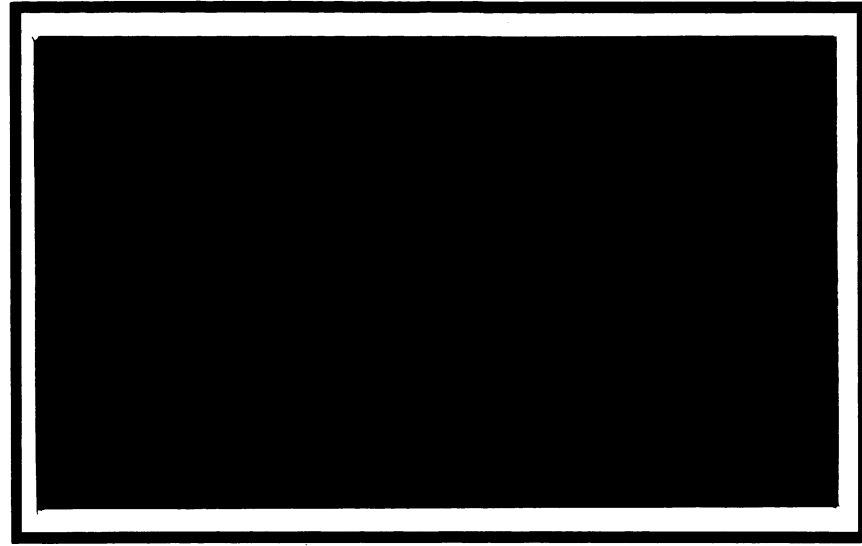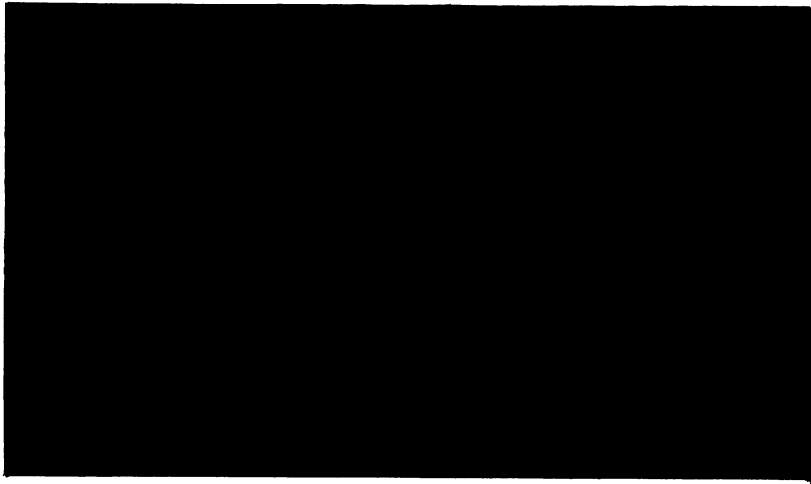# Center for Research on Economic and Social Theory
Research Seminar in Quantitative Economics

Discussion Paper

DEPARTMENT OF ECONOMICS
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ECONOMETRIC REVIEW OF ALTERNATIVE FISCAL

AND MONETARY POLICIES, 1971-75

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R-101

October 1977

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I. Introduction

This paper attempts a selective and particular type of evaluation of monetary and fiscal policies in the U.S. over the period 1971-75. The investigation is carried out in the context of a set of well-known macroeconometric models of the U.S. economy with an experimental design that not only helps to evaluate the actual policies followed, but also assesses the ability of these models to offer useful advice to policy makers.

It has often been argued that the economic instability manifested during the 1970's is rooted in economic events and policy decisions which can be traced back to the mid-1960's. It would be something of an exaggeration to claim that between 1966 and 1975 the American economy displayed every possible manifestation of economic instability. Obviously there exist other events that might have come to pass and didn't. But the list of what actually transpired, in the form of both exogenous shocks and endogenous responses, is enormous -- potentially a gold mine of variance for any econometrician. Consider the following enumeration, which includes only major events:

1) A sudden acceleration of defense spending associated with the War in Vietnam (1966)

2) A severe credit-crunch and the term "disintermediation" became part of the standard economic vocabulary (1966)

3) A mini-recession (1967)

4) A temporary 10 percent tax surcharge partially neutralized by a substantial loosening of monetary policy (1968)

5) A "normal" recession, at least in part engineered to slow down the rate of inflation (1969)

6) An acceleration in the rate of inflation and a sharp increase in the unemployment rate (1970)

7) The UAW strike against General Motors which lasted more than two months and obscured the lower turning point of the recession (1970).

8) A wage and price freeze followed by various on-again, off-again phases of wage and price controls (1971-73)

9) The collapse of fixed exchange rates (1971)

10) The Russian Wheat Deal, world-wide harvest shortfalls, and a 40 percent increase in the wholesale price of farm products (1973)

11) The OPEC Cartel, a quadrupling of the price of imported crude oil, the energy crisis, more harvest shortfalls and raw material shortages, double-digit inflation and interest rates (1974)

12) A maxi-recession with unemployment reaching nearly 9 percent and price inflation moderating to a "mere" 5 percent (1974-75)

13) Federal income tax rebates, and two to four hundred dollar rebates from automobile manufacturers, not to mention small rebates on a miscellany of other manufactured items (1975)

-- how different from the events of the first half of the 1960's when many of us had come to believe that an activist fiscal policy, supported by monetary policy, could be counted on to produce sustainable and non-inflationary prosperity. Who or what pushed us off the trajectory of economic stability? Was it all bad luck, all exogenous? Did we hit some low probability set of initial conditions which uncovered an unstable root in the economic system? Did we misinterpret the apparent policy successes of the first half of the 1960's? Is policy variation really destabilizing, or did we pursue a decade of inappropriate fiscal and monetary policies? Are there feasible economic policies which would have fared better against the kinds of instability listed above? If so, can an optimal set of policies be identified?

It seems unlikely that better short-term stabilization policy would have prevented the quadrupling of oil prices, and we have no economic tools to modulate sharp changes in growing conditions in our farm regions. But policy actions can either reinforce or mