032D+01	0.20000D+01	0.19032D+01	0.20000D+01	0.19032D+01
0.41732D+01	0.20000D+01	0.21732D+01	0.20000D+01	0.21732D+01
0.44082D+01	0.20000D+01	0.24082D+01	0.20000D+01	0.24082D+01
0.45657D+01	0.20000D+01	0.25657D+01	0.20000D+01	0.25657D+01
0.46729D+01	0.20000D+01	0.26729D+01	0.20000D+01	0.26729D+01
0.47212D+01	0.20000D+01	0.27212D+01	0.20000D+01	0.27212D+01
0.47875D+01	0.20000D+01	0.27875D+01	0.20000D+01	0.27875D+01
0.48740D+01	0.20000D+01	0.28740D+01	0.20000D+01	0.28740D+01
0.49531D+01	0.20000D+01	0.29531D+01	0.20000D+01	0.29531D+01
0.50192D+01	0.20000D+01	0.30192D+01	0.20000D+01	0.30192D+01
0.51273D+01	0.20000D+01	0.31273D+01	0.20000D+01	0.31273D+01
0.51767D+01	0.20000D+01	0.31767D+01	0.20000D+01	0.31767D+01
0.50662D+01	0.20000D+01	0.30662D+01	0.20000D+01	0.30662D+01
0.51966D+01	0.20000D+01	0.31966D+01	0.20000D+01	0.31966D+01

INVENTORIES	CONSUMPTION	NON-RES. INV	RES. INV	INVENT. INV	INTEREST	GNP
0.18090D+03	0.45188D+03	0.81388D+02	0.29721D+02	0.13584D+02	0.58903D+01	0.72911D+03
0.18479D+03	0.45679D+03	0.83792D+02	0.28935D+02	0.15592D+02	0.59968D+01	0.73848D+03
0.18726D+03	0.45975D+03	0.85520D+02	0.27125D+02	0.98816D+01	0.60970D+01	0.73758D+03
0.18943D+03	0.46118D+03	0.86296D+02	0.25394D+02	0.86670D+01	0.61922D+01	0.73832D+03
0.19116D+03	0.46306D+03	0.86772D+02	0.24169D+02	0.69005D+01	0.62842D+01	0.73899D+03
0.19257D+03	0.46460D+03	0.86342D+02	0.23516D+02	0.56361D+01	0.63747D+01	0.73932D+03
0.19365D+03	0.46673D+03	0.85524D+02	0.23335D+02	0.43292D+01	0.64635D+01	0.74004D+03
0.19451D+03	0.46903D+03	0.84852D+02	0.23480D+02	0.34546D+01	0.65487D+01	0.74151D+03
0.19509D+03	0.47365D+03	0.84380D+02	0.23834D+02	0.23099D+01	0.66280D+01	0.74505D+03
0.19541D+03	0.47949D+03	0.84167D+02	0.24320D+02	0.12930D+01	0.66997D+01	0.75000D+03
0.19574D+03	0.48593D+03	0.84313D+02	0.24906D+02	0.13305D+01	0.67625D+01	0.75676D+03
0.19653D+03	0.48976D+03	0.84714D+02	0.25568D+02	0.31445D+01	0.68149D+01	0.76293D+03
0.19784D+03	0.49271D+03	0.85307D+02	0.26297D+02	0.52456D+01	0.68571D+01	0.76882D+03
0.19920D+03	0.49786D+03	0.86053D+02	0.27102D+02	0.54391D+01	0.68877D+01	0.77537D+03
0.20036D+03	0.50449D+03	0.86904D+02	0.27994D+02	0.46352D+01	0.69017D+01	0.78217D+03
0.20163D+03	0.50896D+03	0.87677D+02	0.28978D+02	0.50712D+01	0.68951D+01	0.78769D+03
0.20291D+03	0.51540D+03	0.88530D+02	0.30104D+02	0.51302D+01	0.68703D+01	0.79487D+03
0.20448D+03	0.52210D+03	0.89765D+02	0.31453D+02	0.62702D+01	0.68384D+01	0.80628D+03
0.20633D+03	0.52656D+03	0.90031D+02	0.32962D+02	0.73992D+01	0.68149D+01	0.81134D+03
0.20693D+03	0.52829D+03	0.90486D+02	0.34340D+02	0.24264D+01	0.68046D+01	0.79826D+03

TABLE G.10.b: Experiment E.1

GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
0.15238D+03	0.13950D+03	0.12885D+02
0.15296D+03	0.13967D+03	0.13289D+02
0.15451D+03	0.13984D+03	0.14677D+02
0.15563D+03	0.14000D+03	0.15624D+02
0.15659D+03	0.14017D+03	0.16421D+02
0.15749D+03	0.14034D+03	0.17153D+02
0.15823D+03	0.14051D+03	0.17726D+02
0.15871D+03	0.14068D+03	0.18034D+02
0.15886D+03	0.14084D+03	0.18013D+02
0.15872D+03	0.14101D+03	0.17708D+02
0.15831D+03	0.14118D+03	0.17124D+02
0.15785D+03	0.14135D+03	0.16493D+02
0.15748D+03	0.14152D+03	0.15955D+02
0.15725D+03	0.14169D+03	0.15556D+02
0.15661D+03	0.14186D+03	0.14746D+02
0.15565D+03	0.14203D+03	0.13619D+02
0.15455D+03	0.14220D+03	0.12345D+02
0.15557D+03	0.14237D+03	0.13200D+02
0.15279D+03	0.14254D+03	0.10245D+02
0.14272D+03	0.14272D+03	0.0

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.70337D+01	0.57000D+01	0.13337D+01
0.69179D+01	0.57000D+01	0.12179D+01
0.68283D+01	0.57000D+01	0.11283D+01
0.67681D+01	0.57000D+01	0.10681D+01
0.67360D+01	0.57000D+01	0.10360D+01
0.67318D+01	0.57000D+01	0.10318D+01
0.67475D+01	0.57000D+01	0.10475D+01
0.67697D+01	0.57000D+01	0.10697D+01
0.67875D+01	0.57000D+01	0.10875D+01
0.67946D+01	0.57000D+01	0.10946D+01
0.67864D+01	0.57000D+01	0.10864D+01
0.67580D+01	0.57000D+01	0.10580D+01
0.67095D+01	0.57000D+01	0.10095D+01
0.66369D+01	0.57000D+01	0.93692D+00
0.65215D+01	0.57000D+01	0.82146D+00
0.63428D+01	0.57000D+01	0.64284D+00
0.61154D+01	0.57000D+01	0.41154D+00
0.59086D+01	0.57000D+01	0.20864D+00
0.57612D+01	0.57000D+01	0.61169D-01
0.57064D+01	0.57000D+01	0.64332D-02

RATE OF GROWTH OF PRICES (PERCENT, 4.D2*(ACTUAL STATE VARIABLE))

OPTIMAL	TARGET 1	DEVIATION 1	TARGET 2	DEVIATION 2
0.56030D+01	0.20000D+01	0.36030D+01	0.20000D+01	0.36030D+01
0.65645D+01	0.20000D+01	0.45645D+01	0.20000D+01	0.45645D+01
0.55284D+01	0.20000D+01	0.35284D+01	0.20000D+01	0.35284D+01
0.51399D+01	0.20000D+01	0.31399D+01	0.20000D+01	0.31399D+01
0.48007D+01	0.20000D+01	0.28007D+01	0.20000D+01	0.28007D+01
0.45012D+01	0.20000D+01	0.25012D+01	0.20000D+01	0.25012D+01
0.41949D+01	0.20000D+01	0.21949D+01	0.20000D+01	0.21949D+01
0.39739D+01	0.20000D+01	0.19739D+01	0.20000D+01	0.19739D+01
0.38707D+01	0.20000D+01	0.18707D+01	0.20000D+01	0.18707D+01
0.38731D+01	0.20000D+01	0.18731D+01	0.20000D+01	0.18731D+01
0.39495D+01	0.20000D+01	0.19495D+01	0.20000D+01	0.19495D+01
0.40033D+01	0.20000D+01	0.20033D+01	0.20000D+01	0.20033D+01
0.39960D+01	0.20000D+01	0.19960D+01	0.20000D+01	0.19960D+01
0.40040D+01	0.20000D+01	0.20040D+01	0.20000D+01	0.20040D+01
0.40289D+01	0.20000D+01	0.20289D+01	0.20000D+01	0.20289D+01
0.39791D+01	0.20000D+01	0.19791D+01	0.20000D+01	0.19791D+01
0.39712D+01	0.20000D+01	0.19712D+01	0.20000D+01	0.19712D+01
0.41902D+01	0.20000D+01	0.21902D+01	0.20000D+01	0.21902D+01
0.41510D+01	0.20000D+01	0.21510D+01	0.20000D+01	0.21510D+01
0.31113D+01	0.20000D+01	0.11113D+01	0.20000D+01	0.11113D+01

TABLE G.11.a: Experiment F.1

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.26855D+01	0.20000D+01	0.68548D+00	0.20000D+01	0.68548D+00
0.26557D+01	0.20000D+01	0.65573D+00	0.20000D+01	0.65573D+00
0.29723D+01	0.20000D+01	0.97231D+00	0.20000D+01	0.97231D+00
0.32067D+01	0.20000D+01	0.12067D+01	0.20000D+01	0.12067D+01
0.34327D+01	0.20000D+01	0.14327D+01	0.20000D+01	0.14327D+01
0.36815D+01	0.20000D+01	0.16815D+01	0.20000D+01	0.16815D+01
0.39234D+01	0.20000D+01	0.19234D+01	0.20000D+01	0.19234D+01
0.41370D+01	0.20000D+01	0.21370D+01	0.20000D+01	0.21370D+01
0.42799D+01	0.20000D+01	0.22799D+01	0.20000D+01	0.22799D+01
0.43772D+01	0.20000D+01	0.23772D+01	0.20000D+01	0.23772D+01
0.44197D+01	0.20000D+01	0.24197D+01	0.20000D+01	0.24197D+01
0.44828D+01	0.20000D+01	0.24828D+01	0.20000D+01	0.24828D+01
0.45668D+01	0.20000D+01	0.25668D+01	0.20000D+01	0.25669D+01
0.46485D+01	0.20000D+01	0.26485D+01	0.20000D+01	0.26485D+01
0.47223D+01	0.20000D+01	0.27223D+01	0.20000D+01	0.27223D+01
0.48389D+01	0.20000D+01	0.28389D+01	0.20000D+01	0.28389D+01
0.49005D+01	0.20000D+01	0.29005D+01	0.20000D+01	0.29005D+01
0.48192D+01	0.20000D+01	0.28192D+01	0.20000D+01	0.28192D+01
0.49670D+01	0.20000D+01	0.29670D+01	0.20000D+01	0.29670D+01

INVENTORIES	CONSUMPTION	NON RES. INV	RES. INV	INVENT. INV	INTEREST	GNP
0.18685D+03	0.45263D+03	0.81379D+02	0.29729D+02	[illegible]	[illegible]	[illegible]
0.18471D+03	[illegible]	0.83600D+02	[illegible]	[illegible]	[illegible]	0.23871D+03
[illegible]	0.46076D+03	[illegible]	0.28380D+02	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	0.86617D+02	[illegible]	[illegible]	[illegible]	[illegible]
0.19136D+03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.24396D+03
0.19296D+03	[illegible]	[illegible]	[illegible]	0.44624D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.19608D+03	0.47851D+03	[illegible]	[illegible]	[illegible]	[illegible]	0.25388D+03
0.19459D+03	0.48429D+03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	0.49159D+03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.19864D+03	[illegible]	[illegible]	[illegible]	0.38040D+01	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.27891D+03
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.36820D+01	[illegible]
[illegible]	[illegible]	0.89234D+02	[illegible]	[illegible]	[illegible]	0.29240D+03
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.33934D+02	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.35058D+02	[illegible]	[illegible]	[illegible]

TABLE G.11.b: Experiment F.1

GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
0.12223D+03	0.13950D+03	-0.17268D+02
0.12935D+03	0.13967D+03	-0.10315D+02
0.12586D+03	0.13984D+03	-0.13976D+02
0.13166D+03	0.14000D+03	-0.83385D+01
0.13399D+03	0.14017D+03	-0.61800D+01
0.13709D+03	0.14034D+03	-0.32464D+01
0.13921D+03	0.14051D+03	-0.13012D+01
0.14099D+03	0.14068D+03	0.31743D+00
0.14181D+03	0.14084D+03	0.96719D+00
0.14145D+03	0.14101D+03	0.43761D+00
0.14040D+03	0.14118D+03	-0.78482D+00
0.13950D+03	0.14135D+03	-0.18479D+01
0.13897D+03	0.14152D+03	-0.25552D+01
0.13834D+03	0.14169D+03	-0.33492D+01
0.13754D+03	0.14186D+03	-0.43238D+01
0.13716D+03	0.14203D+03	-0.48715D+01
0.13574D+03	0.14220D+03	-0.64667D+01
0.13528D+03	0.14237D+03	-0.70937D+01
0.13418D+03	0.14254D+03	-0.83643D+01
0.13256D+03	0.14272D+03	-0.10156D+02

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.57867D+01	0.57000D+01	0.86743D-01
0.57584D+01	0.57000D+01	0.58353D-01
0.57346D+01	0.57000D+01	0.34595D-01
0.57191D+01	0.57000D+01	0.19092D-01
0.57121D+01	0.57000D+01	0.12108D-01
0.57132D+01	0.57000D+01	0.13228D-01
0.57209D+01	0.57000D+01	0.20936D-01
0.57327D+01	0.57000D+01	0.32733D-01
0.57458D+01	0.57000D+01	0.45767D-01
0.57580D+01	0.57000D+01	0.57977D-01
0.57685D+01	0.57000D+01	0.68489D-01
0.57768D+01	0.57000D+01	0.76833D-01
0.57829D+01	0.57000D+01	0.82885D-01
0.57845D+01	0.57000D+01	0.84518D-01
0.57814D+01	0.57000D+01	0.81445D-01
0.57717D+01	0.57000D+01	0.71709D-01
0.57518D+01	0.57000D+01	0.51760D-01
0.57315D+01	0.57000D+01	0.31541D-01
0.57114D+01	0.57000D+01	0.11399D-01
0.57015D+01	0.57000D+01	0.14884D-02

RATE OF GROWTH OF PRICES (FERCENT, 4.D2*(ACTUAL STATE VARIABLE))

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.29693D+01	0.20000D+01	0.96930D+00	0.20000D+01	0.96930D+00
0.26143D+01	0.20000D+01	0.61427D+00	0.20000D+01	0.61427D+00
0.28069D+01	0.20000D+01	0.80688D+00	0.20000D+01	0.80688D+00
0.26750D+01	0.20000D+01	0.67497D+00	0.20000D+01	0.67497D+00
0.26424D+01	0.20000D+01	0.64240D+00	0.20000D+01	0.64240D+00
0.25898D+01	0.20000D+01	0.58981D+00	0.20000D+01	0.58981D+00
0.25434D+01	0.20000D+01	0.54340D+00	0.20000D+01	0.54340D+00
0.25175D+01	0.20000D+01	0.51753D+00	0.20000D+01	0.51753D+00
0.24919D+01	0.20000D+01	0.49195D+00	0.20000D+01	0.49195D+00
0.24983D+01	0.20000D+01	0.49832D+00	0.20000D+01	0.49832D+00
0.25045D+01	0.20000D+01	0.50451D+00	0.20000D+01	0.50451D+00
0.25225D+01	0.20000D+01	0.52254D+00	0.20000D+01	0.52254D+00
0.25215D+01	0.20000D+01	0.52147D+00	0.20000D+01	0.52147D+00
0.25290D+01	0.20000D+01	0.52898D+00	0.20000D+01	0.52898D+00
0.25290D+01	0.20000D+01	0.52897D+00	0.20000D+01	0.52897D+00
0.25323D+01	0.20000D+01	0.53229D+00	0.20000D+01	0.53229D+00
0.25260D+01	0.20000D+01	0.52599D+00	0.20000D+01	0.52599D+00
0.25282D+01	0.20000D+01	0.52817D+00	0.20000D+01	0.52817D+00
0.24738D+01	0.20000D+01	0.47379D+00	0.20000D+01	0.47379D+00
0.22575D+01	0.20000D+01	0.25754D+00	0.20000D+01	0.25754D+00

TABLE G.12.a: Experiment G.1

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.47610D+01	0.20000D+01	0.27610D+01	0.20000D+01	0.27610D+01
0.49347D+01	0.20000D+01	0.29347D+01	0.20000D+01	0.29347D+01
0.51373D+01	0.20000D+01	0.31373D+01	0.20000D+01	0.31373D+01
0.53493D+01	0.20000D+01	0.33493D+01	0.20000D+01	0.33493D+01
0.54778D+01	0.20000D+01	0.34778D+01	0.20000D+01	0.34778D+01
0.56640D+01	0.20000D+01	0.36640D+01	0.20000D+01	0.36640D+01
0.57840D+01	0.20000D+01	0.37840D+01	0.20000D+01	0.37840D+01
0.59404D+01	0.20000D+01	0.39404D+01	0.20000D+01	0.39404D+01
0.60506D+01	0.20000D+01	0.40506D+01	0.20000D+01	0.40506D+01
0.61786D+01	0.20000D+01	0.41786D+01	0.20000D+01	0.41786D+01
0.62812D+01	0.20000D+01	0.42812D+01	0.20000D+01	0.42812D+01
0.63888D+01	0.20000D+01	0.43888D+01	0.20000D+01	0.43888D+01
0.64949D+01	0.20000D+01	0.44949D+01	0.20000D+01	0.44949D+01
0.66173D+01	0.20000D+01	0.46173D+01	0.20000D+01	0.46173D+01
0.67300D+01	0.20000D+01	0.47300D+01	0.20000D+01	0.47300D+01
0.68327D+01	0.20000D+01	0.48327D+01	0.20000D+01	0.48327D+01
0.69401D+01	0.20000D+01	0.49401D+01	0.20000D+01	0.49401D+01
0.70299D+01	0.20000D+01	0.50299D+01	0.20000D+01	0.50299D+01
0.71650D+01	0.20000D+01	0.51650D+01	0.20000D+01	0.51650D+01

INVENTORIES	CONSUMPTION	NON-RES. INV	RES. INV	INVENT. INV	INTEREST	GNP
0.17720D+03	0.44535D+03	0.77414D+02	0.29153D+02	-0.11837D+01	0.55073D+01	0.67296D+03
0.17640D+03	0.44460D+03	0.76228D+02	0.28408D+02	-0.32158D+01	0.55764D+01	0.67537D+03
0.17752D+03	0.44373D+03	0.75210D+02	0.27694D+02	0.44596D+01	0.56412D+01	0.67695D+03
0.17834D+03	0.44249D+03	0.73 ,91D+02	0.27175D+02	0.33173D+01	0.57026D+01	0.67814D+03
0.17986D+03	0.44249D+03	0.72042D+02	0.26908D+02	0.60441D+01	0.57613D+01	0.68147D+03
0.18105D+03	0.44265D+03	0.71854D+02	0.26855D+02	0.47976D+01	0.58128D+01	0.68325D+03
0.18226D+03	0.44398D+03	0.71762D+02	0.26973D+02	0.40234D+01	0.58723D+01	0.68675D+03
0.18316D+03	0.44575D+03	0.71704D+02	0.27197D+02	0.36047D+01	0.59247D+01	0.68925D+03
0.18366D+03	0.44996D+03	0.71800D+02	0.27491D+02	0.20125D+01	0.59749D+01	0.69308D+03
0.18369D+03	0.45529D+03	0.71906D+02	0.27810D+02	0.98990D 01	0.60227D+01	0.69657D+03
0.18350D+03	0.46101D+03	0.72157D+02	0.28165D+02	-0.76996D+00	0.60681D+01	0.70096D+03
0.18366D+03	0.46398D+03	0.72438D+02	0.28521D+02	0.66168D+00	0.61109D+01	0.70511D+03
0.18437D+03	0.46604D+03	0.72816D+02	0.28882D+02	0.28480D+01	0.61513D+01	0.70955D+03
0.18514D+03	0.47015D+03	0.73225D+02	0.29240D+02	0.30516D+01	0.61889D+01	0.71403D+03
0.18569D+03	0.47561D+03	0.73691D+02	0.29619D+02	0.22060D+01	0.62235D+01	0.71866D+03
0.18647D+03	0.47894D+03	0.74177D+02	0.30000D+02	0.31280D+01	0.62549D+01	0.72341D+03
0.18729D+03	0.48404D+03	0.74690D+02	0.30395D+02	0.32789D+01	0.62823D+01	0.72814D+03
0.18809D+03	0.48873D+03	0.75241D+02	0.30811D+02	0.31787D+01	0.63072D+01	0.73324D+03
0.18925D+03	0.49131D+03	0.75736D+02	0.31240D+02	0.46556D+01	0.63297D+01	0.73712D+03
0.19048D+03	0.49317D+03	0.75993D+02	0.31648D+02	0.49058D+01	0.63519D+01	0.73828D+03

TABLE G.12.b: TABLE G.1

GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
0.13323D+03	0.13950D+03	-0.62674D+01
0.13544D+03	0.13967D+03	-0.42225D+01
0.13644D+03	0.13984D+03	-0.33961D+01
0.13859D+03	0.14000D+03	-0.14119D+01
0.14099D+03	0.14017D+03	0.81958D+00
0.14255D+03	0.14034D+03	0.22135D+01
0.14412D+03	0.14051D+03	0.36107D+01
0.14520D+03	0.14068D+03	0.45198D+01
0.14568D+03	0.14084D+03	0.48307D+01
0.14532D+03	0.14101D+03	0.43012D+01
0.14444D+03	0.14118D+03	0.32583D+01
0.14381D+03	0.14135D+03	0.24541D+01
0.14346D+03	0.14152D+03	0.19357D+01
0.14310D+03	0.14169D+03	0.14076D+01
0.14256D+03	0.14186D+03	0.70270D+00
0.14235D+03	0.14203D+03	0.31859D+00
0.14123D+03	0.14220D+03	-0.97124D+00
0.14128D+03	0.14237D+03	-0.10889D+01
0.13949D+03	0.14254D+03	-0.30571D+01
0.13567D+03	0.14272D+03	-0.70449D+01

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.56596D+01	0.57000D+01	-0.40443D-01
0.55895D+01	0.57000D+01	-0.11049D+00
0.55340D+01	0.57000D+01	-0.16598D+00
0.55003D+01	0.57000D+01	-0.19966D+00
0.54891D+01	0.57000D+01	-0.21087D+00
0.54991D+01	0.57000D+01	-0.20089D+00
0.55266D+01	0.57000D+01	-0.17339D+00
0.55647D+01	0.57000D+01	-0.13534D+00
0.56061D+01	0.57000D+01	-0.93940D-01
0.56459D+01	0.57000D+01	-0.54065D-01
0.56835D+01	0.57000D+01	-0.16539D-01
0.57190D+01	0.57000D+01	0.18957D-01
0.57537D+01	0.57000D+01	0.53741D-01
0.57820D+01	0.57000D+01	0.81966D-01
0.58056D+01	0.57000D+01	0.10564D+00
0.58174D+01	0.57000D+01	0.11743D+00
0.57986D+01	0.57000D+01	0.98633D-01
0.57716D+01	0.57000D+01	0.71619D-01
0.57289D+01	0.57000D+01	0.28948D-01
0.57040D+01	0.57000D+01	0.39823D-02

RATE OF GROWTH OF PRICES (PERCENT, 4.02*(ACTUAL STATE VARIABLE))

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.39342D+01	0.20000D+01	0.19342D+01	0.20000D+01	0.19342D+01
0.38694D+01	0.20000D+01	0.18694D+01	0.20000D+01	0.18694D+01
0.37615D+01	0.20000D+01	0.17615D+01	0.20000D+01	0.17615D+01
0.37315D+01	0.20000D+01	0.17315D+01	0.20000D+01	0.17315D+01
0.35372D+01	0.20000D+01	0.15372D+01	0.20000D+01	0.15372D+01
0.34696D+01	0.20000D+01	0.14696D+01	0.20000D+01	0.14696D+01
0.33582D+01	0.20000D+01	0.13582D+01	0.20000D+01	0.13582D+01
0.32955D+01	0.20000D+01	0.12955D+01	0.20000D+01	0.12955D+01
0.32545D+01	0.20000D+01	0.12545D+01	0.20000D+01	0.12545D+01
0.32625D+01	0.20000D+01	0.12625D+01	0.20000D+01	0.12625D+01
0.32964D+01	0.20000D+01	0.12964D+01	0.20000D+01	0.12964D+01
0.33289D+01	0.20000D+01	0.13289D+01	0.20000D+01	0.13289D+01
0.33295D+01	0.20000D+01	0.13295D+01	0.20000D+01	0.13295D+01
0.33322D+01	0.20000D+01	0.13322D+01	0.20000D+01	0.13322D+01
0.33326D+01	0.20000D+01	0.13326D+01	0.20000D+01	0.13326D+01
0.33212D+01	0.20000D+01	0.13212D+01	0.20000D+01	0.13212D+01
0.33017D+01	0.20000D+01	0.13017D+01	0.20000D+01	0.13017D+01
0.33226D+01	0.20000D+01	0.13226D+01	0.20000D+01	0.13226D+01
0.31938D+01	0.20000D+01	0.11938D+01	0.20000D+01	0.11938D+01
0.26890D+01	0.20000D+01	0.68900D+00	0.20000D+01	0.68900D+00

TABLE G.13.a: Experiment G.3

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.40006D+01	0.20000D+01	0.20006D+01	0.20000D+01	0.20006D+01
0.42511D+01	0.20000D+01	0.22511D+01	0.20000D+01	0.22511D+01
0.43167D+01	0.20000D+01	0.23167D+01	0.20000D+01	0.23167D+01
0.45227D+01	0.20000D+01	0.25227D+01	0.20000D+01	0.25227D+01
0.46540D+01	0.20000D+01	0.26540D+01	0.20000D+01	0.26540D+01
0.48202D+01	0.20000D+01	0.28202D+01	0.20000D+01	0.28202D+01
0.49537D+01	0.20000D+01	0.29537D+01	0.20000D+01	0.29537D+01
0.50950D+01	0.20000D+01	0.30950D+01	0.20000D+01	0.30950D+01
0.51996D+01	0.20000D+01	0.31996D+01	0.20000D+01	0.31996D+01
0.52969D+01	0.20000D+01	0.32969D+01	0.20000D+01	0.32969D+01
0.53665D+01	0.20000D+01	0.33665D+01	0.20000D+01	0.33665D+01
0.54425D+01	0.20000D+01	0.34425D+01	0.20000D+01	0.34425D+01
0.55276D+01	0.20000D+01	0.35276D+01	0.20000D+01	0.35276D+01
0.56298D+01	0.20000D+01	0.36298D+01	0.20000D+01	0.36298D+01
0.57230D+01	0.20000D+01	0.37230D+01	0.20000D+01	0.37230D+01
0.58183D+01	0.20000D+01	0.38183D+01	0.20000D+01	0.38183D+01
0.59137D+01	0.20000D+01	0.39137D+01	0.20000D+01	0.39137D+01
0.59741D+01	0.20000D+01	0.39741D+01	0.20000D+01	0.39741D+01
0.61591D+01	0.20000D+01	0.41591D+01	0.20000D+01	0.41591D+01

INVENTORIES	CONSUMPTION	NON-RES. INV	RES. INV	INVENT. INV	INTEREST	GNP
0.17853D+03	0.44790D+03	0.78867D+02	0.29361D+02	0.41168D+01	0.54849D+01	0.69348D+03
0.17912D+03	0.44903D+03	0.78713D+02	0.28919D+02	0.23812D+01	0.55422D+01	0.69449D+03
0.18060D+03	0.45020D+03	0.78051D+02	0.28613D+02	0.62408D+01	0.55957D+01	0.70035D+03
0.18227D+03	0.45073D+03	0 78220D+02	0.28518D+02	0.63267D+01	0.56474D+01	0.70239D+03
0.18390D+03	0.45221D+03	0.77932D+02	0.28639D+02	0.65455D+01	0.56986D+01	0.70631D+03
0.18544D+03	0.45369D+03	0.77984D+02	0.28912D+02	0.61293D+01	0.57501D+01	0.70927D+03
0.18677D+03	0.45610D+03	0.78194D+02	0.29275D+02	0.53553D+01	0.58022D+01	0.71304D+03
0.18792D+03	0.45804D+03	0.78293D+02	0.29664D+02	0.45674D+01	0.58544D+01	0.71656D+03
0.18866D+03	0.46388D+03	0.78536D+02	0.30046D+02	0.29899D+01	0.59060D+01	0.72113D+03
0.18902D+03	0.47003D+03	0.78837D+02	0.30405D+02	0.14392D+01	0.59563D+01	0.72603D+03
0.18924D+03	0.47656D+03	0.79298D+02	0.30745D+02	0.86068D+00	0.60051D+01	0.73190D+03
0.18985D+03	0.48032D+03	0.79838D+02	0.31068D+02	0.24585D+01	0.60524D+01	0.73749D+03
0.19102D+03	0.48313D+03	0.80469D+02	0.31302D+02	0.46679D+01	0.60986D+01	0.74311D+03
0.19223D+03	0.48796D+03	0.81143D+02	0.31689D+02	0.48418D+01	0.61425D+01	0.74873D+03
0.19322D+03	0.49410D+03	0.81057D+02	0.31998D+02	0.39718D+01	0.61844D+01	0.75449D+03
0.19442D+03	0.49805D+03	0.82547D+02	0.32312D+02	0.47698D+01	0.62229D+01	0.76003D+03
0.1956[illegible]D+03	0.50374D+03	0.83234D+02	0.32640D+02	0.48254D+01	0.62544D+01	0.76567D+03
0.19682D+03	0.50905D+03	0.83929D+02	0.33007D+02	0.48128D+01	0.62918D+01	0.77214D+03
0.19828D+03	0.51202D+03	0.84529D+02	0.33399D+02	0.58035D+01	0.63036D+01	0.77524D+03
0.19940D+03	0.51357D+03	0.84478D+02	0.33750D+02	0.44779D+01	0.63254D+01	0.77205D+03

TABLE G.13.b: Experiment G.3

GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
0.13690D+03	0.13950D+03	-0.25983D+01
0.13817D+03	0.13967D+03	-0.15017D+01
0.13963D+03	0.13984D+03	-0.20674D+00
0.14112D+03	0.14000D+03	0.11147D+01
0.14294D+03	0.14017D+03	0.27667D+01
0.14415D+03	0.14034D+03	0.38093D+01
0.14536D+03	0.14051D+03	0.48490D+01
0.14621D+03	0.14068D+03	0.55335D+01
0.14655D+03	0.14084D+03	0.57007D+01
0.14620D+03	0.14101D+03	0.51871D+01
0.14542D+03	0.14118D+03	0.42418D+01
0.14489D+03	0.14135D+03	0.35351D+01
0.14462D+03	0.14152D+03	0.30996D+01
0.14437D+03	0.14169D+03	0.26780D+01
0.14396D+03	0.14186D+03	0.20950D+01
0.14379D+03	0.14203D+03	0.17557D+01
0.14287D+03	0.14220D+03	0.66298D+00
0.14318D+03	0.14237D+03	0.80486D+00
0.14125D+03	0.14254D+03	-0.12917D+01
0.13684D+03	0.14272D+03	-0.58764D+01

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.54597D+01	0.57000D+01	-0.24033D+00
0.53780D+01	0.57000D+01	-0.32200D+00
0.53162D+01	0.57000D+01	-0.38383D+00
0.52806D+01	0.57000D+01	-0.41939D+00
0.52726D+01	0.57000D+01	-0.42740D+00
0.52909D+01	0.57000D+01	-0.40905D+00
0.53312D+01	0.57000D+01	-0.36876D+00
0.53845D+01	0.57000D+01	-0.31546D+00
0.54418D+01	0.57000D+01	-0.25821D+00
0.54972D+01	0.57000D+01	-0.20277D+00
0.55508D+01	0.57000D+01	-0.14920D+00
0.56041D+01	0.57000D+01	-0.95937D-01
0.56597D+01	0.57000D+01	-0.40282D-01
0.57103D+01	0.57000D+01	0.10342D-01
0.57609D+01	0.57000D+01	0.60877D-01
0.58009D+01	0.57000D+01	0.10087D+00
0.57999D+01	0.57000D+01	0.99942D-01
0.57839D+01	0.57000D+01	0.83860D-01
0.57365D+01	0.57000D+01	0.36455D-01
0.57052D+01	0.57000D+01	0.51672D-02

RATE OF GROWTH OF PRICES (PERCENT, 4.02*(ACTUAL STATE VARIABLE))

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.42571D+01	0.20000D+01	0.22571D+01	0.20000D+01	0.22571D+01
0.43577D+01	0.20000D+01	0.23577D+01	0.20000D+01	0.23577D+01
0.41253D+01	0.20000D+01	0.21253D+01	0.20000D+01	0.21253D+01
0.41136D+01	0.20000D+01	0.21136D+01	0.20000D+01	0.21136D+01
0.39069D+01	0.20000D+01	0.19069D+01	0.20000D+01	0.19069D+01
0.38275D+01	0.20000D+01	0.18275D+01	0.20000D+01	0.18275D+01
0.37093D+01	0.20000D+01	0.17093D+01	0.20000D+01	0.17093D+01
0.36349D+01	0.20000D+01	0.16349D+01	0.20000D+01	0.16349D+01
0.35942D+01	0.20000D+01	0.15942D+01	0.20000D+01	0.15942D+01
0.36065D+01	0.20000D+01	0.16065D+01	0.20000D+01	0.16065D+01
0.36523D+01	0.20000D+01	0.16523D+01	0.20000D+01	0.16523D+01
0.36905D+01	0.20000D+01	0.16905D+01	0.20000D+01	0.16905D+01
0.36879D+01	0.20000D+01	0.16879D+01	0.20000D+01	0.16879D+01
0.36859D+01	0.20000D+01	0.16859D+01	0.20000D+01	0.16859D+01
0.36824D+01	0.20000D+01	0.16824D+01	0.20000D+01	0.16824D+01
0.36572D+01	0.20000D+01	0.16572D+01	0.20000D+01	0.16572D+01
0.36277D+01	0.20000D+01	0.16277D+01	0.20000D+01	0.16277D+01
0.36549D+01	0.20000D+01	0.16548D+01	0.20000D+01	0.16548D+01
0.34970D+01	0.20000D+01	0.14970D+01	0.20000D+01	0.14970D+01
0.28941D+01	0.20000D+01	0.89411D+00	0.20000D+01	0.89411D+00

TABLE G.14.a: Experiment G.4

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.37461D+01	0.20000D+01	0.17461D+01	0.20000D+01	0.17461D+01
0.39686D+01	0.20000D+01	0.19686D+01	0.20000D+01	0.19686D+01
0.40288D+01	0.20000D+01	0.20288D+01	0.20000D+01	0.20288D+01
0.42047D+01	0.20000D+01	0.22047D+01	0.20000D+01	0.22047D+01
0.43324D+01	0.20000D+01	0.23324D+01	0.20000D+01	0.23324D+01
0.44825D+01	0.20000D+01	0.24825D+01	0.20000D+01	0.24825D+01
0.46113D+01	0.20000D+01	0.26113D+01	0.20000D+01	0.26113D+01
0.47430D+01	0.20000D+01	0.27430D+01	0.20000D+01	0.27430D+01
0.48374D+01	0.20000D+01	0.28374D+01	0.20000D+01	0.28374D+01
0.49198D+01	0.20000D+01	0.29198D+01	0.20000D+01	0.29198D+01
0.49717D+01	0.20000D+01	0.29717D+01	0.20000D+01	0.29717D+01
0.50343D+01	0.20000D+01	0.30343D+01	0.20000D+01	0.30343D+01
0.51106D+01	0.20000D+01	0.31106D+01	0.20000D+01	0.31106D+01
0.52052D+01	0.20000D+01	0.32052D+01	0.20000D+01	0.32052D+01
0.52918D+01	0.20000D+01	0.32918D+01	0.20000D+01	0.32918D+01
0.53889D+01	0.20000D+01	0.33889D+01	0.20000D+01	0.33889D+01
0.54806D+01	0.20000D+01	0.34806D+01	0.20000D+01	0.34806D+01
0.55312D+01	0.20000D+01	0.35312D+01	0.20000D+01	0.35312D+01
0.57346D+01	0.20000D+01	0.37346D+01	0.20000D+01	0.37346D+01

INVENTORIES	CONSUMPTION	NON-RES. INV	RES. INV	INVENT. INV	INTEREST	GNP
0.17897D+03	0.44879D+03	0.79353D+02	0.29430D+02	0.58743D+01	0.54497D+01	0.70035D+03
0.18012D+03	0.45077D+03	0.79647D+02	0.29166D+02	0.45864D+01	0.54979D+01	0.70234D+03
0.18105D+03	0.45271D+03	0.90179D+02	0.29144D+02	0.69231D+01	0.55432D+01	0.70859D+03
0.18365D+03	0.45401D+03	0.79974D+02	0.29351D+02	0.72210D+01	0.55877D+01	0.71168D+03
0.18539D+03	0.45615D+03	0.80178D+02	0.29736D+02	0.69568D+01	0.56329D+01	0.71596D+03
0.18704D+03	0.45823D+03	0.80403D+02	0.30218D+02	0.65956D+01	0.56798D+01	0.71960D+03
0.18848D+03	0.46116D+03	0.80745D+02	0.30728D+02	0.57623D+01	0.57287D+01	0.72375D+03
0.18974D+03	0.46437D+03	0.80983D+02	0.31206D+02	0.50207D+01	0.57790D+01	0.72778D+03
0.19062D+03	0.46984D+03	0.81337D+02	0.31630D+02	0.35369D+01	0.58295D+01	0.73289D+03
0.19114D+03	0.47639D+03	0.81765D+02	0.31994D+02	0.20903D+01	0.58794D+01	0.73844D+03
0.19155D+03	0.48331D+03	0.82355D+02	0.32315D+02	0.16389D+01	0.59286D+01	0.74505D+03
0.19237D+03	0.48746D+03	0.83031D+02	0.32605D+02	0.32859D+01	0.59775D+01	0.75127D+03
0.19374D+03	0.49062D+03	0.83790D+02	0.32874D+02	0.54840D+01	0.60263D+01	0.75739D+03
0.19515D+03	0.49576D+03	0.84584D+02	0.33128D+02	0.56345D+01	0.60741D+01	0.76348D+03
0.19634D+03	0.50220D+03	0.85406D+02	0.33376D+02	0.47475D+01	0.61214D+01	0.76968D+03
0.19771D+03	0.50638D+03	0.86171D+02	0.33617D+02	0.54712D+01	0.61664D+01	0.77543D+03
0.19908D+03	0.51228D+03	0.86920D+02	0.33862D+02	0.54882D+01	0.62035D+01	0.78142D+03
0.20046D+03	0.51781D+03	0.87730D+02	0.34141D+02	0.55325D+01	0.62357D+01	0.78840D+03
0.20205D+03	0.52091D+03	0.88293D+02	0.34446D+02	0.63445D+01	0.62599D+01	0.79125D+03
0.20317D+03	0.52249D+03	0.88132D+02	0.34708D+02	0.44944D+01	0.62834D+01	0.78666D+03

TABLE G.14.b: Experiment G.4

GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
0.13980D+03	0.13950D+03	0.30202D+00
0.14049D+03	0.13967D+03	0.82483D+00
0.14200D+03	0.13984D+03	0.21616D+01
0.14300D+03	0.14000D+03	0.29967D+01
0.14425D+03	0.14017D+03	0.40752D+01
0.14514D+03	0.14034D+03	0.47971D+01
0.14604D+03	0.14051D+03	0.55333D+01
0.14669D+03	0.14068D+03	0.60143D+01
0.14691D+03	0.14084D+03	0.60675D+01
0.14659D+03	0.14101D+03	0.55757D+01
0.14591D+03	0.14118D+03	0.47299D+01
0.14547D+03	0.14135D+03	0.41125D+01
0.14528D+03	0.14152D+03	0.37529D+01
0.14513D+03	0.14169D+03	0.34336D+01
0.14482D+03	0.14186D+03	0.29621D+01
0.14470D+03	0.14203D+03	0.26638D+01
0.14398D+03	0.14220D+03	0.17775D+01
0.14454D+03	0.14237D+03	0.21646D+01
0.14260D+03	0.14254D+03	0.58518D-01
0.13786D+03	0.14272D+03	-0.48582D+01

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.51565D+01	0.57000D+01	-0.54346D+00
0.50727D+01	0.57000D+01	-0.62726D+00
0.50131D+01	0.57000D+01	-0.68692D+00
0.49821D+01	0.57000D+01	-0.71788D+00
0.49820D+01	0.57000D+01	-0.71801D+00
0.50123D+01	0.57000D+01	-0.68767D+00
0.50683D+01	0.57000D+01	-0.63170D+00
0.51391D+01	0.57000D+01	-0.56094D+00
0.52138D+01	0.57000D+01	-0.48619D+00
0.52862D+01	0.57000D+01	-0.41383D+00
0.53574D+01	0.57000D+01	-0.34262D+00
0.54310D+01	0.57000D+01	-0.26901D+00
0.55116D+01	0.57000D+01	-0.18838D+00
0.55904D+01	0.57000D+01	-0.10959D+00
0.56770D+01	0.57000D+01	-0.23044D-01
0.57576D+01	0.57000D+01	0.57574D-01
0.57867D+01	0.57000D+01	0.86719D-01
0.57919D+01	0.57000D+01	0.91863D-01
0.57437D+01	0.57000D+01	0.43723D-01
0.57064D+01	0.57000D+01	0.64079D-02

RATE OF GROWTH OF PRICES (PERCENT, 4.D2*(ACTUAL STATE VARIABLE))

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.45134D+01	0.20000D+01	0.25134D+01	0.20000D+01	0.25134D+01
0.47677D+01	0.20000D+01	0.27677D+01	0.20000D+01	0.27677D+01
0.44388D+01	0.20000D+01	0.24388D+01	0.20000D+01	0.24388D+01
0.44412D+01	0.20000D+01	0.24412D+01	0.20000D+01	0.24412D+01
0.42503D+01	0.20000D+01	0.22503D+01	0.20000D+01	0.22503D+01
0.41713D+01	0.20000D+01	0.21713D+01	0.20000D+01	0.21713D+01
0.40537D+01	0.20000D+01	0.20537D+01	0.20000D+01	0.20537D+01
0.39752D+01	0.20000D+01	0.19752D+01	0.20000D+01	0.19752D+01
0.39377D+01	0.20000D+01	0.19377D+01	0.20000D+01	0.19377D+01
0.39563D+01	0.20000D+01	0.19563D+01	0.20000D+01	0.19563D+01
0.40129D+01	0.20000D+01	0.20129D+01	0.20000D+01	0.20129D+01
0.40555D+01	0.20000D+01	0.20555D+01	0.20000D+01	0.20555D+01
0.40482D+01	0.20000D+01	0.20482D+01	0.20000D+01	0.20482D+01
0.40399D+01	0.20000D+01	0.20399D+01	0.20000D+01	0.20399D+01
0.40301D+01	0.20000D+01	0.20301D+01	0.20000D+01	0.20301D+01
0.39875D+01	0.20000D+01	0.19875D+01	0.20000D+01	0.19875D+01
0.39450D+01	0.20000D+01	0.19450D+01	0.20000D+01	0.19450D+01
0.39719D+01	0.20000D+01	0.19719D+01	0.20000D+01	0.19719D+01
0.37868D+01	0.20000D+01	0.17868D+01	0.20000D+01	0.17868D+01
0.31088D+01	0.20000D+01	0.11088D+01	0.20000D+01	0.11088D+01

TABLE G.15.a: Experiment G.5

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.35442D+01	0.20000D+01	0.15442D+01	0.20000D+01	0.15442D+01
0.37266D+01	0.20000D+01	0.17266D+01	0.20000D+01	0.17266D+01
0.37879D+01	0.20000D+01	0.17879D+01	0.20000D+01	0.17879D+01
0.39301D+01	0.20000D+01	0.19301D+01	0.20000D+01	0.19301D+01
0.40409D+01	0.20000D+01	0.20409D+01	0.20000D+01	0.20409D+01
0.41702D+01	0.20000D+01	0.21702D+01	0.20000D+01	0.21702D+01
0.42869D+01	0.20000D+01	0.22869D+01	0.20000D+01	0.22869D+01
0.44048D+01	0.20000D+01	0.24048D+01	0.20000D+01	0.24048D+01
0.44852D+01	0.20000D+01	0.24852D+01	0.20000D+01	0.24852D+01
0.45508D+01	0.20000D+01	0.25508D+01	0.20000D+01	0.25508D+01
0.45844D+01	0.20000D+01	0.25844D+01	0.20000D+01	0.25844D+01
0.46334D+01	0.20000D+01	0.26334D+01	0.20000D+01	0.26334D+01
0.47012D+01	0.20000D+01	0.27012D+01	0.20000D+01	0.27012D+01
0.47885D+01	0.20000D+01	0.27885D+01	0.20000D+01	0.27885D+01
0.48698D+01	0.20000D+01	0.28698D+01	0.20000D+01	0.28698D+01
0.49707D+01	0.20000D+01	0.29707D+01	0.20000D+01	0.29707D+01
0.50606D+01	0.20000D+01	0.30606D+01	0.20000D+01	0.30606D+01
0.51060D+01	0.20000D+01	0.31060D+01	0.20000D+01	0.31060D+01
0.53255D+01	0.20000D+01	0.33255D+01	0.20000D+01	0.33255D+01

INVENTORIES	CONSUMPTION	NON-RES. INV	RES. INV	INVENT. INV	INTEREST	GNP
0.17931D+03	0.44952D+03	0.79738D+02	0.29485D+02	0.72539D+01	0.53964D+01	0.70580D+03
0.18092D+03	0.45229D+03	0.80423D+02	0.29423D+02	0.64204D+01	0.54335D+01	0.70905D+03
0.18280D+03	0.45493D+03	0.81283D+02	0.29758D+02	0.75102D+01	0.54690D+01	0.71547D+03
0.18477D+03	0.45697D+03	0.81451D+02	0.30340D+02	0.79139D+01	0.55048D+01	0.71968D+03
0.18663D+03	0.45977D+03	0.82138D+02	0.31050D+02	0.7428[illegible]D+01	0.55426D+01	0.72464D+03
0.18841D+03	0.46248D+03	0.82572D+02	0.31780D+02	0.71019D+01	0.55835D+01	0.72907D+03
0.18997D+03	0.46596D+03	0.83079D+02	0.32456D+02	0.62558D+01	0.56281D+01	0.73379D+03
0.19136D+03	0.46966D+03	0.83499D+02	0.33031D+02	0.55519D+01	0.56752D+01	0.73844D+03
0.19240D+03	0.47560D+03	0.84009D+02	0.33494D+02	0.41509D+01	0.57236D+01	0.74417D+03
0.19310D+03	0.48259D+03	0.84594D+02	0.33855D+02	0.27940D+01	0.57721D+01	0.75042D+03
0.19371D+03	0.48994D+03	0.85336D+02	0.34147D+02	0.24452D+01	0.58210D+01	0.75778D+03
0.19474D+03	0.49449D+03	0.86162D+02	0.34391D+02	0.41282D+01	0.58700D+01	0.76463D+03
0.19631D+03	0.49801D+03	0.87058D+02	0.34603D+02	0.63042D+01	0.59223D+01	0.77125D+03
0.19792D+03	0.50348D+03	0.87977D+02	0.34790D+02	0.64293D+01	0.59742D+01	0.77701D+03
0.19930D+03	0.51021D+03	0.88906D+02	0.34959D+02	0.55201D+01	0.60281D+01	0.78442D+03
0.20004D+03	0.51462D+03	0.89742D+02	0.35105D+02	0.61631D+01	0.60818D+01	0.79032D+03
0.20238D+03	0.52070D+03	0.90544D+02	0.35236D+02	0.61412D+01	0.61270D+01	0.79660D+03
0.20393D+03	0.52641D+03	0.91402D+02	0.35388D+02	0.62254D+01	0.61667D+01	0.80396D+03
0.20566D+03	0.52960D+03	0.91967D+02	0.35559D+02	0.68887D+01	0.61951D+01	0.80662D+03
0.20602D+03	0.53112D+03	0.91715D+02	0.35689D+02	0.46537D+01	0.62215D+01	0.80104D+03

TABLE G.15.b: Experiment G.5

GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
0.14207D+03	0.13950D+03	0.25696D+01
0.14240D+03	0.13967D+03	0.27306D+01
0.14369D+03	0.13984D+03	0.38580D+01
0.14428D+03	0.14000D+03	0.42778D+01
0.14500D+03	0.14017D+03	0.48264D+01
0.14558D+03	0.14034D+03	0.52429D+01
0.14622D+03	0.14051D+03	0.57173D+01
0.14669D+03	0.14068D+03	0.60165D+01
0.14682D+03	0.14084D+03	0.59786D+01
0.14653D+03	0.14101D+03	0.55174D+01
0.14596D+03	0.14118D+03	0.47733D+01
0.14559D+03	0.14135D+03	0.42424D+01
0.14548D+03	0.14152D+03	0.39563D+01
0.14543D+03	0.14169D+03	0.37379D+01
0.14524D+03	0.14186D+03	0.33735D+01
0.14515D+03	0.14203D+03	0.31214D+01
0.14465D+03	0.14220D+03	0.24463D+01
0.14543D+03	0.14237D+03	0.30541D+01
0.14360D+03	0.14254D+03	0.10577D+01
0.13878D+03	0.14272D+03	-0.39346D+01

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.47215D+01	0.57000D+01	-0.97852D+00
0.46511D+01	0.57000D+01	-0.10489D+01
0.46067D+01	0.57000D+01	-0.10933D+01
0.45900D+01	0.57000D+01	-0.11100D+01
0.46046D+01	0.57000D+01	-0.10954D+01
0.46522D+01	0.57000D+01	-0.10478D+01
0.47280D+01	0.57000D+01	-0.97195D+00
0.48194D+01	0.57000D+01	-0.88061D+00
0.49137D+01	0.57000D+01	-0.78631D+00
0.50042D+01	0.57000D+01	-0.69584D+00
0.50942D+01	0.57000D+01	-0.60581D+00
0.51903D+01	0.57000D+01	-0.50973D+00
0.52998D+01	0.57000D+01	-0.40019D+00
0.54127D+01	0.57000D+01	-0.28731D+00
0.55457D+01	0.57000D+01	-0.15435D+00
0.56819D+01	0.57000D+01	-0.18070D-01
0.57560D+01	0.57000D+01	0.56050D-01
0.57954D+01	0.57000D+01	0.95359D-01
0.57511D+01	0.57000D+01	0.51116D-01
0.57078D+01	0.57000D+01	0.77844D-02

RATE OF GROWTH OF PRICES (PERCENT, 4.D2*(ACTUAL STATE VARIABLE))

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.47151D+01	0.20000D+01	0.27151D+01	0.20000D+01	0.27151D+01
0.51075D+01	0.20000D+01	0.31075D+01	0.20000D+01	0.31075D+01
0.47134D+01	0.20000D+01	0.27134D+01	0.20000D+01	0.27134D+01
0.47368D+01	0.20000D+01	0.27368D+01	0.20000D+01	0.27368D+01
0.45864D+01	0.20000D+01	0.25864D+01	0.20000D+01	0.25864D+01
0.45238D+01	0.20000D+01	0.25238D+01	0.20000D+01	0.25238D+01
0.44134D+01	0.20000D+01	0.24134D+01	0.20000D+01	0.24134D+01
0.43374D+01	0.20000D+01	0.23374D+01	0.20000D+01	0.23374D+01
0.43062D+01	0.20000D+01	0.23062D+01	0.20000D+01	0.23062D+01
0.43321D+01	0.20000D+01	0.23321D+01	0.20000D+01	0.23321D+01
0.43983D+01	0.20000D+01	0.23983D+01	0.20000D+01	0.23983D+01
0.44438D+01	0.20000D+01	0.24438D+01	0.20000D+01	0.24438D+01
0.44302D+01	0.20000D+01	0.24302D+01	0.20000D+01	0.24302D+01
0.44143D+01	0.20000D+01	0.24143D+01	0.20000D+01	0.24143D+01
0.43959D+01	0.20000D+01	0.23959D+01	0.20000D+01	0.23959D+01
0.43333D+01	0.20000D+01	0.23333D+01	0.20000D+01	0.23333D+01
0.42741D+01	0.20000D+01	0.22741D+01	0.20000D+01	0.22741D+01
0.42921D+01	0.20000D+01	0.22921D+01	0.20000D+01	0.22921D+01
0.40793D+01	0.20000D+01	0.20793D+01	0.20000D+01	0.20793D+01
0.33470D+01	0.20000D+01	0.13470D+01	0.20000D+01	0.13470D+01

TABLE G.16.a: Experiment G.6

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.33852D+01	0.20000D+01	0.13852D+01	0.20000D+01	0.13852D+01
0.35227D+01	0.20000D+01	0.15227D+01	0.20000D+01	0.15227D+01
0.35818D+01	0.20000D+01	0.15818D+01	0.20000D+01	0.15818D+01
0.36847D+01	0.20000D+01	0.16847D+01	0.20000D+01	0.16847D+01
0.37635D+01	0.20000D+01	0.17635D+01	0.20000D+01	0.17635D+01
0.38644D+01	0.20000D+01	0.18644D+01	0.20000D+01	0.18644D+01
0.39616D+01	0.20000D+01	0.19616D+01	0.20000D+01	0.19616D+01
0.40604D+01	0.20000D+01	0.20604D+01	0.20000D+01	0.20604D+01
0.41226D+01	0.20000D+01	0.21226D+01	0.20000D+01	0.21226D+01
0.41690D+01	0.20000D+01	0.21690D+01	0.20000D+01	0.21690D+01
0.41831D+01	0.20000D+01	0.21831D+01	0.20000D+01	0.21831D+01
0.42178D+01	0.20000D+01	0.22178D+01	0.20000D+01	0.22178D+01
0.42767D+01	0.20000D+01	0.22767D+01	0.20000D+01	0.22767D+01
0.43565D+01	0.20000D+01	0.23565D+01	0.20000D+01	0.23565D+01
0.44331D+01	0.20000D+01	0.24331D+01	0.20000D+01	0.24331D+01
0.45385D+01	0.20000D+01	0.25385D+01	0.20000D+01	0.25385D+01
0.46286D+01	0.20000D+01	0.26286D+01	0.20000D+01	0.26286D+01
0.46747D+01	0.20000D+01	0.26747D+01	0.20000D+01	0.26747D+01
0.49085D+01	0.20000D+01	0.29085D+01	0.20000D+01	0.29085D+01

INVENTORIES	CONSUMPTION	NON-RES. INV	RES. INV	INVENT. INV	INTEREST	GNP
0.17958D+03	0.45013D+03	0.80042D+02	0.29529D+02	0.83195D+01	0.53198D+01	0.71009D+03
0.18156D+03	0.45362D+03	0.81059D+02	0.29706D+02	0.79047D+01	0.53440D+01	0.71469D+03
0.18356D+03	0.45694D+03	0.82205D+02	0.30496D+02	0.80232D+01	0.53681D+01	0.72136D+03
0.18569D+03	0.45974D+03	0.82714D+02	0.31553D+02	0.84981D+01	0.53937D+01	0.72679D+03
0.18768D+03	0.46326D+03	0.83904D+02	0.32663D+02	0.79843D+01	0.54226D+01	0.73281D+03
0.18961D+03	0.46665D+03	0.84599D+02	0.33689D+02	0.77167D+01	0.54564D+01	0.73823D+03
0.19133D+03	0.47075D+03	0.85326D+02	0.34558D+02	0.68716D+01	0.54953D+01	0.74372D+03
0.19288D+03	0.47502D+03	0.85983D+02	0.35235D+02	0.62037D+01	0.55382D+01	0.74913D+03
0.19410D+03	0.48148D+03	0.86704D+02	0.35731D+02	0.48705D+01	0.55833D+01	0.75561D+03
0.19499D+03	0.48897D+03	0.87484D+02	0.36077D+02	0.35874D+01	0.56294D+01	0.76265D+03
0.19582D+03	0.49680D+03	0.88410D+02	0.36325D+02	0.33107D+01	0.56770D+01	0.77081D+03
0.19708D+03	0.50179D+03	0.89407D+02	0.36509D+02	0.50249D+01	0.57270D+01	0.77832D+03
0.19887D+03	0.50571D+03	0.90456D+02	0.36650D+02	0.71715D+01	0.57808D+01	0.78547D+03
0.20069D+03	0.51154D+03	0.91510D+02	0.36756D+02	0.72689D+01	0.58372D+01	0.79251D+03
0.20227D+03	0.51857D+03	0.92552D+02	0.36829D+02	0.63336D+01	0.58990D+01	0.79952D+03
0.20400D+03	0.52321D+03	0.93462D+02	0.36860D+02	0.68933D+01	0.59638D+01	0.80558D+03
0.20570D+03	0.52948D+03	0.94314D+02	0.36846D+02	0.68278D+01	0.60203D+01	0.81211D+03
0.20743D+03	0.53532D+03	0.95207D+02	0.36827D+02	0.69208D+01	0.60707D+01	0.81970D+03
0.20930D+03	0.53858D+03	0.95763D+02	0.36812D+02	0.74590D+01	0.61054D+01	0.82222D+03
0.21054D+03	0.54006D+03	0.95435D+02	0.36761D+02	0.49726D+01	0.61362D+01	0.81601D+03

TABLE G.16.b: Experiment G.6

GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
0.14376D+03	0.13950D+03	0.42632D+01
0.14385D+03	0.13967D+03	0.41804D+01
0.14477D+03	0.13984D+03	0.49334D+01
0.14496D+03	0.14000D+03	0.49585D+01
0.14519D+03	0.14017D+03	0.50219D+01
0.14548D+03	0.14034D+03	0.51459D+01
0.14590D+03	0.14051D+03	0.53897D+01
0.14621D+03	0.14068D+03	0.55307D+01
0.14627D+03	0.14084D+03	0.54237D+01
0.14602D+03	0.14101D+03	0.50058D+01
0.14555D+03	0.14118D+03	0.43693D+01
0.14528D+03	0.14135D+03	0.39278D+01
0.14524D+03	0.14152D+03	0.37176D+01
0.14529D+03	0.14169D+03	0.35998D+01
0.14521D+03	0.14186D+03	0.33440D+01
0.14518D+03	0.14203D+03	0.31518D+01
0.14489D+03	0.14220D+03	0.26901D+01
0.14586D+03	0.14237D+03	0.34827D+01
0.14427D+03	0.14254D+03	0.17307D+01
0.13966D+03	0.14272D+03	-0.30565D+01

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.40958D+01	0.57000D+01	-0.16042D+01
0.40691D+01	0.57000D+01	-0.16309D+01
0.40641D+01	0.57000D+01	-0.16359D+01
0.40788D+01	0.57000D+01	-0.16212D+01
0.41198D+01	0.57000D+01	-0.15802D+01
0.41931D+01	0.57000D+01	-0.15069D+01
0.42953D+01	0.57000D+01	-0.14047D+01
0.44116D+01	0.57000D+01	-0.12884D+01
0.45276D+01	0.57000D+01	-0.11724D+01
0.46362D+01	0.57000D+01	-0.10638D+01
0.47444D+01	0.57000D+01	-0.95560D+00
0.48632D+01	0.57000D+01	-0.83679D+00
0.50044D+01	0.57000D+01	-0.69560D+00
0.51568D+01	0.57000D+01	-0.54320D+00
0.53486D+01	0.57000D+01	-0.35144D+00
0.55606D+01	0.57000D+01	-0.13938D+00
0.57004D+01	0.57000D+01	0.36271D-03
0.57927D+01	0.57000D+01	0.92693D-01
0.57590D+01	0.57000D+01	0.58971D-01
0.57094D+01	0.57000D+01	0.94067D-02

RATE OF GROWTH OF PRICES (PERCENT, 4.D2*(ACTUAL STATE VARIABLE))

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.48678D+01	0.20000D+01	0.28678D+01	0.20000D+01	0.28678D+01
0.53813D+01	0.20000D+01	0.33813D+01	0.20000D+01	0.33813D+01
0.49599D+01	0.20000D+01	0.29599D+01	0.20000D+01	0.29599D+01
0.50229D+01	0.20000D+01	0.30229D+01	0.20000D+01	0.30229D+01
0.49384D+01	0.20000D+01	0.29384D+01	0.20000D+01	0.29384D+01
0.49109D+01	0.20000D+01	0.29109D+01	0.20000D+01	0.29109D+01
0.48145D+01	0.20000D+01	0.28145D+01	0.20000D+01	0.28145D+01
0.47460D+01	0.20000D+01	0.27460D+01	0.20000D+01	0.27460D+01
0.47230D+01	0.20000D+01	0.27230D+01	0.20000D+01	0.27230D+01
0.47559D+01	0.20000D+01	0.27559D+01	0.20000D+01	0.27559D+01
0.48296D+01	0.20000D+01	0.28296D+01	0.20000D+01	0.28296D+01
0.48760D+01	0.20000D+01	0.28760D+01	0.20000D+01	0.28760D+01
0.48550D+01	0.20000D+01	0.28550D+01	0.20000D+01	0.28550D+01
0.48302D+01	0.20000D+01	0.28302D+01	0.20000D+01	0.28302D+01
0.48017D+01	0.20000D+01	0.28017D+01	0.20000D+01	0.28017D+01
0.47177D+01	0.20000D+01	0.27177D+01	0.20000D+01	0.27177D+01
0.46379D+01	0.20000D+01	0.26379D+01	0.20000D+01	0.26379D+01
0.46353D+01	0.20000D+01	0.26353D+01	0.20000D+01	0.26353D+01
0.43929D+01	0.20000D+01	0.23929D+01	0.20000D+01	0.23929D+01
0.36277D+01	0.20000D+01	0.16277D+01	0.20000D+01	0.16277D+01

TABLE G.17.a: Experiment G.7

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.32648D+01	0.20000D+01	0.12648D+01	0.20000D+01	0.12648D+01
0.33553D+01	0.20000D+01	0.13553D+01	0.20000D+01	0.13553D+01
0.34005D+01	0.20000D+01	0.14005D+01	0.20000D+01	0.14005D+01
0.34541D+01	0.20000D+01	0.14541D+01	0.20000D+01	0.14541D+01
0.34830D+01	0.20000D+01	0.14830D+01	0.20000D+01	0.14830D+01
0.35446D+01	0.20000D+01	0.15446D+01	0.20000D+01	0.15446D+01
0.36139D+01	0.20000D+01	0.16139D+01	0.20000D+01	0.16139D+01
0.36876D+01	0.20000D+01	0.16876D+01	0.20000D+01	0.16876D+01
0.37272D+01	0.20000D+01	0.17272D+01	0.20000D+01	0.17272D+01
0.37518D+01	0.20000D+01	0.17518D+01	0.20000D+01	0.17518D+01
0.37451D+01	0.20000D+01	0.17451D+01	0.20000D+01	0.17451D+01
0.37643D+01	0.20000D+01	0.17643D+01	0.20000D+01	0.17643D+01
0.38130D+01	0.20000D+01	0.18130D+01	0.20000D+01	0.18130D+01
0.38845D+01	0.20000D+01	0.18845D+01	0.20000D+01	0.18845D+01
0.39557D+01	0.20000D+01	0.19557D+01	0.20000D+01	0.19557D+01
0.40651D+01	0.20000D+01	0.20651D+01	0.20000D+01	0.20651D+01
0.41572D+01	0.20000D+01	0.21572D+01	0.20000D+01	0.21572D+01
0.42111D+01	0.20000D+01	0.22111D+01	0.20000D+01	0.22111D+01
0.44576D+01	0.20000D+01	0.24576D+01	0.20000D+01	0.24576D+01

INVENTORIES	CONSUMPTION	NON-RES. INV	RES. INV	INVENT. INV	INTEREST	GNP
0.17977D+03	0.45064D+03	0.80272D+02	0.29562D+02	0.90954D+01	0.52097D+01	0.71333D+03
0.18203D+03	0.45482D+03	0.81565D+02	0.30038D+02	0.90395D+01	0.52195D+01	0.71932D+03
0.18415D+03	0.45884D+03	0.82971D+02	0.31432D+02	0.84841D+01	0.52312D+01	0.72650D+03
0.18642D+03	0.46247D+03	0.83811D+02	0.33108D+02	0.90567D+01	0.52456D+01	0.73341D+03
0.18859D+03	0.46682D+03	0.85566D+02	0.34722D+02	0.86763D+01	0.52644D+01	0.74097D+03
0.19072D+03	0.47099D+03	0.86598D+02	0.36103D+02	0.85154D+01	0.52897D+01	0.74769D+03
0.19263D+03	0.47581D+03	0.87625D+02	0.37186D+02	0.76683D+01	0.53219D+01	0.75418D+03
0.19439D+03	0.48075D+03	0.88593D+02	0.37963D+02	0.70290D+01	0.53594D+01	0.76054D+03
0.19583D+03	0.48783D+03	0.89594D+02	0.38475D+02	0.57428D+01	0.54001D+01	0.76791D+03
0.19696D+03	0.49590D+03	0.90617D+02	0.38783D+02	0.45125D+01	0.54423D+01	0.77584D+03
0.19803D+03	0.50428D+03	0.91761D+02	0.38963D+02	0.43006D+01	0.54870D+01	0.78486D+03
0.19953D+03	0.50979D+03	0.92956D+02	0.39067D+02	0.60174D+01	0.55360D+01	0.79311D+03
0.20157D+03	0.51417D+03	0.94179D+02	0.39123D+02	0.81301D+01	0.55914D+01	0.80084D+03
0.20362D+03	0.52041D+03	0.95385D+02	0.39136D+02	0.81986D+01	0.56521D+01	0.80842D+03
0.20543D+03	0.52778D+03	0.96554D+02	0.39104D+02	0.72367D+01	0.57232D+01	0.81588D+03
0.20736D+03	0.53269D+03	0.97549D+02	0.39001D+02	0.77167D+01	0.58025D+01	0.82214D+03
0.20926D+03	0.53915D+03	0.98459D+02	0.38813D+02	0.76000D+01	0.58742D+01	0.82891D+03
0.21117D+03	0.54510D+03	0.99376D+02	0.38576D+02	0.76559D+01	0.59397D+01	0.83657D+03
0.21319D+03	0.54840D+03	0.99917D+02	0.38312D+02	0.80892D+01	0.59836D+01	0.83900D+03
0.21456D+03	0.54907D+03	0.99531D+02	0.38013D+02	0.54937D+01	0.60206D+01	0.83256D+03

TABLE G.17.b: Experiment G.7

GOVERNMENT SPENDING

OPTIMAL	TARGET	DEVIATION
0.14528D+03	0.13950D+03	0.57770D+01
0.14495D+03	0.13967D+03	0.52812D+01
0.14470D+03	0.13984D+03	0.48629D+01
0.14401D+03	0.14000D+03	0.40077D+01
0.14335D+03	0.14017D+03	0.31780D+01
0.14314D+03	0.14034D+03	0.27991D+01
0.14323D+03	0.14051D+03	0.27178D+01
0.14335D+03	0.14068D+03	0.26768D+01
0.14341D+03	0.14084D+03	0.25606D+01
0.14334D+03	0.14101D+03	0.23259D+01
0.14316D+03	0.14118D+03	0.19721D+01
0.14311D+03	0.14135D+03	0.17563D+01
0.14324D+03	0.14152D+03	0.17163D+01
0.14347D+03	0.14169D+03	0.17788D+01
0.14361D+03	0.14186D+03	0.17448D+01
0.14376D+03	0.14203D+03	0.17234D+01
0.14386D+03	0.14220D+03	0.16562D+01
0.14496D+03	0.14237D+03	0.25913D+01
0.14446D+03	0.14254D+03	0.19153D+01
0.14150D+03	0.14272D+03	-0.12156D+01

SHORT TERM BOND RATE

OPTIMAL	TARGET	DEVIATION
0.14325D+01	0.57000D+01	-0.42675D+01
0.19312D+01	0.57000D+01	-0.37688D+01
0.23124D+01	0.57000D+01	-0.33876D+01
0.25696D+01	0.57000D+01	-0.31304D+01
0.27562D+01	0.57000D+01	-0.29438D+01
0.29336D+01	0.57000D+01	-0.27664D+01
0.31234D+01	0.57000D+01	-0.25766D+01
0.33059D+01	0.57000D+01	-0.23941D+01
0.34578D+01	0.57000D+01	-0.22422D+01
0.35691D+01	0.57000D+01	-0.21309D+01
0.36634D+01	0.57000D+01	-0.20366D+01
0.37762D+01	0.57000D+01	-0.19238D+01
0.39440D+01	0.57000D+01	-0.17560D+01
0.41520D+01	0.57000D+01	-0.15480D+01
0.44945D+01	0.57000D+01	-0.12055D+01
0.49708D+01	0.57000D+01	-0.72918D+00
0.53792D+01	0.57000D+01	-0.32076D+00
0.57283D+01	0.57000D+01	0.28319D-01
0.57759D+01	0.57000D+01	0.75899D-01
0.57144D+01	0.57000D+01	0.14430D-01

RATE OF GROWTH OF PRICES (PERCENT, 4.D2*(ACTUAL STATE VARIABLE))

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.50190D+01	0.2000(D+01	0.30190D+01	0.20000D+01	0.30190D+01
0.57307D+01	0.20000D+01	0.37307D+01	0.20000D+01	0.37307D+01
0.54556D+01	0.20000D+01	0.34556D+01	0.20000D+01	0.34556D+01
0.57433D+01	0.20000D+01	0.37433D+01	0.20000D+0.	0.37433D+01
0.58957D+01	0.20000D+01	0.38957D+01	0.20000D+01	0.38957D+01
0.59956D+01	0.20000D+01	0.39956D+01	0.20000D+01	0.39956D+01
0.59198D+01	0.20000D+01	0.39198D+01	0.20000D+01	0.39190D+01
0.58518D+01	0.20000D+01	0.38518D+01	0.20000D+01	0.38518D+01
0.58244D+01	0.20000D+01	0.38244D+01	0.20000D+01	0.38244D+01
0.58462D+01	0.20000D+01	0.38462D+01	0.20000D+01	0.38462D+01
0.59122D+01	0.20000D+01	0.39122D+01	0.20000D+01	0.39122D+01
0.59486D+01	0.20000D+01	0.39406D+01	0.20000D+01	0.39486D+01
0.59135D+01	0.20000D+01	0.39135D+01	0.20000D+01	0.39135D+01
0.58790D+01	0.20000D+01	0.38790D+01	0.20000D+01	0.38790D+01
0.58465D+01	0.20000D+01	0.38465D+01	0.20000D+01	0.38465D+01
0.57430D+01	0.20000D+01	0.37430D+01	0.20000D+01	0.37430D+01
0.56293D+01	0.20000D+01	0.36293D+01	0.20000D+01	0.36293D+01
0.55456D+01	0.20000D+01	0.35456D+01	0.20000D+01	0.35456D+01
0.52381D+01	0.20000D+01	0.32381D+01	0.20000D+01	0.32381D+01
0.44970D+01	0.20000D+01	0.24970D+01	0.20000D+01	0.24970D+01

TABLE G.18.a: Experiment G.9

RATE OF UNEMPLOYMENT (PERCENT)

OPTIMAL	TARGET-1	DEVIATION-1	TARGET-2	DEVIATION-2
0.35311D+01	0.20000D+01	0.15311D+01	0.20000D+01	0.15311D+01
0.31457D+01	0.20000D+01	0.11457D+01	0.20000D+01	0.11457D+01
0.31279D+01	0.20000D+01	0.11279D+01	0.20000D+01	0.11279D+01
0.30476D+01	0.20000D+01	0.10476D+01	0.20000D+01	0.10476D+01
0.29233D+01	0.20000D+01	0.92330D+00	0.20000D+01	0.92330D+00
0.27676D+01	0.20000D+01	0.76763D+00	0.20000D+01	0.76763D+00
0.27057D+01	0.20000D+01	0.70569D+00	0.20000D+01	0.70569D+00
0.27000D+01	0.20000D+01	0.69999D+00	0.20000D+01	0.69999D+00
0.27134D+01	0.20000D+01	0.71340D+00	0.20000D+01	0.71340D+00
0.27065D+01	0.20000D+01	0.70647D+00	0.20000D+01	0.70647D+00
0.26910D+01	0.20000D+01	0.69095D+00	0.20000D+01	0.69095D+00
0.26467D+01	0.20000D+01	0.64666D+00	0.20000D+01	0.64666D+00
0.26341D+01	0.20000D+01	0.63409D+00	0.20000D+01	0.63409D+00
0.26556D+01	0.20000D+01	0.65564D+00	0.20000D+01	0.65564D+00
0.26993D+01	0.20000D+01	0.69933D+00	0.20000D+01	0.69933D+00
0.27428D+01	0.20000D+01	0.74281D+00	0.20000D+01	0.74281D+00
0.28383D+01	0.20000D+01	0.83834D+00	0.20000D+01	0.83834D+00
0.29244D+01	0.20000D+01	0.92436D+00	0.20000D+01	0.92436D+00
0.30139D+01	0.20000D+01	0.10139D+01	0.20000D+01	0.10139D+01
0.32718D+01	0.20000D+01	0.12718D+01	0.20000D+01	0.12718D+01

INVENTORIES	CONSUMPTION	NON-RES. INV	RES. INV	INVENT. INV	INTEREST	GNP
0.17991D+03	0.45153D+03	0.80499D+02	0.29594D+02	0.96498D+01	0.47411D+01	0.71655D+03
0.18243D+03	0.45718D+03	0.82184D+02	0.31179D+02	0.10071D+02	0.47492D+01	0.72556D+03
0.18481D+03	0.46311D+03	0.841[illegible]7D+02	0.34859D+02	0.94990D+01	0.47587D+01	0.73633D+03
0.18748D+03	0.46917D+03	0.85827D+02	0.38640D+02	0.10696D+02	0.47632D+01	0.74834D+03
0.19025D+03	0.47586D+03	0.89313D+02	0.41721D+02	0.11097D+02	0.47667D+01	0.76134D+03
0.19308D+03	0.48220D+03	0.91429D+02	0.43910D+02	0.11303D+02	0.47768D+01	0.77198D+03
0.19564D+03	0.48897D+03	0.93463D+02	0.45285D+02	0.10250D+02	0.47966D+01	0.78119D+03
0.19802D+03	0.49566D+03	0.95361D+02	0.46009D+02	0.95207D+01	0.48226D+01	0.78990D+03
0.20006D+03	0.50432D+03	0.97138D+02	0.46268D+02	0.81578D+01	0.48499D+01	0.79929D+03
0.20179D+03	0.51383D+03	0.98762D+02	0.46240D+02	0.68968D+01	0.48755D+01	0.80907D+03
0.20346D+03	0.52355D+03	0.10039D+03	0.46095D+02	0.66929D+01	0.49016D+01	0.81989D+03
0.20556D+03	0.53031D+03	0.10202D+03	0.45944D+02	0.83987D+01	0.49338D+01	0.82978D+03
0.20817D+03	0.53587D+03	0.10363D+03	0.45831D+02	0.10467D+02	0.49790D+01	0.83904D+03
0.21080D+03	0.54322D+03	0.10520D+03	0.45742D+02	0.10520D+02	0.50363D+01	0.84815D+03
0.21320D+03	0.55162D+03	0.10672D+03	0.45631D+02	0.95775D+01	0.51234D+01	0.85715D+03
0.21570D+03	0.55739D+03	0.10802D+03	0.45399D+02	0.10010D+02	0.52446D+01	0.86457D+03
0.21815D+03	0.56450D+03	0.10918D+03	0.44920D+02	0.98126D+01	0.53686D+01	0.87227D+03
0.22055D+03	0.57078D+03	0.11022D+03	0.44155D+02	0.95913D+01	0.54936D+01	0.87971D+03
0.22303D+03	0.57422D+03	0.11081D+03	0.43142D+02	0.98900D+01	0.55742D+01	0.88252D+03
0.22494D+03	0.57586D+03	0.11047D+03	0.42003D+02	0.76728D+01	0.56332D+01	0.87750D+03

TABLE G.18.b: Experiment G.9

APPENDIX H: Feasible Bargains: Graphs of Experiments Not Reported in Chapter 3.

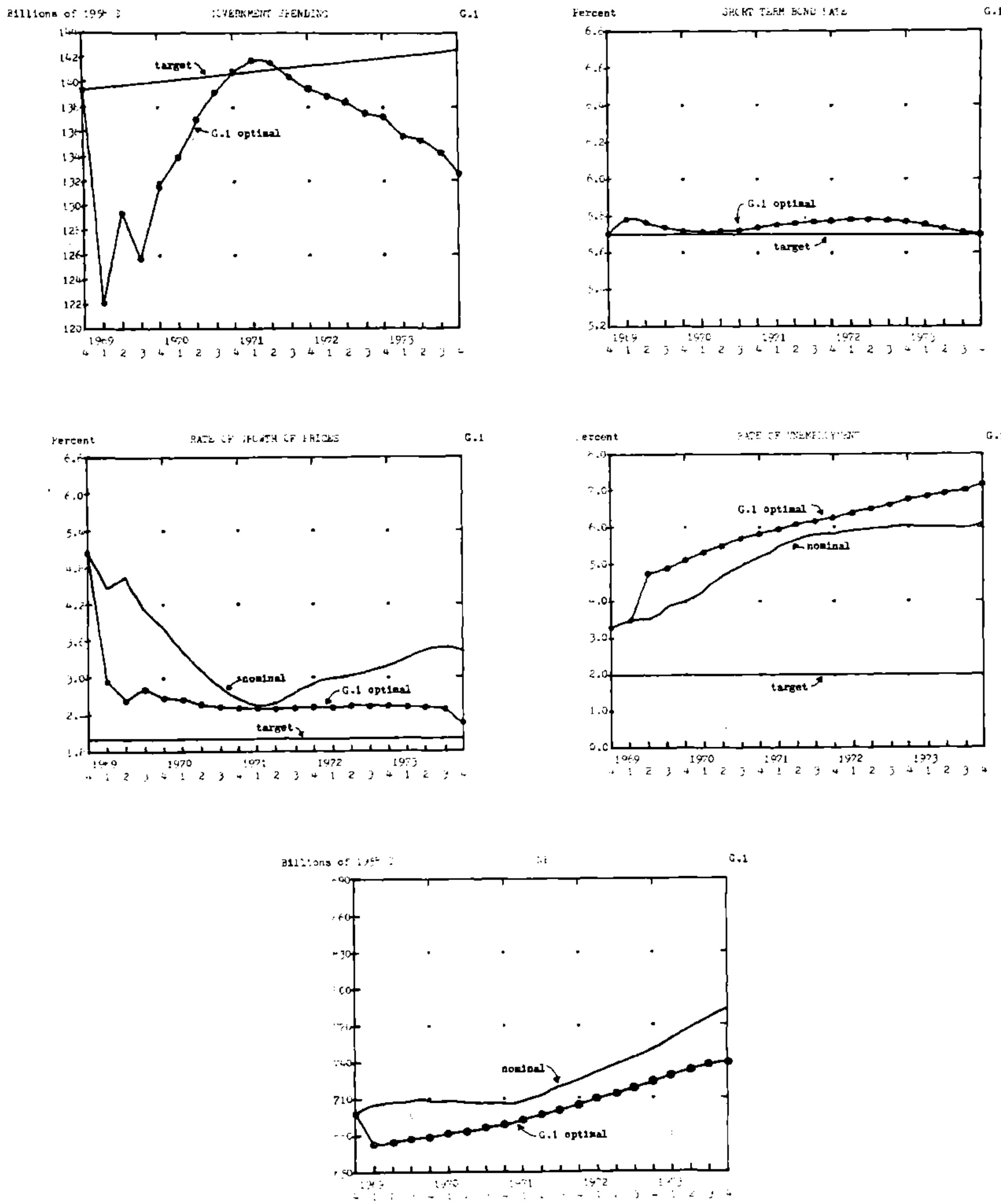

FIGURE H.1 Experiment G.1

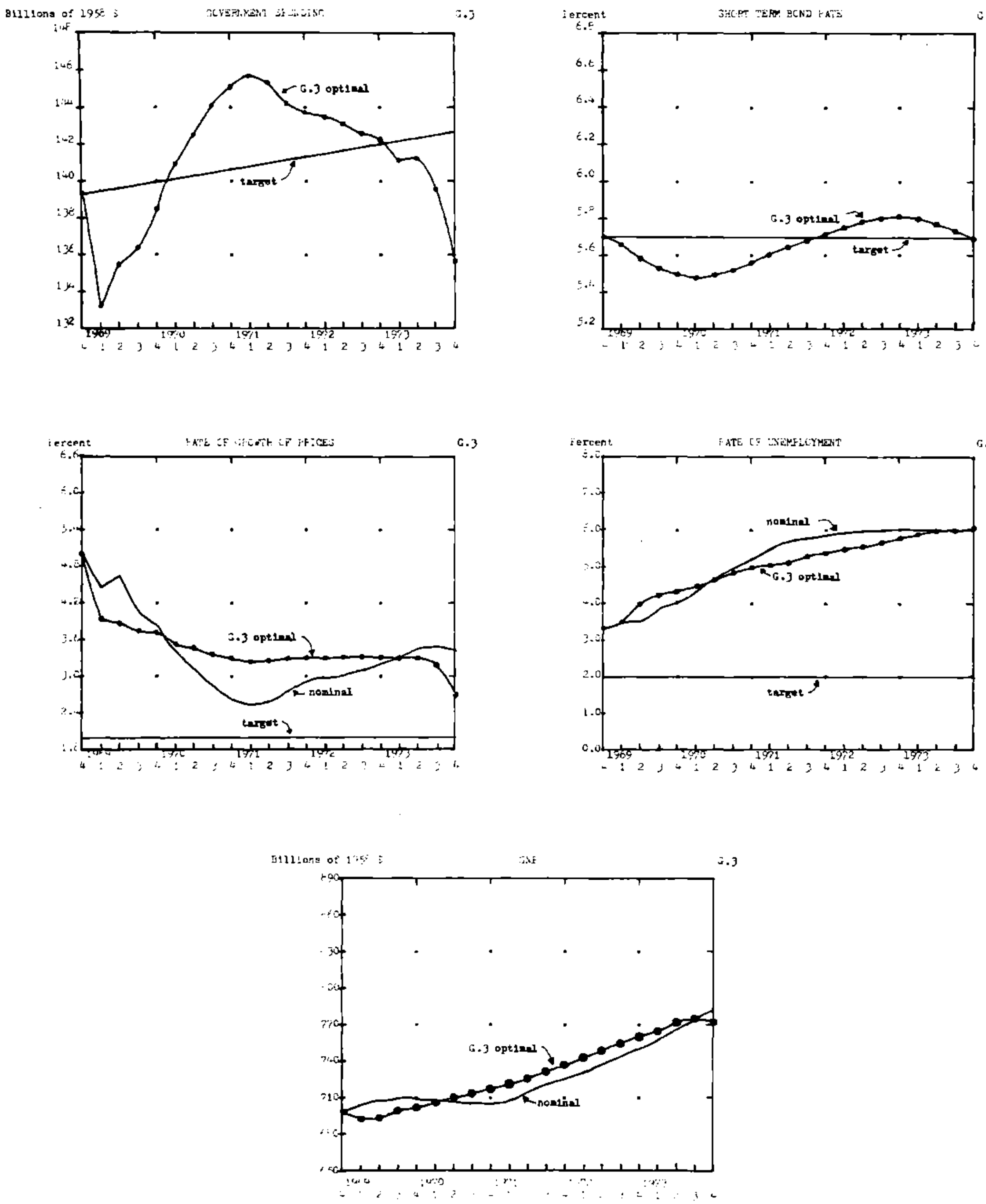

FIGURE H.2 Experiment G.3

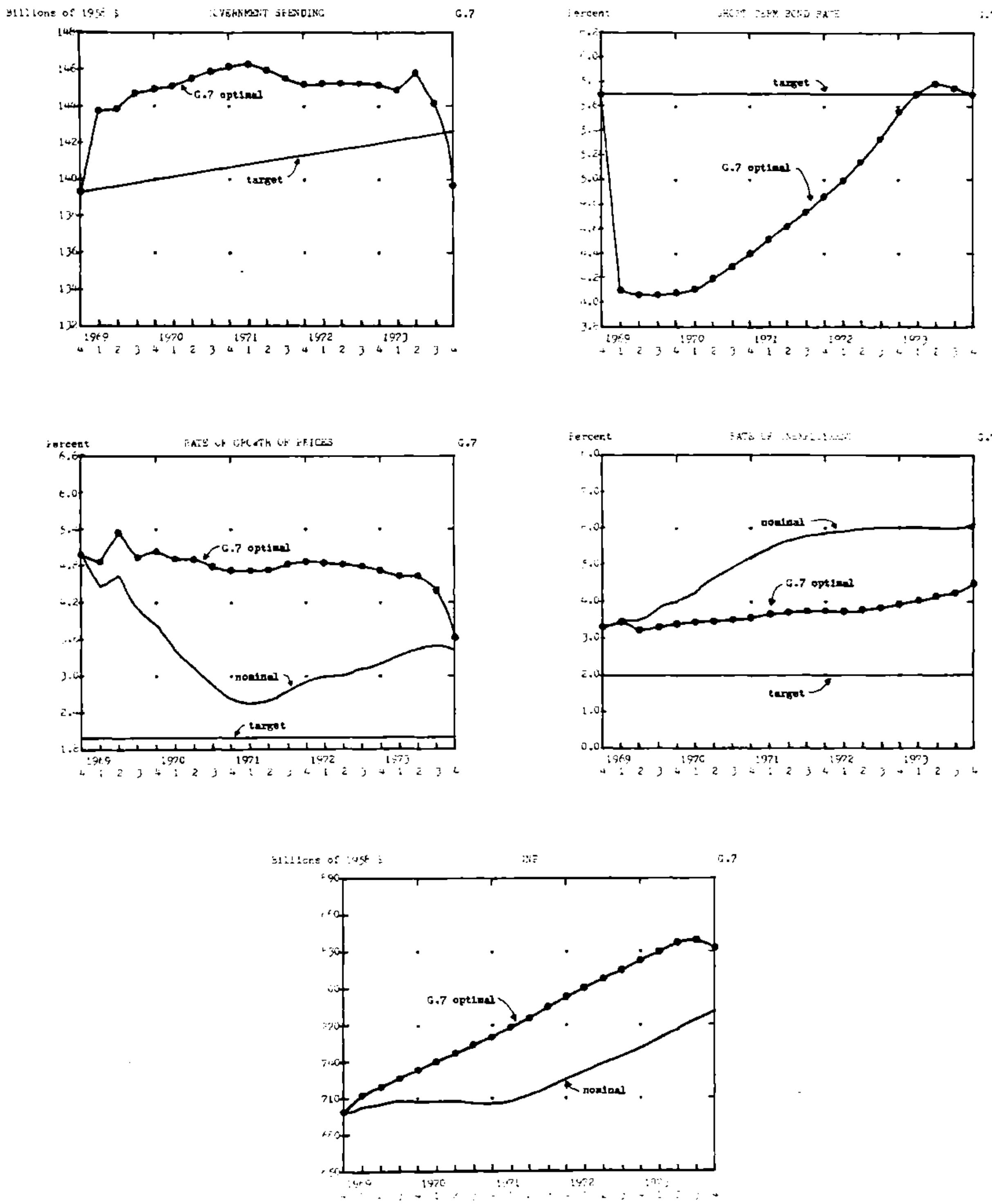

FIGURE H.3 Experiment G.7

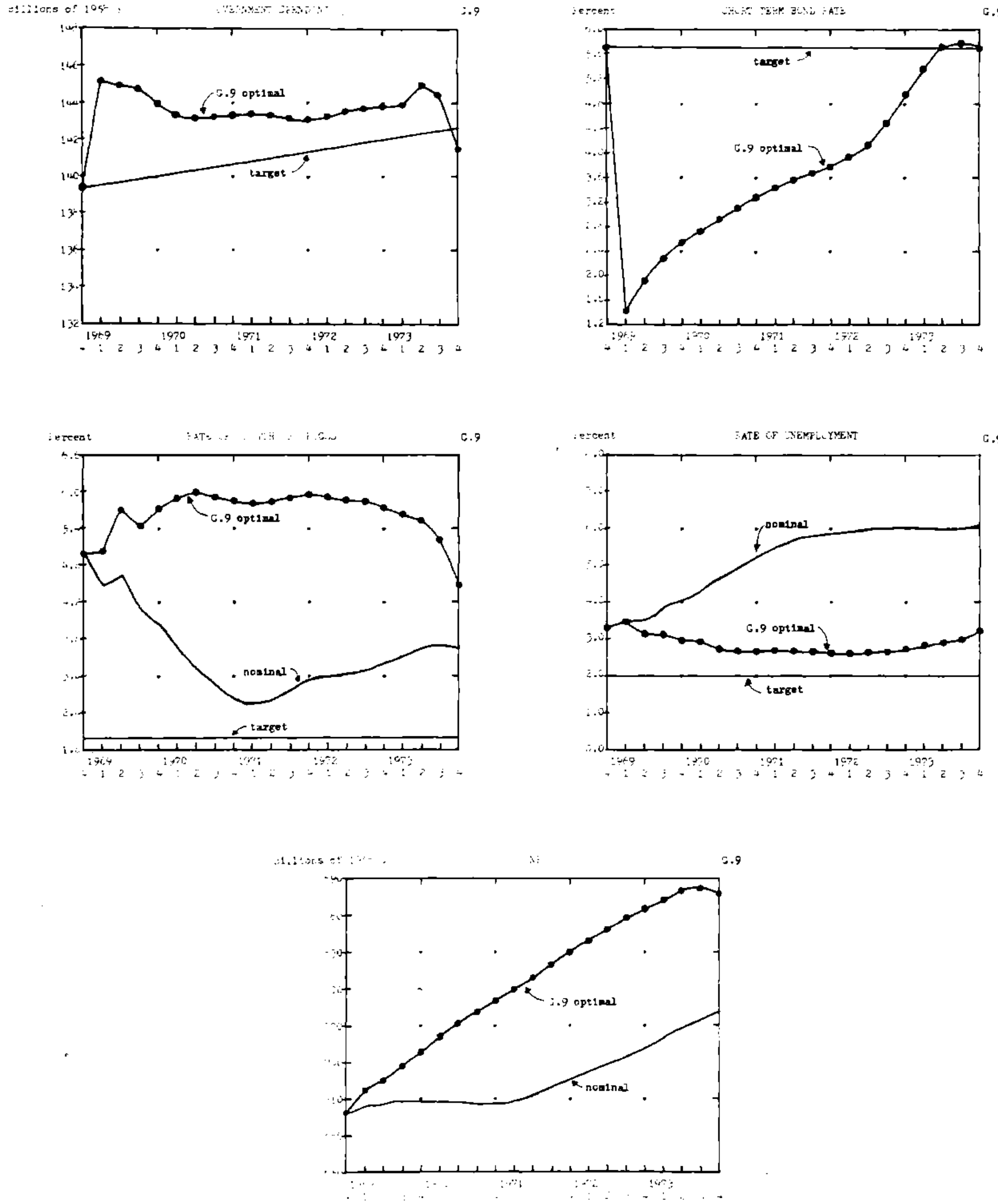

FIGURE H.4 Experiment G.9

APPENDIX I: Computer Program Listings

The following programs were used to calculate the various optimal trajectories. The programs make extensive use of subroutines in MIT's LIDS linear systems software package.

Subroutines VINS, VEXT, MINS and MEXT remove/insert vectors or matrices into/from arrays to keep track of results through time.

Main Program EXPER sets up and runs the experiment, reading in data and printing out results.

Subroutine COOP computes either centralized or cooperative solutions (one-sided or joint optimizations).

Subroutine NASHO computes the Nash open-loop competitive solution; NASHC computes the Nash closed-loop competitive solution.

Subroutine COST computes the cost functions - note that the cost due to the initial state is ignored; only the cost which can be affected by control is calculated.

Subroutine REACT calculates the matrices used in experiments C.1, C.2 and D.1 (see eq. (2.2.31), (2.2.40)).

```
      SUBROUTINE VINS(NPD,NR,NT,GT,G)
      INTEGER NPD,NR,NT,I
      DOUBLE PRECISION GT(NPD,NR),G(NR)
C   PURPOSE:  BEGIN WITH THE NR VECTOR: G
C             AND INSERT IT INTO THE (NT)TH SUBVECTOR
C             OF THE NPD-BY-NR MATRIX: GT
      DO 10 I = 1,NR
       GT(NT,I) = G(I)
   10 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE VEXT(NPD,NR,NT,GT,G)
      INTEGER NPD,NR,NT,I
      DOUBLE PRECISION GT(NPD,NR),G(NR)
C   PURPOSE:  BEGIN WITH THE NPD-BY-NR MATRIX: GT
C             PICK OUT THE (NT)TH SUBVECTOR AND
C             PLACE IT IN THE NR VECTOR: G
      DO 10 I = 1,NR
      G(I) = GT(NT,I)
   10 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE MINS(NPD,NR,NC,NT,KT,K)
      INTEGER NT,NR,NC,NPD,I,J
      DOUBLE PRECISION KT(NPD,NR,NC),K(NR,NC)
C   PURPOSE:  BEGIN WITH NR-BY-NC MATRIX: K
C             AND INSERT IT INTO THE (NT)TH SUBMATRIX
C             OF THE NPD-BY-NR-BY-NC ARRAY: KT
      DO 20 I = 1,NR
      DO 10 J = 1,NC
      KT(NT,I,J) = K(I,J)
   10 CONTINUE
   20 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE MEXT(NPD,NR,NC,NT,KT,K)
      INTEGER NT,NR,NC,NPD,I,J
      DOUBLE PRECISION KT(NPD,NR,NC),K(NR,NC)
C   PURPOSE:  BEGIN WITH NPD-BY-NR-BY-NC ARRAY: KT
C             PICK OUT THE (NT)TH OF THE NPD SUBMATRICES
C             OF DIMENSION NR-BY-NC AND PUT IT INTO K
      DO 20 I = 1,NR
      DO 10 J = 1,NC
      K(I,J) = KT(NT,I,J)
   10 CONTINUE
   20 CONTINUE
      RETURN
      END
```

<u>FIGURE I.1</u>   Subroutines VINS, VEXT, MINS, MEXT

```
      INTEGER NY,NX1,NX2,NW,NPD,NR,NX11,NPD1,T,TT,IPVT(2)
      DOUBLE PRECISION YT(20,27),Y(27),X1T(20,1),X2T(20,1),
     1 X1(1),X2(1),YHATT1(20,27),YHATT2(20,27),YHAT1(27),YHAT2(27),
     2 U1HATT(20,1),U2HATT(20,1),U1HAT(1),U2HAT(1),WT(20,5),
     3 W(5),Y0(27),WP(5),YP(27),X1P(1),X2P(1)
      DOUBLE PRECISION KT(20,27,27),KP(27,27),K(27,27),
     1  K1T(20,27,27),K1P(27,27),K1(27,27),K2T(20,27,27),
     2  K2P(27,27),K2(27,27),GT(20,27),GP(27),G(27),G3T(20,27),
     3  G3P(27),G1T(20,27),G1P(27),G1(27),G2T(20,27),G2P(27),G2(27)
      DOUBLE PRECISION EIT(20,27,27),EI(27,27),EIP(27,27),
     1  RIBT11(1,27),RIBT22(1,27),RIBT21(1,27),RIBT12(1,27),
     2  BRBT11(27,27),BRBT22(27,27),BRBT12(27,27),BRBT21(27,27),
     3  BRBT(27,27)
      DOUBLE PRECISION RBK1(1,27),RBK2(1,27),RK11(1,1),RK21(1,1),
     1  RK12(1,1),RK22(1,1),ER(2,2),ER1(2,2),RBKE1(1,27),RBKE2(1,27),
     2  BRBG11(27),BRBG22(27),BRBG(27)
      DOUBLE PRECISION BE(27,2),RBKE(2,27),BU(27),BERI(27,2),
     1  COND,WORK(2),OMALP,ALPHA,AKE(27,27),AKEA(27,27),AKE1(27,27),
     2  AKE2(27,27),AKEA1(27,27),AKEA2(27,27),GINTER,GSLOPE,RSB,RGP1,
     3  RGP2,UR1,UR2
      DOUBLE PRECISION A(27,27),AT(27,27),B1(27,1),B1T(1,27),
     1  B2(27,1),B2T(1,27),C(27,5),Q1(27,27),Q2(27,27),Q(27,27),
     2  R11(1,1),RI11(1,1),R21(1,1),R12(1,1),R22(1,1),RI22(1,1),
     3  R1(1,1),RI1(1,1),R2(1,1),RI2(1,1),IDENT(2,2)
      DOUBLE PRECISION BRI1(27,1),BRI2(27,1),RRBT21(1,27),RRBT12(1,27),
     1  RRBG1(1),RRBG2(1),B1G2(1),B2G1(1),G1A(27),G2A(27),ET(27,27),
     2  K1A(27,27),K2A(27,27),ETK1(27,27),ETK2(27,27),EKBR1(27,1),
     3  EKBR2(27,1),RRBK1(1,27),RRBK2(1,27),B1K2(1,27),B2K1(1,27)
      DOUBLE PRECISION J1,J2,DELY1(27),DELY2(27),DELX1(1),DELX2(1),
     1    W1,W2,Q0(27,27),QT(27,27),ROO(1,1),RTO(1,1),ROT(1,1),RTT(1,1),
     2    BUT(1,27),CU(1,1),CUT(1,1),DU(1,1),DUT(1,1)
      DOUBLE PRECISION AC1(27,27),AC2(27,27),BC1(27,1),BC2(27,1),
     1  CC1(27,5),CC2(27,5),AR(27,27),CR(27,5)
      COMMON/INOU/KIN,KOUT
      KIN = 5
      KOUT = 6
      NY = 27
      NX1 = 1
      NX2 = 1
      NW = 5
      NPD = 20
      NR = NX1 + NX2
      NX11 = NX1 + 1
      NPD1 = NPD + 1
      DO 5 I = 1,NY
      DO 5 J = 1,NY
      Q1(I,J) = 0.D0
    5 Q2(I,J) = 0.D0
      READ(KIN,*) ALPHA,GINTER,GSLOPE,RSB,RGP1,RGP2,UR1,UR2
      READ(KIN,*) (Q1(I,I),I=1,8)
      READ(KIN,*) (Q2(I,I),I=1,8)
      READ(KIN,*) R11,R21,R12,R22
      DO 10 I = 1,NY
   10 READ(KIN,*) (A(I,J),J=1,NY)
      DO 15 I = 1,NY
```

FIGURE I.2.a Main Program EXPER

```
   15 READ(KIN,*) B1(I,1)
      DO 20 I = 1,NY
   20 READ(KIN,*) B2(I,1)
      DO 25 I = 1,NY
   25 READ(KIN,*) (C(I,J),J=1,5)
      DO 30 J = 1,4
   30 READ(KIN,*) (WT(I,J),I=1,NPD)
      DO 35 I = 1,NPD
   35 WT(I,5) = 1.D0
      DO 40 I = 1,NPD
      DO 40 J = 1,NY
      YHATT1(I,J) = 0.D0
   40 YHATT2(I,J) = 0.D0
      U1HATT(1,1) = GINTER
      DO 45 I = 2,NPD
   45 U1HATT(I,1) = GSLOPE*U1HATT(I-1,1)
      DO 50 I = 1,NPD
      U2HATT(I,1) = RSB
      YHATT1(I,7) = RGP1
      YHATT1(I,8) = UR1
      YHATT2(I,7) = RGP2
   50 YHATT2(I,8) = UR2
      READ(KIN,*) (Y0(I),I=1,27)
      IF(KOUT.EQ.6) GO TO 109
      CALL REACT(A,B1,B2,C,AC1,AC2,BC1,BC2,CC1,CC2,AR,CR)
C     CALL SAVE(27,27,27,27,AC1,A)
C     CALL SAVE(27,27,27,27,AC2,A)
      CALL SAVE(27,27,27,27,AR,A)
C     CALL SAVE(27,27,27,1,BC1,B1)
      DO 6 I = 1,27
    6 B2(I,1) = 0.D0
C     CALL SAVE(27,27,27,1,BC2,B2)
      DO 7 I = 1,27
    7 B1(I,1) = 0.D0
C     CALL SAVE(27,27,27,5,CC1,C)
C     CALL SAVE(27,27,27,5,CC2,C)
      CALL SAVE(27,27,27,5,CR,C)
  109 CONTINUE
      WRITE(KOUT,200)
  200 FORMAT(//,2X,'    ALPHA      ',/)
      WRITE(KOUT,201) ALPHA
  201 FORMAT(2X,D12.5)
      WRITE(KOUT,202)
  202 FORMAT(//,2X,'THE FIRST EIGHT DIAGONAL ELEMENTS OF Q1',/)
      WRITE(KOUT,203) (Q1(I,I),I=1,8)
  203 FORMAT(2X,8D12.4)
      WRITE(KOUT,204)
  204 FORMAT(//,2X,'THE FIRST EIGHT DIAGONAL ELEMENTS OF Q2',/)
      WRITE(KOUT,203) (Q2(I,I),I=1,8)
      WRITE(KOUT,205)
  205 FORMAT(//,2X,'R11, R21, R12, R22',/)
      WRITE(KOUT,206) R11(1,1),R21(1,1),R12(1,1),R22(1,1)
  206 FORMAT(2X,4D12.4)
C     CALL MATIO(27,27,27,A,3)
C     CALL MATIO(27,27,1,B1,3)
```

FIGURE I.2.b Main Program EXPER

```
C     CALL MATIO(27,27,1,B2,3)
C     CALL MATIO(27,27,5,C,3)
C     CALL MATIO(20,20,5,WT,3)
C     CALL MATIO(27,27,1,Y0,3)
      CALL SAVE(NY,NY,NY,NY,Q1,Q0)
      CALL SAVE(NY,NY,NY,NY,Q2,QT)
      ROO(1,1) = R11(1,1)
      RTO(1,1) = R21(1,1)
      ROT(1,1) = R12(1,1)
      RTT(1,1) = R22(1,1)
C     Q1(7,7) = 0.D0
C     Q1(8,8) = 0.D0
C     Q2(7,7) = 0.D0
C     Q2(8,8) = 0.D0
      IF(KIN.EQ.5) GO TO 919
      CALL COOP(NY,NX1,NX2,NW,NPD,NR,
     1 KT,KP,K,GT,GP,G,G3T,G3P,YT,Y,X1T,X1,X2T,X2,YHATT1,YHATT2,
     2 YHAT1,YHAT2,YP,X1P,X2P,U1HAT,U2HAT,U1HATT,U2HATT,WT,WP,W,
     3 Y0,EIT,EI,EIP,RIBT11,RIBT22,BRBT11,BRBT22,BRBT,RBK1,RBK2,
     4 RK11,RK21,RK12,RK22,ER,ERI,BRBG,BE,RBKE,BU,BERI,A,AT,B1,B1T,
     5 B2,B2T,C,Q1,Q2,Q,R11,R21,R12,R22,R1,RI1,R2,RI2,ALPHA,IDENT,
     6 AKE,AKEA,RBKE1,RBKE2,COND,IPVT,WORK)
  919 CONTINUE
      CALL NASHO(NY,NX1,NX2,NW,NPD,NR,NX11,NPD1,T,TT,
     1 K1T,K1P,K1,K2T,K2P,K2,G2T,G2P,G2,G1T,G1P,G1,
     2 G3T,G3P,YT,Y,X1T,X1,X2T,X2,YHATT1,YHATT2,YHAT1,YHAT2,YP,X1P,X2P,
     3 U1HAT,U2HAT,U1HATT,U2HATT,WT,WP,W,Y0,EIT,EI,EIP,
     4 RIBT11,RIBT21,RIBT12,RIBT22,BRBT11,BRBT21,RBKE1,
     5 BRBT12,BRBT22,RBK1,RBK2,RK11,RK21,RK12,RK22,RBKE2,
     6 ER,ERI,BRBG11,BRBG22,BE,RBKE,BU,BERI,AKE1,AKE2,
     7 AKEA1,AKEA2,A,AT,B1,B1T,B2,B2T,C,Q1,Q2,R11,RI11,
     8 R21,R12,R22,RI22,IDENT,COND,IPVT,WORK)
      IF(KIN.EQ.5) GO TO 924
      CALL NASHC(NY,NX1,NX2,NW,NPD,NR,NX11,NPD1,T,TT,
     1 K1T,K1P,K1,K2T,K2P,K2,G2T,G2P,G2,G1T,G1P,G1,
     2 G3T,G3P,YT,Y,X1T,X1,X2T,X2,YHATT1,YHATT2,YHAT1,YHAT2,YP,X1P,X2P,
     3 U1HAT,U2HAT,U1HATT,U2HATT,WT,WP,W,Y0,EIT,EI,EIP,
     4 RIBT11,RIBT21,RIBT12,RIBT22,BRBT11,BRBT21,RBKE1,
     5 BRBT12,BRBT22,RBK1,RBK2,RK11,RK21,RK12,RK22,RBKE2,
     6 ER,ERI,BRBG11,BRBG22,BE,RBKE,BU,BERI,AKE1,AKE2,
     7 AKEA1,AKEA2,A,AT,B1,B1T,B2,B2T,C,Q1,Q2,R11,RI11,
     8 R21,R12,R22,RI22,BRI1,BRI2,RRBT21,RRBT12,RRBG1,RRBG2,
     9 B1G2,B2G1,G1A,G2A,ET,K1A,K2A,ETK1,ETK2,EKBR1,EKBR2,
     A RRBK1,RRBK2,B1K2,B2K1,IDENT,COND,IPVT,WORK)
  924 CONTINUE
      IF(KOUT.EQ.6) GO TO 929
      DO 390 I = 1,NPD
  390 X2T(I,1) = YT(I,25)
      DO 395 I = 1,NPD
  395 X1T(I,1) = YT(I,23)
  929 CONTINUE
      CALL COST(NY,NX1,NX2,NPD,YT,Y,X1T,X1,X2T,X2,YHATT1,YHAT1,
     1     YHATT2,YHAT2,U1HATT,U1HAT,U2HATT,U2HAT,Q0,QT,ROO,RTO,
     2     ROT,RTT,J1,J2,DELY1,DELY2,DELX1,DELX2,W1,W2,BU,BUT,CU,CUT,
     3     DU,DUT)
```

FIGURE I.2.c Main Program EXPER

```
      WRITE(KOUT,401)
  401 FORMAT(//,2X,'GOVERNMENT SPENDING',/)
      WRITE(KOUT,403)
  403 FORMAT(2X,'  OPTIMAL    ',2X,'   TARGET    ',2X,' DEVIATION   ',/)
      DO 300 I = 1,NPD
      DELX1(1) = X1T(I,1) - U1HATT(I,1)
  300 WRITE(KOUT,410) X1T(I,1),U1HATT(I,1),DELX1(1)
      WRITE(KOUT,402)
  402 FORMAT(//,2X,'SHORT TERM BOND RATE',/)
      WRITE(KOUT,403)
      DO 305 I = 1,NPD
      DELX2(1) = X2T(I,1) - U2HATT(I,1)
  305 WRITE(KOUT,410) X2T(I,1),U2HATT(I,1),DELX2(1)
      WRITE(KOUT,404)
  404 FORMAT(//,2X,'RATE OF GROWTH OF PRICES (PERCENT, 4.D2*(ACTUAL STAT
     1E VARIABLE))',/)
      WRITE(KOUT,406)
      DO 310 I = 1,NPD
      Y(7) = 4.D2*YT(I,7)
      YHAT1(7) = 4.D2*YHATT1(I,7)
      YHAT2(7) = 4.D2*YHATT2(I,7)
      DELY1(7) = Y(7) - YHAT1(7)
      DELY2(7) = Y(7) - YHAT2(7)
  310 WRITE(KOUT,420) Y(7),YHAT1(7),DELY1(7),YHAT2(7),DELY2(7)
      WRITE(KOUT,405)
  405 FORMAT(//,2X,'RATE OF UNEMPLOYMENT (PERCENT)',/)
      WRITE(KOUT,406)
  406 FORMAT(2X,'  OPTIMAL    ',2X,'  TARGET-1   ',2X,'DEVIATION-1 ',2X,
     1       '  TARGET-2   ',2X,'DEVIATION-2 ',/)
      DO 315 I = 1,NPD
      DELY1(8) = YT(I,8) - YHATT1(I,8)
      DELY2(8) = YT(I,8) - YHATT2(I,8)
  315 WRITE(KOUT,420) YT(I,8),YHATT1(I,8),DELY1(8),YHATT2(I,8),DELY2(8)
      WRITE(KOUT,407)
  407 FORMAT(//,2X,'OPTIMAL COST',/)
      WRITE(KOUT,408)
  408 FORMAT(2X,'  PLAYER-1   ',2X,'  PLAYER-2   ',/)
      WRITE(KOUT,430) J1,J2
      WRITE(KOUT,440)
  440 FORMAT(//,2X,'INVENTORIES ',2X,'CONSUMPTION ',2X,'NON-RES. INV',2X
     1,'  RES. INV   ',2X,'INVENT. INV ',/)
      DO 320 I = 1,NPD
  320 WRITE(KOUT,420) YT(I,1),YT(I,2),YT(I,3),YT(I,4),YT(I,5)
      WRITE(KOUT,450)
  450 FORMAT(//,2X,'  INTEREST   ',2X,'    GNP      ',/)
      DO 460 I = 1,NPD
      Y(1) = YT(I,2) + YT(I,3) + YT(I,4) + YT(I,5) + X1T(I,1)
  460 WRITE(KOUT,430) YT(I,6),Y(1)
  410 FORMAT(2X,D12.5,2X,D12.5,2X,D12.5)
  420 FORMAT(2X,D12.5,2X,D12.5,2X,D12.5,2X,D12.5,2X,D12.5)
  430 FORMAT(2X,D12.5,2X,D12.5)
  999 STOP
      END
```

FIGURE I.2.d   Main Program EXPER

```
      SUBROUTINE COOP(NY,NX1,NX2,NW,NPD,NR,
     1  KT,KP,K,GT,GP,G,G3T,G3P,YT,Y,X1T,X1,X2T,X2,YHATT1,YHATT2,
     2  YHAT1,YHAT2,YP,X1P,X2P,U1HAT,U2HAT,U1HATT,U2HATT,WT,WP,W,
     3  Y0,EIT,EI,EIP,RIBT11,RIBT22,BRBT11,BRBT22,BRBT,RBK1,RBK2,
     4  RK11,RK21,RK12,RK22,ER,ERI,BRBG,BE,RBKE,BU,BERI,A,AT,B1,B1T,
     5  B2,B2T,C,Q1,Q2,Q,R11,R21,R12,R22,R1,RI1,R2,RI2,ALPHA,IDENT,
     6  AKE,AKEA,RBKE1,RBKE2,COND,IPVT,WORK)
      INTEGER NY,NX1,NX2,NW,NPD,NR,NX11,NPD1,T,TT,IPVT(NR)
      DOUBLE PRECISION KT(NPD,NY,NY),KP(NY,NY),K(NY,NY),
     1                 GT(NPD,NY),GP(NY),G(NY),G3T(NPD,NY),G3P(NY)
      DOUBLE PRECISION YT(NPD,NY),Y(NY),X1T(NPD,NX1),X1(NX1),
     1               X2T(NPD,NX2),X2(NX2),YHATT1(NPD,NY),YHATT2(NPD,NY),
     2               YHAT1(NY),YHAT2(NY),U1HATT(NPD,NX1),U1HAT(NX1),
     3                 U2HATT(NPD,NX2),U2HAT(NX2),WT(NPD,NW),
     4                 W(NW),Y0(NY),WP(NW),YP(NY),X1P(NX1),X2P(NX2)
      DOUBLE PRECISION EIT(NPD,NY,NY),EI(NY,NY),EIP(NY,NY),
     1                 RIBT11(NX1,NY),RIBT22(NX2,NY),
     2                 BRBT11(NY,NY),BRBT22(NY,NY),BRBT(NY,NY)
      DOUBLE PRECISION RBK1(NX1,NY),RBK2(NX2,NY),
     1                 RK11(NX1,NX1),RK21(NX2,NX1),
     2                 RK12(NX1,NX2),RK22(NX2,NX2),
     3                 ER(NR,NR),ERI(NR,NR),BRBG(NY)
      DOUBLE PRECISION BE(NY,NR),RBKE(NR,NY),BU(NY),
     1                 BERI(NY,NR),COND,WORK(NR),OMALP,ALPHA,
     2                 AKE(NY,NY),AKEA(NY,NY),
     3                 RBKE1(NX1,NY),RBKE2(NX2,NY)
      DOUBLE PRECISION A(NY,NY),AT(NY,NY),B1(NY,NX1),B1T(NX1,NY),
     1                 B2(NY,NX2),B2T(NX2,NY),C(NY,NW),
     2                 Q1(NY,NY),Q2(NY,NY),Q(NY,NY),
     3                 R11(NX1,NX1),RI1(NX1,NX1),R21(NX1,NX1),
     4                 R12(NX2,NX2),R1(NX1,NX1),R2(NX2,NX2),
     5                 R22(NX2,NX2),RI2(NX2,NX2),IDENT(NR,NR)
      COMMON/INOJ/KIN,KOUT
C
C    PRECALCULATING OFTEN-USED MATRICES
C
C    DIMENSIONS
C
      NR = NX1 + NX2
      NX11 = NX1 + 1
      NPD1 = NPD + 1
C
C    SET OMALP = 1 - ALPHA
C
      OMALP = 1.D0 - ALPHA
C
C    CALCULATE IDENT   (NR*NR IDENTITY MATRIX)
C
      DO 30 I = 1,NR
      DO 20 J = 1,NR
   20 IDENT(I,J) = 0.D0
   30 IDENT(I,I) = 1.D0
C
C    CALCULATE:   R1 = ALPHA*R11 + (1-ALPHA)*R21
C                 R2 = ALPHA*R12 + (1-ALPHA)*R22
```

<u>FIGURE I.3.a</u>   Subroutine COOP

```
C
      CALL MSCALE(NX1,NX1,NX1,ALPHA,R11)
      CALL MSCALE(NX1,NX1,NX1,OMALP,R21)
      CALL MSCALE(NX2,NX2,NX2,ALPHA,R12)
      CALL MSCALE(NX2,NX2,NX2,OMALP,R22)
      CALL MADD(NX1,NX1,NX1,NX1,NX1,R11,R21,R1)
      CALL MADD(NX2,NX2,NX2,NX2,NX2,R12,R22,R2)
C
C   CALCULATE R1-INVERSE, R2-INVERSE
C
      CALL SAVE(NR,NX1,NX1,NX1,IDENT,RI1)
      CALL SAVE(NR,NX2,NX2,NX2,IDENT,RI2)
      CALL MLINEQ(NX1,NX1,NX1,NX1,R1,RI1,COND,IPVT,WORK)
      CALL MLINEQ(NX2,NX2,NX2,NX2,R2,RI2,COND,IPVT,WORK)
C
C   CALCULATE R-INVERSE * B-TRANSPOSE
C
      CALL TRNATB(NY,NX1,NY,NX1,B1,B1T)
      CALL TRNATB(NY,NX2,NY,NX2,B2,B2T)
      CALL MMUL(NX1,NX1,NX1,NY,NX1,NX1,RI1,B1T,RIBT11)
      CALL MMUL(NX2,NX2,NX2,NY,NX2,NX2,RI2,B2T,RIBT22)
C
C   CALCULATE B * R-INVERSE * B-TRANSPOSE
C
      CALL MMUL(NY,NX1,NY,NY,NY,NX1,B1,RIBT11,BRBT11)
      CALL MMUL(NY,NX2,NY,NY,NY,NX2,B2,RIBT22,BRBT22)
C
C   CALCULATE BRBT = B1*R1-INVERSE*B1-TRANSPOSE
C                  + B2*R2-INVERSE*B2-TRANSPOSE
C
      CALL MADD(NY,NY,NY,NY,NY,BRBT11,BRBT22,BRBT)
C
C   CALCULATE AT = (I+A)-TRANSPOSE
C
      CALL TRNATB(NY,NY,NY,NY,A,AT)
C
C   CALCULATE ALPHA*Q1, (1-ALPHA)*Q2, Q (THEIR SUM)
C
      CALL MSCALE(NY,NY,NY,ALPHA,Q1)
      CALL MSCALE(NY,NY,NY,OMALP,Q2)
      CALL MADD(NY,NY,NY,NY,NY,Q1,Q2,Q)
C
C   INITIALIZE RICCATI AND TRACKING EQUATIONS
C
      CALL SAVE(NY,NY,NY,NY,Q,K)
      CALL VEXT(NPD,NY,NPD,YHATT1,YHAT1)
      CALL VEXT(NPD,NY,NPD,YHATT2,YHAT2)
      CALL MMUL(NY,NY,NY,1,NY,NY,NY,Q1,YHAT1,YP)
      CALL MMUL(NY,NY,NY,1,NY,NY,NY,Q2,YHAT2,Y)
      CALL MSCALE(NY,NY,1,-1.D0,YP)
      CALL MSCALE(NY,NY,1,-1.D0,Y)
      CALL MADD(NY,NY,NY,NY,1,YP,Y,G)
      CALL MINS(NPD,NY,NY,NPD,KT,K)
      CALL VINS(NPD,NY,NPD,GT,G)
C
```

FIGURE I.3.b Subroutine COOP

```
C     SOLVE FOR RICCATI AND TRACKING TIME HISTORIES
C
      DO 500 TT = 1,NPD
      T = NPD + 1 - TT
      IF(T.EQ.NPD) GO TO 400
C
C     SAVE K,G,EI FROM LAST PERIOD
C
      CALL SAVE(NY,NY,NY,NY,K,KP)
      CALL SAVE(NY,NY,NY,1,G,GP)
      CALL SAVE(NY,NY,NY,NY,EI,EIP)
C
C     CALCULATE RICCATI K
C
      CALL MMUL(NY,NY,NY,NY,NY,NY,AT,KP,K)
      CALL MMUL(NY,NY,NY,NY,NY,NY,K,EIP,AKE)
      CALL MMUL(NY,NY,NY,NY,NY,NY,AKE,A,AKEA)
      CALL MADD(NY,NY,NY,NY,NY,Q,AKEA,K)
      CALL MINS(NPD,NY,NY,T,KT,K)
C
C     CALCULATE TRACKING G
C
      CALL MMUL(NY,NY,NY,1,NY,NY,BRBT,GP,BRBG)
      CALL MSCALE(NY,NY,1,-1.D0,BRBG)
      CALL VEXT(NPD,NX1,T+1,U1HATT,U1HAT)
      CALL VEXT(NPD,NX2,T+1,U2HATT,U2HAT)
      CALL VEXT(NPD,NW,T+1,WT,W)
      CALL MMUL(NY,NX1,NY,1,NY,NX1,B1,U1HAT,BU)
      CALL MADD(NY,NY,NY,NY,1,BRBG,BU,G3P)
      CALL MMUL(NY,NX2,NY,1,NY,NX2,B2,U2HAT,BU)
      CALL MADD(NY,NY,NY,NY,1,G3P,BU,G3P)
      CALL MMUL(NY,NW,NY,1,NY,NW,C,W,BU)
      CALL MADD(NY,NY,NY,NY,1,G3P,BU,G3P)
      CALL VINS(NPD,NY,T+1,G3T,G3P)
      CALL MMUL(NY,NY,NY,1,NY,NY,AKE,G3P,G)
      CALL VEXT(NPD,NY,T,YHATT1,YHAT1)
      CALL MMUL(NY,NY,NY,1,NY,NY,Q1,YHAT1,BU)
      CALL MSUB(NY,NY,NY,NY,1,G,BU,G)
      CALL VEXT(NPD,NY,T,YHATT2,YHAT2)
      CALL MMUL(NY,NY,NY,1,NY,NY,Q2,YHAT2,BU)
      CALL MSUB(NY,NY,NY,NY,1,G,BU,G)
      CALL MMUL(NY,NY,NY,1,NY,NY,AT,GP,BU)
      CALL MADD(NY,NY,NY,NY,1,G,BU,G)
      CALL VINS(NPD,NY,T,GT,G)
C
C     CALCULATE EI   (E-INVERSE)
C
  400 CALL MMUL(NX1,NY,NX1,NY,NX1,NY,RIBT11,K,RBK1)
      CALL MMUL(NX2,NY,NX2,NY,NX2,NY,RIBT22,K,RBK2)
      CALL MMUL(NX1,NY,NX1,NX1,NX1,NY,RBK1,B1,RK11)
      CALL MMUL(NX1,NY,NX1,NX2,NX1,NY,RBK1,B2,RK12)
      CALL MMUL(NX2,NY,NX2,NX1,NX2,NY,RBK2,B1,RK21)
      CALL MMUL(NX2,NY,NX2,NX2,NX2,NY,RBK2,B2,RK22)
      DO 420 I = 1,NX1
      DO 420 J = 1,NX1
```

FIGURE I.3.c Subroutine COOP

```
  420 ER(I,J) = RK11(I,J)
      DO 430 I = 1,NX1
      DO 430 J = NX11,NR
  430 ER(I,J) = RK12(I,J-NX1)
      DO 440 I = NX11,NR
      DO 440 J = 1,NX1
  440 ER(I,J) = RK21(I-NX1,J)
      DO 450 I = NX11,NR
      DO 450 J = NX11,NR
  450 ER(I,J) = RK22(I-NX1,J-NX1)
      DO 460 I = 1,NR
  460 ER(I,I) = 1.D0 + ER(I,I)
      CALL SAVE(NR,NR,NR,NR,IDENT,ERI)
      CALL MLINEQ(NR,NR,NR,NR,ER,ERI,COND,IPVT,WORK)
      DO 470 I = 1,NY
      DO 463 J = 1,NX1
  463 BE(I,J) = B1(I,J)
      DO 466 J = 1,NX2
  466 BE(I,J+NX1) = B2(I,J)
  470 CONTINUE
      DO 480 J = 1,NY
      DO 473 I = 1,NX1
  473 RBKE(I,J) = RBK1(I,J)
      DO 476 I = 1,NX2
  476 RBKE(I+NX1,J) = RBK2(I,J)
  480 CONTINUE
      CALL MMUL(NY,NR,NY,NR,NY,NR,BE,ERI,BERI)
      CALL MMUL(NY,NR,NY,NY,NY,NR,BERI,RBKE,EI)
      DO 485 I = 1,NY
      DO 485 J = 1,NY
  485 EI(I,J) = -1.D0*EI(I,J)
      DO 490 I = 1,NY
  490 EI(I,I) = 1.D0 + EI(I,I)
 500  CALL MINS(NPD,NY,NY,T,EIT,EI)
C
C   CALCULATE CONTROL AND STATE TRAJECTORIES
C
      DO 700 T = 1,NPD1
      TT = T-1
      IF(TT.EQ.0) GO TO 600
      CALL SAVE(NY,NY,NY,1,Y,YP)
      CALL SAVE(NX1,NX1,NX1,1,X1,X1P)
      CALL SAVE(NX2,NX2,NX2,1,X2,X2P)
      CALL VEXT(NPD,NW,TT,WT,WP)
      CALL MMUL(NY,NY,NY,1,NY,NY,A,YP,Y)
      CALL MMUL(NY,NX1,NY,1,NY,NX1,B1,X1P,YP)
      CALL MADD(NY,NY,NY,NY,1,Y,YP,Y)
      CALL MMUL(NY,NX2,NY,1,NY,NX2,B2,X2P,YP)
      CALL MADD(NY,NY,NY,NY,1,Y,YP,Y)
      CALL MMUL(NY,NW,NY,1,NY,NW,C,WP,YP)
      CALL MADD(NY,NY,NY,NY,1,Y,YP,Y)
      CALL VINS(NPD,NY,TT,YT,Y)
      IF(T.EQ.NPD1) GO TO 700
      GO TO 601
  600 CALL SAVE(NY,NY,NY,1,Y0,Y)
```

FIGURE I.3.d   Subroutine COOP

```
      CALL VEXT(NPD,NY,1,GT,GP)
      CALL VEXT(NPD,NX1,1,U1HATT,U1HAT)
      CALL VEXT(NPD,NX2,1,U2HATT,U2HAT)
      CALL VEXT(NPD,NW,1,WT,W)
      CALL MMUL(NY,NY,NY,1,NY,NY,BRBT,GP,BRBG)
      CALL MSCALE(NY,NY,1,-1.D0,BRBG)
      CALL MMUL(NY,NX1,NY,1,NY,NX1,B1,U1HAT,BU)
      CALL MADD(NY,NY,NY,NY,1,BRBG,BU,G3P)
      CALL MMUL(NY,NX2,NY,1,NY,NX1,B2,U2HAT,BU)
      CALL MADD(NY,NY,NY,NY,1,G3P,BU,G3P)
      CALL MMUL(NY,NW,NY,1,NY,NW,C,W,BU)
      CALL MADD(NY,NY,NY,NY,1,G3P,BU,G3P)
      CALL VINS(NPD,NY,1,G3T,G3P)
  601 CALL VEXT(NPD,NY,T,G3T,G3P)
      CALL MMUL(NY,NY,NY,1,NY,NY,A,Y,YP)
      CALL MADD(NY,NY,NY,NY,1,G3P,YP,G3P)
      CALL MEXT(NPD,NY,NY,T,KT,KP)
      CALL MEXT(NPD,NY,NY,T,EIT,EIP)
      CALL MMUL(NX1,NY,NX1,NY,NX1,NY,RIBT11,KP,RBK1)
      CALL MMUL(NX2,NY,NX2,NY,NX2,NY,RIBT22,KP,RBK2)
      CALL MMUL(NX1,NY,NX1,NY,NX1,NY,RBK1,EIP,RBKE1)
      CALL MMUL(NX2,NY,NX2,NY,NX2,NY,RBK2,EIP,RBKE2)
      CALL MMUL(NX1,NY,NX1,1,NX1,NY,RBKE1,G3P,X1)
      CALL MMUL(NX2,NY,NX2,1,NX2,NY,RBKE2,G3P,X2)
      CALL MSCALE(NX1,NX1,1,-1.D0,X1)
      CALL MSCALE(NX2,NX2,1,-1.D0,X2)
      CALL VEXT(NPD,NY,T,GT,G)
      CALL MMUL(NX1,NY,NX1,1,NX1,NY,RIBT11,G,X1P)
      CALL MMUL(NX2,NY,NX2,1,NX2,NY,RIBT22,G,X2P)
      CALL MSUB(NX1,NX1,NX1,NX1,1,X1,X1P,X1)
      CALL MSUB(NX2,NX2,NX2,NX2,1,X2,X2P,X2)
      CALL VEXT(NPD,NX1,T,U1HATT,U1HAT)
      CALL VEXT(NPD,NX2,T,U2HATT,U2HAT)
      CALL MADD(NX1,NX1,NX1,NX1,1,X1,U1HAT,X1)
      CALL MADD(NX2,NX2,NX2,NX2,1,X2,U2HAT,X2)
      CALL VINS(NPD,NX1,T,X1T,X1)
      CALL VINS(NPD,NX2,T,X2T,X2)
  700 CONTINUE
      IF(KOUT.EQ.6) GO TO 999
      CALL MATIO(NY,NY,NY,A,3)
      CALL MATIO(NY,NY,NY,AT,3)
      CALL MATIO(NY,NY,NX1,B1,3)
      CALL MATIO(NX1,NX1,NY,B1T,3)
      CALL MATIO(NY,NY,NX2,B2,3)
      CALL MATIO(NX2,NX2,NY,B2T,3)
      CALL MATIO(NY,NY,NW,C,3)
      CALL MATIO(NY,NY,NY,Q1,3)
      CALL MATIO(NY,NY,NY,Q2,3)
      CALL MATIO(NY,NY,NY,Q,3)
      CALL MATIO(NX1,NX1,NX1,R1,3)
      CALL MATIO(NX1,NX1,NX1,RI1,3)
      CALL MATIO(NX2,NX2,NX2,R2,3)
      CALL MATIO(NX2,NX2,NX2,RI2,3)
      CALL MATIO(NR,NR,NR,IDENT,3)
  999 RETURN
```

FIGURE I.3.e Subroutine COOP

```
      END                                                              00002760
```

FIGURE I.3.f Subroutine COOP

```
      SUBROUTINE NASHO(NY,NX1,NX2,NW,NPD,NR,NX11,NPD1,T,TT,
     1  K1T,K1P,K1,K2T,K2P,K2,G2T,G2P,G2,G1T,G1P,G1,
     2  G3T,G3P,YT,Y,X1T,X1,X2T,X2,YHATT1,YHATT2,YHAT1,YHAT2,YP,X1P,X2P,
     3  U1HAT,U2HAT,U1HATT,U2HATT,WT,WP,W,YO,EIT,EI,EIP,
     4  RIBT11,RIBT21,RIBT12,RIBT22,BRBT11,BRBT21,RBKE1,
     5  BRBT12,BRBT22,RBK1,RBK2,RK11,RK21,RK12,RK22,RBKE2,
     6  ER,ERI,BRBG11,BRBG22,BR,RBKE,BU,BERI,AKE1,AKE2,
     7  AKEA1,AKEA2,A,AT,B1,B1T,B2,B2T,C,Q1,Q2,R11,RI11,
     8  R21,R12,R22,RI22,IDENT,COND,IPVT,WORK)
      INTEGER NY,NX1,NX2,NW,NPD,NR,NX11,NPD1,T,TT,IPVT(NR)
      DOUBLE PRECISION K1T(NPD,NY,NY),K1P(NY,NY),K1(NY,NY),
     1                 K2T(NPD,NY,NY),K2P(NY,NY),K2(NY,NY),
     2                 G1T(NPD,NY),G1P(NY),G1(NY),
     3                 G2T(NPD,NY),G2P(NY),G2(NY),
     4                 G3T(NPD,NY),G3P(NY)
      DOUBLE PRECISION YT(NPD,NY),Y(NY),X1T(NPD,NX1),X1(NX1),
     1               X2T(NPD,NX2),X2(NX2),YHATT1(NPD,NY),YHATT2(NPD,NY),
     2               YHAT1(NY),YHAT2(NY),U1HATT(NPD,NX1),U1HAT(NX1),
     3                 U2HATT(NPD,NX2),U2HAT(NX2),WT(NPD,NW),
     4                 W(NW),YO(NY),WP(NW),YP(NY),X1P(NX1),X2P(NX2)
      DOUBLE PRECISION EIT(NPD,NY,NY),EI(NY,NY),EIP(NY,NY),
     1                 RIBT11(NX1,NY),RIBT21(NX1,NY),
     2                 RIBT12(NX2,NY),RIBT22(NX2,NY),
     3                 BRBT11(NY,NY),BRBT21(NY,NY),
     4                 BRBT12(NY,NY),BRBT22(NY,NY)
      DOUBLE PRECISION RBK1(NX1,NY),RBK2(NX2,NY),
     1                 RK11(NX1,NX1),RK21(NX2,NX1),
     2                 RK12(NX1,NX2),RK22(NX2,NX2),
     3                 ER(NR,NR),ERI(NR,NR),RBKE1(NX1,NY),RBKE2(NX2,NY),
     4                 BRBG11(NY),BRBG22(NY)
      DOUBLE PRECISION BR(NY,NR),RBKE(NR,NY),BU(NY),
     1                 BERI(NY,NR),AKE1(NY,NY),AKE2(NY,NY),
     2                 AKEA1(NY,NY),AKEA2(NY,NY),COND,WORK(NR)
      DOUBLE PRECISION A(NY,NY),AT(NY,NY),B1(NY,NX1),B1T(NX1,NY),
     1                 B2(NY,NX2),B2T(NX2,NY),C(NY,NW),
     2                 Q1(NY,NY),Q2(NY,NY),
     3                 R11(NX1,NX1),RI11(NX1,NX1),R21(NX1,NX1),
     4                 R12(NX2,NX2),
     5                 R22(NX2,NX2),RI22(NX2,NX2),IDENT(NR,NR)
      COMMON/INOU/KIN,KOUT
C
C   PRECALCULATING OFTEN-USED MATRICES
C
C   DIMENSIONS
C
      NR = NX1 + NX2
      NX11 = NX1 + 1
      NPD1 = NPD + 1
C
C   CALCULATE IDENT  (NR*NR IDENTITY MATRIX)
C
      DO 30 I = 1,NR
      DO 20 J = 1,NR
   20 IDENT(I,J) = 0.D0
   30 IDENT(I,I) = 1.D0
```

FIGURE I.4.a Subroutine NASHO

```
C
C     CALCULATE R-INVERSE  (R IS DESTROYED)
C
        CALL SAVE(NR,NX1,NX1,NX1,IDENT,RI11)
        CALL SAVE(NR,NX2,NX2,NX2,IDENT,RI22)
        CALL MLINEQ(NX1,NX1,NX1,NX1,R11,RI11,COND,IPVT,WORK)
        CALL MLINEQ(NX2,NX2,NX2,NX2,R22,RI22,COND,IPVT,WORK)
C
C     CALCULATE R-INVERSE * B-TRANSPOSE
C
        CALL TRNATB(NY,NX1,NY,NX1,B1,B1T)
        CALL TRNATB(NY,NX2,NY,NX2,B2,B2T)
        CALL MMUL(NX1,NX1,NX1,NY,NX1,NX1,RI11,B1T,RIBT11)
        CALL MMUL(NX2,NX2,NX2,NY,NX2,NX2,RI22,B2T,RIBT22)
C
C     CALCULATE B * R-INVERSE * B-TRANSPOSE
C
        CALL MMUL(NY,NX1,NY,NY,NY,NX1,B1,RIBT11,BRBT11)
        CALL MMUL(NY,NX2,NY,NY,NY,NX2,B2,RIBT22,BRBT22)
C
C     CALCULATE AT = (I+A)-TRANSPOSE
C
        CALL TRNATB(NY,NY,NY,NY,A,AT)
C
C     INITIALIZE RICCATI AND TRACKING EQUATIONS
C
        CALL SAVE(NY,NY,NY,NY,Q1,K1)
        CALL SAVE(NY,NY,NY,NY,Q2,K2)
        CALL VEXT(NPD,NY,NPD,YHATT1,YHAT1)
        CALL VEXT(NPD,NY,NPD,YHATT2,YHAT2)
        CALL MMUL(NY,NY,NY,1,NY,NY,Q1,YHAT1,G1)
        CALL MMUL(NY,NY,NY,1,NY,NY,Q2,YHAT2,G2)
        CALL MSCALE(NY,NY,1,-1.D0,G1)
        CALL MSCALE(NY,NY,1,-1.D0,G2)
        CALL MINS(NPD,NY,NY,NPD,K1T,K1)
        CALL MINS(NPD,NY,NY,NPD,K2T,K2)
        CALL VINS(NPD,NY,NPD,G1T,G1)
        CALL VINS(NPD,NY,NPD,G2T,G2)
C
C     SOLVE FOR RICCATI AND TRACKING TIME HISTORIES
C
        DO 500 TT = 1,NPD
        T = NPD + 1 - TT
        IF(T.EQ.NPD) GO TO 400
C
C     SAVE K1,K2,G1,G2,EI FROM LAST PERIOD
C
        CALL SAVE(NY,NY,NY,NY,K1,K1P)
        CALL SAVE(NY,NY,NY,NY,K2,K2P)
        CALL SAVE(NY,NY,NY,1,G1,G1P)
        CALL SAVE(NY,NY,NY,1,G2,G2P)
        CALL SAVE(NY,NY,NY,NY,EI,EIP)
C
C     CALCULATE RICCATI K
C
```

FIGURE I.4.b Subroutine NASHO

```
      CALL MMUL(NY,NY,NY,NY,NY,NY,AT,K1P,K1)
      CALL MMUL(NY,NY,NY,NY,NY,NY,AT,K2P,K2)
      CALL MMUL(NY,NY,NY,NY,NY,NY,K1,EIP,AKE1)
      CALL MMUL(NY,NY,NY,NY,NY,NY,K2,EIP,AKE2)
      CALL MMUL(NY,NY,NY,NY,NY,NY,AKE1,A,AKEA1)
      CALL MMUL(NY,NY,NY,NY,NY,NY,AKE2,A,AKEA2)
      CALL MADD(NY,NY,NY,NY,NY,Q1,AKEA1,K1)
      CALL MADD(NY,NY,NY,NY,NY,Q2,AKEA2,K2)
      CALL MINS(NPD,NY,NY,T,K1T,K1)
      CALL MINS(NPD,NY,NY,T,K2T,K2)
C
C   CALCULATE TRACKING G
C
      CALL MMUL(NY,NY,NY,1,NY,NY,BRBT11,G1P,BRBG11)
      CALL MMUL(NY,NY,NY,1,NY,NY,BRBT22,G2P,BRBG22)
      CALL MADD(NY,NY,NY,NY,1,BRBG11,BRBG22,G3P)
      CALL MSCALE(NY,NY,1,-1.D0,G3P)
      CALL VEXT(NPD,NX1,T+1,U1HATT,U1HAT)
      CALL VEXT(NPD,NX2,T+1,U2HATT,U2HAT)
      CALL VEXT(NPD,NW,T+1,WT,W)
      CALL MMUL(NY,NX1,NY,1,NY,NX1,B1,U1HAT,BU)
      CALL MADD(NY,NY,NY,NY,1,G3P,BU,G3P)
      CALL MMUL(NY,NX2,NY,1,NY,NX2,B2,U2HAT,BU)
      CALL MADD(NY,NY,NY,NY,1,G3P,BU,G3P)
      CALL MMUL(NY,NW,NY,1,NY,NW,C,W,BU)
      CALL MADD(NY,NY,NY,NY,1,G3P,BU,G3P)
      CALL MMUL(NY,NY,NY,1,NY,NY,AKE1,G3P,G1)
      CALL MMUL(NY,NY,NY,1,NY,NY,AKE2,G3P,G2)
      CALL VINS(NPD,NY,T+1,G3T,G3P)
      CALL VEXT(NPD,NY,T,YHATT1,YHAT1)
      CALL VEXT(NPD,NY,T,YHATT2,YHAT2)
      CALL MMUL(NY,NY,NY,1,NY,NY,Q1,YHAT1,BU)
      CALL MSUB(NY,NY,NY,NY,1,G1,BU,G1)
      CALL MMUL(NY,NY,NY,1,NY,NY,Q2,YHAT2,BU)
      CALL MSUB(NY,NY,NY,NY,1,G2,BU,G2)
      CALL MMUL(NY,NY,NY,1,NY,NY,AT,G1P,BU)
      CALL MADD(NY,NY,NY,NY,1,G1,BU,G1)
      CALL MMUL(NY,NY,NY,1,NY,NY,AT,G2P,BU)
      CALL MADD(NY,NY,NY,NY,1,G2,BU,G2)
      CALL VINS(NPD,NY,T,G1T,G1)
      CALL VINS(NPD,NY,T,G2T,G2)
C
C   CALCULATE EI  (E-INVERSE)
C
  400 CALL MMUL(NX1,NY,NX1,NY,NX1,NY,RIBT11,K1,RBK1)
      CALL MMUL(NX2,NY,NX2,NY,NX2,NY,RIBT22,K2,RBK2)
      CALL MMUL(NX1,NY,NX1,NX1,NX1,NY,RBK1,B1,RK11)
      CALL MMUL(NX1,NY,NX1,NX2,NX1,NY,RBK1,B2,RK12)
      CALL MMUL(NX2,NY,NX2,NX1,NX2,NY,RBK2,B1,RK21)
      CALL MMUL(NX2,NY,NX2,NX2,NX2,NY,RBK2,B2,RK22)
      DO 420 I = 1,NX1
      DO 420 J = 1,NX1
  420 ER(I,J) = RK11(I,J)
      DO 430 I = 1,NX1
      DO 430 J = NX11,NR
```

FIGURE I.4.c   Subroutine NASHO

```
  430 ER(I,J) = RK12(I,J-NX1)
      DO 440 I = NX11,NR
      DO 440 J = 1,NX1
  440 ER(I,J) = RK21(I-NX1,J)
      DO 450 I = NX11,NR
      DO 450 J = NX11,NR
  450 ER(I,J) = RK22(I-NX1,J-NX1)
      DO 460 I = 1,NR
  460 ER(I,I) = 1.D0 + ER(I,I)
      CALL SAVE(NR,NR,NR,NR,IDENT,ERI)
      CALL MLINEQ(NR,NR,NR,NR,ER,ERI,COND,IPVT,WORK)
      DO 470 I = 1,NY
      DO 463 J = 1,NX1
  463 BE(I,J) = B1(I,J)
      DO 466 J = 1,NX2
  466 BE(I,J+NX1) = B2(I,J)
  470 CONTINUE
      DO 480 J = 1,NY
      DO 473 I = 1,NX1
  473 RBKE(I,J) = RBK1(I,J)
      DO 476 I = 1,NX2
  476 RBKE(I+NX1,J) = RBK2(I,J)
  480 CONTINUE
      CALL MMUL(NY,NR,NY,NR,NY,NR,BE,ERI,BERI)
      CALL MMUL(NY,NR,NY,NY,NY,NR,BERI,RBKE,EI)
      DO 485 I = 1,NY
      DO 485 J = 1,NY
  485 EI(I,J) = -1.D0*EI(I,J)
      DO 490 I = 1,NY
  490 EI(I,I) = 1.D0 + EI(I,I)
  500 CALL MINS(NPD,NY,NY,T,EIT,EI)
C
C   CALCULATE CONTROL AND STATE TRAJECTORIES
C
      DO 700 T = 1,NPD1
      TT = T-1
      IF(TT.EQ.0) GO TO 600
      CALL SAVE(NY,NY,NY,1,Y,YP)
      CALL SAVE(NX1,NX1,NX1,1,X1,X1P)
      CALL SAVE(NX2,NX2,NX2,1,X2,X2P)
      CALL VEXT(NPD,NW,TT,WT,WP)
      CALL MMUL(NY,NY,NY,1,NY,NY,A,YP,Y)
      CALL MMUL(NY,NX1,NY,1,NY,NX1,B1,X1P,YP)
      CALL MADD(NY,NY,NY,NY,1,Y,YP,Y)
      CALL MMUL(NY,NX2,NY,1,NY,NX2,B2,X2P,YP)
      CALL MADD(NY,NY,NY,NY,1,Y,YP,Y)
      CALL MMUL(NY,NW,NY,1,NY,NW,C,WP,YP)
      CALL MADD(NY,NY,NY,NY,1,Y,YP,Y)
      CALL VINS(NPD,NY,TT,YT,Y)
      IF(T.EQ.NPD1) GO TO 700
      GO TO 601
  600 CALL SAVE(NY,NY,NY,1,Y0,Y)
      CALL VEXT(NPD,NY,1,G1T,G1P)
      CALL VEXT(NPD,NY,1,G2T,G2P)
      CALL VEXT(NPD,NX1,1,U1HATT,U1HAT)
```

FIGURE I.4.d Subroutine NASHO

```
      CALL VEXT(NPD,NX2,1,U2HATT,U2HAT)
      CALL VEXT(NPD,NW,1,WT,W)
      CALL MMUL(NY,NY,NY,1,NY,NY,BRBT11,G1P,BRBG11)
      CALL MMUL(NY,NY,NY,1,NY,NY,BRBT22,G2P,BRBG22)
      CALL MADD(NY,NY,NY,NY,1,BRBG11,BRBG22,G3P)
      CALL MSCALE(NY,NY,1,-1.D0,G3P)
      CALL MMUL(NY,NX1,NY,1,NY,NX1,B1,U1HAT,BU)
      CALL MADD(NY,NY,NY,NY,1,G3P,BU,G3P)
      CALL MMUL(NY,NX2,NY,1,NY,NX1,B2,U2HAT,BU)
      CALL MADD(NY,NY,NY,NY,1,G3P,BU,G3P)
      CALL MMUL(NY,NW,NY,1,NY,NW,C,W,BU)
      CALL MADD(NY,NY,NY,NY,1,G3P,BU,G3P)
      CALL VINS(NPD,NY,1,G3T,G3P)
  601 CALL VEXT(NPD,NY,T,G3T,G3P)
      CALL MMUL(NY,NY,NY,1,NY,NY,A,Y,YP)
      CALL MADD(NY,NY,NY,NY,1,G3P,YP,G3P)
      CALL MEXT(NPD,NY,NY,T,K1T,K1P)
      CALL MEXT(NPD,NY,NY,T,K2T,K2P)
      CALL MEXT(NPD,NY,NY,T,EIT,EIP)
      CALL MMUL(NX1,NY,NX1,NY,NX1,NY,RIBT11,K1P,RBK1)
      CALL MMUL(NX2,NY,NX2,NY,NX2,NY,RIBT22,K2P,RBK2)
      CALL MMUL(NX1,NY,NX1,NY,NX1,NY,RBK1,EIP,RBKE1)
      CALL MMUL(NX2,NY,NX2,NY,NX2,NY,RBK2,EIP,RBKE2)
      CALL MMUL(NX1,NY,NX1,1,NX1,NY,RBKP1,G3P,X1)
      CALL MMUL(NX2,NY,NX2,1,NX2,NY,RBKP2,G3P,X2)
      CALL MSCALE(NX1,NX1,1,-1.D0,X1)
      CALL MSCALE(NX2,NX2,1,-1.D0,X2)
      CALL VEXT(NPD,NY,T,G1T,G1)
      CALL VEXT(NPD,NY,T,G2T,G2)
      CALL MMUL(NX1,NY,NX1,1,NX1,NY,RIBT11,G1,X1P)
      CALL MMUL(NX2,NY,NX2,1,NX2,NY,RIBT22,G2,X2P)
      CALL MSUB(NX1,NX1,NX1,NX1,1,X1,X1P,X1)
      CALL MSUB(NX2,NX2,NX2,NX2,1,X2,X2P,X2)
      CALL VEXT(NPD,NX1,T,U1HATT,U1HAT)
      CALL VEXT(NPD,NX2,T,U2HATT,U2HAT)
      CALL MADD(NX1,NX1,NX1,NX1,1,X1,U1HAT,X1)
      CALL MADD(NX2,NX2,NX2,NX2,1,X2,U2HAT,X2)
      CALL VINS(NPD,NX1,T,X1T,X1)
      CALL VINS(NPD,NX2,T,X2T,X2)
  700 CONTINUE
      IF(KOUT.EQ.6) GO TO 999
      CALL MATIO(NY,NY,NY,A,3)
      CALL MATIO(NY,NY,NY,AT,3)
      CALL MATIO(NY,NY,NX1,B1,3)
      CALL MATIO(NX1,NX1,NY,B1T,3)
      CALL MATIO(NY,NY,NX2,B2,3)
      CALL MATIO(NX2,NX2,NY,B2T,3)
      CALL MATIO(NY,NY,NW,C,3)
      CALL MATIO(NY,NY,NY,Q1,3)
      CALL MATIO(NY,NY,NY,Q2,3)
      CALL MATIO(NX1,NX1,NX1,R11,3)
      CALL MATIO(NX1,NX1,NX1,RI11,3)
      CALL MATIO(NX1,NX1,NX1,R21,3)
      CALL MATIO(NX2,NX2,NX2,R12,3)
      CALL MATIO(NX2,NX2,NX2,R22,3)
```

FIGURE I.4.e   Subroutine NASHO

```
      CALL MATIO(NX2,NX2,NX2,RI22,3)                                    NAS02760
      CALL MATIO(NR,NR,NR,IDENT,3)                                      NAS02770
  999 RETURN                                                            NAS02780
      END                                                               NAS02790
```

FIGURE I.4.f   Subroutine NASHO

```
      SUBROUTINE NASHC(NY,NX1,NX2,NW,NPD,NR,NX11,NPD1,T,TT,
     1  K1T,K1P,K1,K2T,K2P,K2,G2T,G2P,G2,G1T,G1P,G1,
     2  G3T,G3P,YT,Y,X1T,X1,X2T,X2,YHATT1,YHATT2,YHAT1,YHAT2,YP,X1P,X2P,
     3  U1HAT,U2HAT,U1HATT,U2HATT,WT,WP,W,Y0,EIT,EI,EIP,
     4  RIBT11,RIBT21,RIBT12,RIBT22,BRBT11,BRBT21,RBKE1,
     5  BRBT12,BRBT22,RBK1,RBK2,RK11,RK21,RK12,RK22,RBKE2,
     6  ER,ERI,BRBG11,BRBG22,BE,RBKE,BU,BERI,AKE1,AKE2,
     7  AKEA1,AKEA2,A,AT,B1,B1T,B2,B2T,C,Q1,Q2,R11,RI11,
     8  R21,R12,R22,RI22,BRI1,BRI2,RRBT21,RRBT12,RRBG1,RRBG2,
     9  B1G2,B2G1,G1A,G2A,ET,K1A,K2A,ETK1,ETK2,EKBR1,EKBR2,
     A  RRBK1,RRBK2,B1K2,B2K1,IDENT,COND,IPVT,WORK)
      INTEGER NY,NX1,NX2,NW,NPD,NR,NX11,NPD1,T,TT,IPVT(NR)
      DOUBLE PRECISION K1T(NPD,NY,NY),K1P(NY,NY),K1(NY,NY),
     1                 K2T(NPD,NY,NY),K2P(NY,NY),K2(NY,NY),
     2                 G1T(NPD,NY),G1P(NY),G1(NY),
     3                 G2T(NPD,NY),G2P(NY),G2(NY),
     4                 G3T(NPD,NY),G3P(NY)
      DOUBLE PRECISION YT(NPD,NY),Y(NY),X1T(NPD,NX1),X1(NX1),
     1               X2T(NPD,NX2),X2(NX2),YHATT1(NPD,NY),YHATT2(NPD,NY),
     2               YHAT1(NY),YHAT2(NY),U1HATT(NPD,NX1),U1HAT(NX1),
     3                 U2HATT(NPD,NX2),U2HAT(NX2),WT(NPD,NW),
     4                 W(NW),Y0(NY),WP(NW),YP(NY),X1P(NX1),X2P(NX2)
      DOUBLE PRECISION EIT(NPD,NY,NY),EI(NY,NY),EIP(NY,NY),
     1                 RIBT11(NX1,NY),RIBT21(NX1,NY),
     2                 RIBT12(NX2,NY),RIBT22(NX2,NY),
     3                 BRBT11(NY,NY),BRBT21(NY,NY),
     4                 BRBT12(NY,NY),BRBT22(NY,NY)
      DOUBLE PRECISION RBK1(NX1,NY),RBK2(NX2,NY),
     1                 RK11(NX1,NX1),RK21(NX2,NX1),
     2                 RK12(NX1,NX2),RK22(NX2,NX2),
     3                 ER(NR,NR),ERI(NR,NR),RBKE1(NX1,NY),RBKE2(NX2,NY),
     4                 BRBG11(NY),BRBG22(NY)
      DOUBLE PRECISION BE(NY,NR),RBKE(NR,NY),BU(NY),
     1                 BERI(NY,NR),AKE1(NY,NY),AKE2(NY,NY),
     2                 AKEA1(NY,NY),AKEA2(NY,NY),COND,WORK(NR)
      DOUBLE PRECISION A(NY,NY),AT(NY,NY),B1(NY,NX1),B1T(NX1,NY),
     1                 B2(NY,NX2),B2T(NX2,NY),C(NY,NW),
     2                 Q1(NY,NY),Q2(NY,NY),
     3                 R11(NX1,NX1),RI11(NX1,NX1),R21(NX1,NX1),
     4                 R12(NX2,NX2),R22(NX2,NX2),RI22(NX2,NX2),
     5                 BRI1(NY,NX1),BRI2(NY,NX2),RRBT21(NX1,NY),
     6                 RRBT12(NX2,NY),RRBG1(NX1),RRBG2(NX2),B1G2(NX1),
     7                 B2G1(NX2),G1A(NY),G2A(NY),ET(NY,NY),K1A(NY,NY),
     8                 K2A(NY,NY),ETK1(NY,NY),ETK2(NY,NY),EKBR1(NY,NX1),
     9                 EKBR2(NY,NX2),RRBK1(NX1,NY),RRBK2(NX2,NY),
     A                 B1K2(NX1,NY),B2K1(NX2,NY),IDENT(NR,NR)
      COMMON/INOU/KIN,KOUT
C
C    PRECALCULATING OFTEN-USED MATRICES
C
C    DIMENSIONS
C
       NR = NX1 + NX2
       NX11 = NX1 + 1
       NPD1 = NPD + 1
```

FIGURE I.5.a   Subroutine NASHC

```
C
C   CALCULATE IDENT   (NR*NR IDENTITY MATRIX)
C
      DO 30 I = 1,NR
      DO 20 J = 1,NR
   20 IDENT(I,J) = 0.D0
   30 IDENT(I,I) = 1.D0
C
C   CALCULATE R-INVERSE   (R IS DESTROYED)
C
      CALL SAVE(NR,NX1,NX1,NX1,IDENT,RI11)
      CALL SAVE(NR,NX2,NX2,NX2,IDENT,RI22)
      CALL MLINEQ(NX1,NX1,NX1,NX1,R11,RI11,COND,IPVT,WORK)
      CALL MLINEQ(NX2,NX2,NX2,NX2,R22,RI22,COND,IPVT,WORK)
C
C   CALCULATE R-INVERSE * B-TRANSPOSE
C
      CALL TRNATB(NY,NX1,NY,NX1,B1,B1T)
      CALL TRNATB(NY,NX2,NY,NX2,B2,B2T)
      CALL MMUL(NX1,NX1,NX1,NY,NX1,NX1,RI11,B1T,RIBT11)
      CALL MMUL(NX2,NX2,NX2,NY,NX2,NX2,RI22,B2T,RIBT22)
C
C   CALCULATE B * R-INVERSE * B-TRANSPOSE
C
      CALL MMUL(NY,NX1,NY,NY,NY,NX1,B1,RIBT11,BRBT11)
      CALL MMUL(NY,NX2,NY,NY,NY,NX2,B2,RIBT22,BRBT22)
C
C   CALCULATE B * R-INVERSE
C
      CALL MMUL(NY,NX1,NY,NX1,NY,NX1,B1,RI11,BRI1)
      CALL MMUL(NY,NX2,NY,NX2,NY,NX2,B2,RI22,BRI2)
C
C   CALCULATE R-IJ * R-JJ-INVERSE * B-J-TRANSPOSE
C
      CALL MMUL(NX1,NX1,NX1,NY,NX1,NX1,R21,RIBT11,RRBT21)
      CALL MMUL(NX2,NX2,NX2,NY,NX2,NX2,R12,RIBT22,RRBT12)
C
C   CALCULATE AT = (I+A)-TRANSPOSE
C
      CALL TRNATB(NY,NY,NY,NY,A,AT)
C
C   INITIALIZE RICCATI AND TRACKING EQUATIONS
C
      CALL SAVE(NY,NY,NY,NY,Q1,K1)
      CALL SAVE(NY,NY,NY,NY,Q2,K2)
      CALL VEXT(NPD,NY,NPD,YHATT1,YHAT1)
      CALL VEXT(NPD,NY,NPD,YHATT2,YHAT2)
      CALL MMUL(NY,NY,NY,1,NY,NY,Q1,YHAT1,G1)
      CALL MMUL(NY,NY,NY,1,NY,NY,Q2,YHAT2,G2)
      CALL MSCALE(NY,NY,1,-1.D0,G1)
      CALL MSCALE(NY,NY,1,-1.D0,G2)
      CALL MINS(NPD,NY,NY,NPD,K1T,K1)
      CALL MINS(NPD,NY,NY,NPD,K2T,K2)
      CALL VINS(NPD,NY,NPD,G1T,G1)
      CALL VINS(NPD,NY,NPD,G2T,G2)
```

FIGURE I.5.b   Subroutine NASHC

```
C
C     SOLVE FOR RICCATI AND TRACKING TIME HISTORIES
C
        DO 500 TT = 1,NPD
        T = NPD + 1 - TT
        IF(T.EQ.NPD) GO TO 400
C
C     SAVE K1,K2,G1,G2,EI FROM LAST PERIOD
C
        CALL SAVE(NY,NY,NY,NY,K1,K1P)
        CALL SAVE(NY,NY,NY,NY,K2,K2P)
        CALL SAVE(NY,NY,NY,1,G1,G1P)
        CALL SAVE(NY,NY,NY,1,G2,G2P)
        CALL SAVE(NY,NY,NY,NY,EI,EIP)
C
C     CALCULATE RICCATI K
C
        CALL TRNATB(NY,NY,NY,NY,EIP,ET)
        CALL MMUL(NY,NY,NY,NY,NY,NY,ET,K1P,ETK1)
        CALL MMUL(NY,NY,NY,NY,NY,NY,ET,K2P,ETK2)
        CALL MMUL(NY,NY,NY,NX1,NY,NY,ETK1,BRI1,EKBR1)
        CALL MMUL(NY,NY,NY,NX2,NY,NY,ETK2,BRI2,EKBR2)
        CALL MMUL(NX1,NY,NX1,NY,NX1,NY,RRBT21,K1P,RRBK1)
        CALL MMUL(NX2,NY,NX2,NY,NX2,NY,RRBT12,K2P,RRBK2)
        CALL MMUL(NX1,NY,NX1,NY,NX1,NY,B1T,K2P,B1K2)
        CALL MMUL(NX2,NY,NX2,NY,NX2,NY,B2T,K1P,B2K1)
        CALL MSUB(NX1,NX1,NX1,NX1,NY,RRBK1,B1K2,RRBK1)
        CALL MSUB(NX2,NX2,NX2,NX2,NY,RRBK2,B2K1,RRBK2)
        CALL MMUL(NY,NX1,NY,NY,NY,NX1,EKBR1,RRBK1,K2A)
        CALL MMUL(NY,NX2,NY,NY,NY,NX2,EKBR2,RRBK2,K1A)
        CALL MADD(NY,NY,NY,NY,NY,K1A,K1P,K1A)
        CALL MADD(NY,NY,NY,NY,NY,K2A,K2P,K2A)
        CALL MMUL(NY,NY,NY,NY,NY,NY,AT,K1A,K1)
        CALL MMUL(NY,NY,NY,NY,NY,NY,AT,K2A,K2)
        CALL MMUL(NY,NY,NY,NY,NY,NY,K1,EIP,AKE1)
        CALL MMUL(NY,NY,NY,NY,NY,NY,K2,EIP,AKE2)
        CALL MMUL(NY,NY,NY,NY,NY,NY,AKE1,A,AKEA1)
        CALL MMUL(NY,NY,NY,NY,NY,NY,AKE2,A,AKEA2)
        CALL MADD(NY,NY,NY,NY,NY,Q1,AKEA1,K1)
        CALL MADD(NY,NY,NY,NY,NY,Q2,AKEA2,K2)
        CALL MINS(NPD,NY,NY,T,K1T,K1)
        CALL MINS(NPD,NY,NY,T,K2T,K2)
C
C     CALCULATE TRACKING G
C
        CALL MMUL(NY,NY,NY,1,NY,NY,BRBT11,G1P,BRBG11)
        CALL MMUL(NY,NY,NY,1,NY,NY,BRBT22,G2P,BRBG22)
        CALL MADD(NY,NY,NY,NY,1,BRBG11,BRBG22,G3P)
        CALL MSCALE(NY,NY,1,-1.D0,G3P)
        CALL VEXT(NPD,NX1,T+1,U1HATT,U1HAT)
        CALL VEXT(NPD,NX2,T+1,U2HATT,U2HAT)
        CALL VEXT(NPD,NW,T+1,WT,W)
        CALL MMUL(NY,NX1,NY,1,NY,NX1,B1,U1HAT,BU)
        CALL MADD(NY,NY,NY,NY,1,G3P,BU,G3P)
        CALL MMUL(NY,NX2,NY,1,NY,NX2,B2,U2HAT,BU)
```

FIGURE I.5.c   Subroutine NASHC

```
      CALL MADD(NY,NY,NY,NY,1,G3P,BU,G3P)
      CALL MMUL(NY,NW,NY,1,NY,NW,C,W,BU)
      CALL MADD(NY,NY,NY,NY,1,G3P,BU,G3P)
      CALL MMUL(NY,NY,NY,1,NY,NY,AKE1,G3P,G1)
      CALL MMUL(NY,NY,NY,1,NY,NY,AKE2,G3P,G2)
      CALL VINS(NPD,NY,T+1,G3T,G3P)
      CALL VEXT(NPD,NY,T,YHATT1,YHAT1)
      CALL VEXT(NPD,NY,T,YHATT2,YHAT2)
      CALL MMUL(NY,NY,NY,1,NY,NY,Q1,YHAT1,BU)
      CALL MSUB(NY,NY,NY,NY,1,G1,BU,G1)
      CALL MMUL(NY,NY,NY,1,NY,NY,Q2,YHAT2,BU)
      CALL MSUB(NY,NY,NY,NY,1,G2,BU,G2)
      CALL MMUL(NX1,NY,NX1,1,NX1,NY,RRBT21,G1P,RRBG1)
      CALL MMUL(NX2,NY,NX2,1,NX2,NY,RRBT12,G2P,RRBG2)
      CALL MMUL(NX1,NY,NX1,1,NX1,NY,B1T,G2P,B1G2)
      CALL MMUL(NX2,NY,NX2,1,NX2,NY,B2T,G1P,B2G1)
      CALL MSUB(NX1,NX1,NX1,NX1,1,RRBG1,B1G2,RRBG1)
      CALL MSUB(NX2,NX2,NX2,NX2,1,RRBG2,B2G1,RRBG2)
      CALL MMUL(NY,NX1,NY,1,NY,NX1,EKBR1,RRBG1,G2A)
      CALL MMUL(NY,NX2,NY,1,NY,NX2,EKBR2,RRBG2,G1A)
      CALL MADD(NY,NY,NY,NY,1,G1P,G1A,G1A)
      CALL MADD(NY,NY,NY,NY,1,G2P,G2A,G2A)
      CALL MMUL(NY,NY,NY,1,NY,NY,AT,G1A,BU)
      CALL MADD(NY,NY,NY,NY,1,G1,BU,G1)
      CALL MMUL(NY,NY,NY,1,NY,NY,AT,G2A,BU)
      CALL MADD(NY,NY,NY,NY,1,G2,BU,G2)
      CALL VINS(NPD,NY,T,G1T,G1)
      CALL VINS(NPD,NY,T,G2T,G2)
C
C   CALCULATE EI   (E-INVERSE)
C
  400 CALL MMUL(NX1,NY,NX1,NY,NX1,NY,RIBT11,K1,RBK1)
      CALL MMUL(NX2,NY,NX2,NY,NX2,NY,RIBT22,K2,RBK2)
      CALL MMUL(NX1,NY,NX1,NX1,NX1,NY,RBK1,B1,RK11)
      CALL MMUL(NX1,NY,NX1,NX2,NX1,NY,RBK1,B2,RK12)
      CALL MMUL(NX2,NY,NX2,NX1,NX2,NY,RBK2,B1,RK21)
      CALL MMUL(NX2,NY,NX2,NX2,NX2,NY,RBK2,B2,RK22)
      DO 420 I = 1,NX1
      DO 420 J = 1,NX1
  420 ER(I,J) = RK11(I,J)
      DO 430 I = 1,NX1
      DO 430 J = NX11,NR
  430 ER(I,J) = RK12(I,J-NX1)
      DO 440 I = NX11,NR
      DO 440 J = 1,NX1
  440 ER(I,J) = RK21(I-NX1,J)
      DO 450 I = NX11,NR
      DO 450 J = NX11,NR
  450 ER(I,J) = RK22(I-NX1,J-NX1)
      DO 460 I = 1,NR
  460 ER(I,I) = 1.D0 + ER(I,I)
      CALL SAVE(NR,NR,NR,NR,IDENT,ERI)
      CALL MLINEQ(NR,NR,NR,NR,ER,ERI,COND,IPVT,WORK)
      DO 470 I = 1,NY
      DO 463 J = 1,NX1
```

FIGURE I.5.d   Subroutine NASHC

```
  463 BE(I,J) = B1(I,J)
      DO 466 J = 1,NX2
  466 BE(I,J+NX1) = B2(I,J)
  470 CONTINUE
      DO 480 J = 1,NY
      DO 473 I = 1,NX1
  473 RBKE(I,J) = RBK1(I,J)
      DO 476 I = 1,NX2
  476 RBKE(I+NX1,J) = RBK2(I,J)
  480 CONTINUE
      CALL MMUL(NY,NR,NY,NR,NY,NR,BE,ERI,BERI)
      CALL MMUL(NY,NR,NY,NY,NY,NR,BERI,RBKE,EI)
      DO 485 I = 1,NY
      DO 485 J = 1,NY
  485 EI(I,J) = -1.D0*EI(I,J)
      DO 490 I = 1,NY
  490 EI(I,I) = 1.D0 + EI(I,I)
  500 CALL MINS(NPD,NY,NY,T,EIT,EI)
C
C   CALCULATE CONTROL AND STATE TRAJECTORIES
C
      DO 700 T = 1,NPD1
      TT = T-1
      IF(TT.EQ.0) GO TO 600
      CALL SAVE(NY,NY,NY,1,Y,YP)
      CALL SAVE(NX1,NX1,NX1,1,X1,X1P)
      CALL SAVE(NX2,NX2,NX2,1,X2,X2P)
      CALL VEXT(NPD,NW,TT,WT,WP)
      CALL MMUL(NY,NY,NY,1,NY,NY,A,YP,Y)
      CALL MMUL(NY,NX1,NY,1,NY,NX1,B1,X1P,YP)
      CALL MADD(NY,NY,NY,NY,1,Y,YP,Y)
      CALL MMUL(NY,NX2,NY,1,NY,NX2,B2,X2P,YP)
      CALL MADD(NY,NY,NY,NY,1,Y,YP,Y)
      CALL MMUL(NY,NW,NY,1,NY,NW,C,WP,YP)
      CALL MADD(NY,NY,NY,NY,1,Y,YP,Y)
      CALL VINS(NPD,NY,TT,YT,Y)
      IF(T.EQ.NPD1) GO TO 700
      GO TO 601
  600 CALL SAVE(NY,NY,NY,1,YO,Y)
      CALL VEXT(NPD,NY,1,G1T,G1P)
      CALL VEXT(NPD,NY,1,G2T,G2P)
      CALL VEXT(NPD,NX1,1,U1HATT,U1HAT)
      CALL VEXT(NPD,NX2,1,U2HATT,U2HAT)
      CALL VEXT(NPD,NW,1,WT,W)
      CALL MMUL(NY,NY,NY,1,NY,NY,BRBT11,G1P,BRBG11)
      CALL MMUL(NY,NY,NY,1,NY,NY,BRBT22,G2P,BRBG22)
      CALL MADD(NY,NY,NY,NY,1,BRBG11,BRBG22,G3P)
      CALL MSCALE(NY,NY,1,-1.D0,G3P)
      CALL MMUL(NY,NX1,NY,1,NY,NX1,B1,U1HAT,BU)
      CALL MADD(NY,NY,NY,NY,1,G3P,BU,G3P)
      CALL MMUL(NY,NX2,NY,1,NY,NX1,B2,U2HAT,BU)
      CALL MADD(NY,NY,NY,NY,1,G3P,BU,G3P)
      CALL MMUL(NY,NW,NY,1,NY,NW,C,W,BU)
      CALL MADD(NY,NY,NY,NY,1,G3P,BU,G3P)
      CALL VINS(NPD,NY,1,G3T,G3P)
```

FIGURE I.5.e   Subroutine NASHC

```
  601 CALL VEXT(NPD,NY,T,G3T,G3P)                                       NAS02760
      CALL MMUL(NY,NY,NY,1,NY,NY,A,Y,YP)                                NAS02770
      CALL MADD(NY,NY,NY,NY,1,G3P,YP,G3P)                               NAS02780
      CALL MEXT(NPD,NY,NY,T,K1T,K1P)                                    NAS02790
      CALL MEXT(NPD,NY,NY,T,K2T,K2P)                                    NAS02800
      CALL MEXT(NPD,NY,NY,T,EIT,EIP)                                    NAS02810
      CALL MMUL(NX1,NY,NX1,NY,NX1,NY,RIBT11,K1P,RBK1)                   NAS02820
      CALL MMUL(NX2,NY,NX2,NY,NX2,NY,RIBT22,K2P,RBK2)                   NAS02830
      CALL MMUL(NX1,NY,NX1,NY,NX1,NY,RBK1,EIP,RBKE1)                    NAS02840
      CALL MMUL(NX2,NY,NX2,NY,NX2,NY,RBK2,EIP,RBKE2)                    NAS02850
      CALL MMUL(NX1,NY,NX1,1,NX1,NY,RBKE1,G3P,X1)                       NAS02860
      CALL MMUL(NX2,NY,NX2,1,NX2,NY,RBKE2,G3P,X2)                       NAS02870
      CALL MSCALE(NX1,NX1,1,-1.D0,X1)                                   NAS02880
      CALL MSCALE(NX2,NX2,1,-1.D0,X2)                                   NAS02890
      CALL VEXT(NPD,NY,T,G1T,G1)                                        NAS02900
      CALL VEXT(NPD,NY,T,G2T,G2)                                        NAS02910
      CALL MMUL(NX1,NY,NX1,1,NX1,NY,RIBT11,G1,X1P)                      NAS02920
      CALL MMUL(NX2,NY,NX2,1,NX2,NY,RIBT22,G2,X2P)                      NAS02930
      CALL MSUB(NX1,NX1,NX1,NX1,1,X1,X1P,X1)                            NAS02940
      CALL MSUB(NX2,NX2,NX2,NX2,1,X2,X2P,X2)                            NAS02950
      CALL VEXT(NPD,NX1,T,U1HATT,U1HAT)                                 NAS02960
      CALL VEXT(NPD,NX2,T,U2HATT,U2HAT)                                 NAS02970
      CALL MADD(NX1,NX1,NX1,NX1,1,X1,U1HAT,X1)                          NAS02980
      CALL MADD(NX2,NX2,NX2,NX2,1,X2,U2HAT,X2)                          NAS02990
      CALL VINS(NPD,NX1,T,X1T,X1)                                       NAS03000
      CALL VINS(NPD,NX2,T,X2T,X2)                                       NAS03010
  700 CONTINUE                                                          NAS03020
      IF(KOUT.EQ.6) GO TO 999                                           NAS03030
      CALL MATIO(NY,NY,NY,A,3)                                          NAS03040
      CALL MATIO(NY,NY,NY,AT,3)                                         NAS03050
      CALL MATIO(NY,NY,NX1,B1,3)                                        NAS03060
      CALL MATIO(NX1,NX1,NY,B1T,3)                                      NAS03070
      CALL MATIO(NY,NY,NX2,B2,3)                                        NAS03080
      CALL MATIO(NX2,NX2,NY,B2T,3)                                      NAS03090
      CALL MATIO(NY,NY,NW,C,3)                                          NAS03100
      CALL MATIO(NY,NY,NY,Q1,3)                                         NAS03110
      CALL MATIO(NY,NY,NY,Q2,3)                                         NAS03120
      CALL MATIO(NX1,NX1,NX1,R11,3)                                     NAS03130
      CALL MATIO(NX1,NX1,NX1,RI11,3)                                    NAS03140
      CALL MATIO(NX1,NX1,NX1,R21,3)                                     NAS03150
      CALL MATIO(NX2,NX2,NX2,R12,3)                                     NAS03160
      CALL MATIO(NX2,NX2,NX2,R22,3)                                     NAS03170
      CALL MATIO(NX2,NX2,NX2,RI22,3)                                    NAS03180
      CALL MATIO(NR,NR,NR,IDENT,3)                                      NAS03190
  999 RETURN                                                            NAS03200
      END                                                               NAS03210
```

<u>FIGURE I.5.f</u>   Subroutine NASHC

```
      SUBROUTINE COST(NY,NX1,NX2,NPD,YT,Y,X1T,X1,X2T,X2,YHATT1,YHAT1,
     1      YHATT2,YHAT2,U1HATT,U1HAT,U2HATT,U2HAT,Q1,Q2,R11,R21,
     2      R12,R22,J1,J2,DELY1,DELY2,DELX1,DELX2,W1,W2,BU,BUT,CU,CUT,
     3      DU,DUT)
      INTEGER NY,NX1,NX2,NPD,T
      DOUBLE PRECISION YT(NPD,NY),Y(NY),X1T(NPD,NX1),X1(NX1),
     1      X2T(NPD,NX2),X2(NX2),YHATT1(NPD,NY),YHAT1(NY),
     2      YHATT2(NPD,NY),YHAT2(NY),U1HATT(NPD,NX1),U1HAT(NX1),
     3      U2HATT(NPD,NX2),U2HAT(NX2)
      DOUBLE PRECISION Q1(NY,NY),Q2(NY,NY),R11(NX1,NX1),R21(NX1,NX1),
     1      R12(NX2,NX2),R22(NX2,NX2)
      DOUBLE PRECISION J1,J2,DELY1(NY),DELY2(NY),DELX1(NX1),
     1      DELX2(NX2),W1,W2,BU(NY,1),BUT(1,NY),CU(NX1,1),CUT(1,NX1),
     2      DU(NX2,1),DUT(1,NX2)
      COMMON/INOU/KIN,KOUT
      J1 = 0.D0
      J2 = 0.D0
      DO 900 T = 1,NPD
      CALL VEXT(NPD,NY,T,YT,Y)
      CALL VEXT(NPD,NY,T,YHATT1,YHAT1)
      CALL VEXT(NPD,NY,T,YHATT2,YHAT2)
      CALL MSUB(NY,NY,NY,NY,1,Y,YHAT1,DELY1)
      CALL MSUB(NY,NY,NY,NY,1,Y,YHAT2,DELY2)
      CALL VEXT(NPD,NX1,T,X1T,X1)
      CALL VEXT(NPD,NX2,T,X2T,X2)
      CALL VEXT(NPD,NX1,T,U1HATT,U1HAT)
      CALL VEXT(NPD,NX2,T,U2HATT,U2HAT)
      CALL MSUB(NX1,NX1,NX1,NX1,1,X1,U1HAT,DELX1)
      CALL MSUB(NX2,NX2,NX2,NX2,1,X2,U2HAT,DELX2)
      CALL MMUL(NY,NY,NY,1,NY,NY,Q1,DELY1,BU)
      CALL TRNATB(NY,1,NY,1,BU,BUT)
      CALL MMUL(1,NY,1,1,1,NY,BUT,DELY1,W1)
      CALL MMUL(NY,NY,NY,1,NY,NY,Q2,DELY2,BU)
      CALL TRNATB(NY,1,NY,1,BU,BUT)
      CALL MMUL(1,NY,1,1,1,NY,BUT,DELY2,W2)
      J1 = J1 + W1
      J2 = J2 + W2
      CALL MMUL(NX1,NX1,NX1,1,NX1,NX1,R11,DELX1,CU)
      CALL TRNATB(NX1,1,NX1,1,CU,CUT)
      CALL MMUL(1,NX1,1,1,1,NX1,CUT,DELX1,W1)
      CALL MMUL(NX1,NX1,NX1,1,NX1,NX1,R21,DELX1,CU)
      CALL TRNATB(NX1,1,NX1,1,CU,CUT)
      CALL MMUL(1,NX1,1,1,1,NX1,CUT,DELX1,W2)
      J1 = J1 + W1
      J2 = J2 + W2
      CALL MMUL(NX2,NX2,NX2,1,NX2,NX2,R12,DELX2,DU)
      CALL TRNATB(NX2,1,NX2,1,DU,DUT)
      CALL MMUL(1,NX2,1,1,1,NX2,DUT,DELX2,W1)
      CALL MMUL(NX2,NX2,NX2,1,NX2,NX2,R22,DELX2,DU)
      CALL TRNATB(NX2,1,NX2,1,DU,DUT)
      CALL MMUL(1,NX2,1,1,1,NX2,DUT,DELX2,W2)
      J1 = J1 + W1
      J2 = J2 + W2
  900 CONTINUE
      J1 = 0.5D0*J1
```

FIGURE I.6.a   Subroutine COST

```
      J2 = 0.5D0*J2
      RETURN
      END
```

FIGURE I.6.b Subroutine COST

```
      SUBROUTINE REACT(A,B1,B2,C,AC1,AC2,BC1,BC2,CC1,CC2,AR,CR)
      DOUBLE PRECISION A(27,27),B1(27,1),B2(27,1),C(27,5),AC1(27,27),
     1 AC2(27,27),BC1(27,1),BC2(27,1),CC1(27,5),CC2(27,5),AR(27,27),
     2 CR(27,5)
      DOUBLE PRECISION D11(1,27),D12(1,27),D21(1,27),D22(1,27),E11,
     1 E12,E21,E22,F1(1,5),F2(1,5),CON11,CON21,CON12,CON22,
     2 DA1(1,27),DA2(1,27),DB,DC1(1,5),DC2(1,5),DET,SCALE,
     3 AU1(1,27),AU2(1,27),CU1(1,5),CU2(1,5),WORKA(27,27),WORKC(27,5)
      INTEGER I
      COMMON/INOU/KIN,KOUT
C
C  INITIALIZE MATRICES
C
      DO 1 I = 1,27
      D11(1,I) = 0.D0
      D12(1,I) = 0.D0
      D21(1,I) = 0.D0
      D22(1,I) = 0.D0
      BC1(I,1) = 0.D0
    1 BC2(I,1) = 0.D0
      DO 2 I = 1,5
      F1(1,I) = 0.D0
    2 F2(1,I) = 0.D0
      DO 3 I = 1,27
      DO 3 J = 1,27
      AC1(I,J) = 0.D0
    3 AC2(I,J) = 0.D0
      DO 4 I = 1,27
      DO 4 J = 1,5
      CC1(I,J) = 0.D0
    4 CC2(I,J) = 0.D0
      D11(1,2) = -0.0669D0
      D12(1,2) = 0.0669D0
      D21(1,2) = 0.0235D0
      D22(1,2) = -0.0123D0
      D22(1,9) = -0.0112D0
      DO 5 I = 1,3
      D11(1,I+2) = D11(1,2)
      D12(1,I+2) = D12(1,2)
      D21(1,I+2) = D21(1,2)
      D22(1,I+2) = D22(1,2)
    5 D22(1,I+9) = D22(1,9)
      D11(1,7) = -52.72D0
      D12(1,23) = 1.0669D0
      D12(1,8) = 0.442D0
      E11 = -0.0669D0
      E12 = 0.D0
      F1(1,5) = -1.148D0
      D21(1,8) = -0.161D0
      D22(1,23) = -0.0123D0
      D22(1,7) = 29.53D0
      D22(1,25) = 0.872D0
      D22(1,24) = -0.0112D0
      E21 = 0.0235D0
      E22 = 0.D0
```

FIGURE I.7.a Subroutine REACT

```
      F2(1,5) = 0.98800
C
C   CALCULATE GARBAGE FOR SINGLE REACTION FUNCTION CASES C.1, C.2
C
      CALL MMUL(1,27,1,1,1,27,D11,B1,CON11)
      CALL MMUL(1,27,1,1,1,27,D11,B2,CON12)
      CALL MMUL(1,27,1,1,1,27,D21,B1,CON21)
      CALL MMUL(1,27,1,1,1,27,D21,B2,CON22)
      CON11 = 1.D0/(1.D0 - CON11 - E11)
      CON22 = 1.D0/(1.D0 - CON22 - E22)
C
C   CALCULATE A MATRIX FOR CASE C.1
C
      CALL MMUL(1,27,1,27,1,27,D21,A,DA2)
      CALL MADD(1,1,1,1,27,DA2,D22,DA2)
      CALL MSCALE(1,1,27,CON22,DA2)
      CALL MMUL(27,1,27,27,27,1,B2,DA2,AC1)
      CALL MADD(27,27,27,27,27,A,AC1,AC1)
C
C   CALCULATE A MATRIX FOR CASE C.2
C
      CALL MMUL(1,27,1,27,1,27,D11,A,DA1)
      CALL MADD(1,1,1,1,27,DA1,D12,DA1)
      CALL MSCALE(1,1,27,CON11,DA1)
      CALL MMUL(27,1,27,27,27,1,B1,DA1,AC2)
      CALL MADD(27,27,27,27,27,A,AC2,AC2)
C
C   CALCULATE B VECTOR FOR CASE C.1
C
      DB = (CON21+E21)*CON22
      DO 6 I = 1,27
    6 BC1(I,1) = B1(I,1) + DB*B2(I,1)
C
C   CALCULATE B VECTOR FOR CASE C.2
C
      DB = (CON12+E12)*CON11
      DO 7 I = 1,27
    7 BC2(I,1) = DB*B1(I,1) + B2(I,1)
C
C   CALCULATE C MATRIX FOR CASE C.1
C
      CALL MMUL(1,27,1,5,1,27,D21,C,DC2)
      CALL MADD(1,1,1,1,5,DC2,F2,DC2)
      CALL MSCALE(1,1,5,CON22,DC2)
      CALL MMUL(27,1,27,5,27,1,B2,DC2,CC1)
      CALL MADD(27,27,27,27,5,C,CC1,CC1)
C
C   CALCULATE C MATRIX FOR CASE C.2
C
      CALL MMUL(1,27,1,5,1,27,D11,C,DC1)
      CALL MADD(1,1,1,1,5,DC1,F1,DC1)
      CALL MSCALE(1,1,5,CON11,DC1)
      CALL MMUL(27,1,27,5,27,1,B1,DC1,CC2)
      CALL MADD(27,27,27,27,5,C,CC2,CC2)
C
```

FIGURE I.7.b Subroutine REACT

```
C  CALCULATE GARBAGE FOR SIMULTANEOUS REACTIONS CASE C.3
C
      CON11 = 1.D0/CON11
      CON22 = 1.D0/CON22
      CON12 = -1.D0*(CON12 + E12)
      CON21 = -1.D0*(CON21 + E21)
      DET = CON11*CON22 - CON12*CON21
C
C  CALCULATE AU1 AND CU1 MATRICES FOR CASE C.3
C
      SCALE = CON22*CON11/DET
      CALL MSCALE(1,1,27,SCALE,DA1)
      CALL MSCALE(1,1,5,SCALE,DC1)
      SCALE = -1.D0*CON12*CON22/DET
      CALL MSCALE(1,1,27,SCALE,DA2)
      CALL MSCALE(1,1,5,SCALE,DC2)
      CALL MADD(1,1,1,1,27,DA1,DA2,AU1)
      CALL MADD(1,1,1,1,5,DC1,DC2,CU1)
C
C  CALCULATE AU2 AND CU2 MATRICES FOR CASE C.3
C
      SCALE = -1.D0*CON21*CON11/DET
      CALL MSCALE(1,1,27,SCALE,DA1)
      CALL MSCALE(1,1,5,SCALE,DC1)
      SCALE = CON11*CON22/DET
      CALL MSCALE(1,1,27,SCALE,DA2)
      CALL MSCALE(1,1,5,SCALE,DC2)
      CALL MADD(1,1,1,1,27,DA1,DA2,AU2)
      CALL MADD(1,1,1,1,5,DC1,DC2,CU2)
C
C  CALCULATE SIMULTANEOUS REACTIONS AR AND CR MATRICES FOR CASE C.3
C
      CALL MMUL(27,1,27,27,27,1,B1,AU1,WORKA)
      CALL MADD(27,27,27,27,27,A,WORKA,AR)
      CALL MMUL(27,1,27,27,27,1,B2,AU2,WORKA)
      CALL MADD(27,27,27,27,27,AR,WORKA,AR)
      CALL MMUL(27,1,27,5,27,1,B1,CU1,WORKC)
      CALL MADD(27,27,27,27,5,C,WORKC,CR)
      CALL MMUL(27,1,27,5,27,1,B2,CU2,WORKC)
      CALL MADD(27,27,27,27,5,CR,WORKC,CR)
      RETURN
      END
```

<u>FIGURE I.7.c</u>   Subroutine REACT

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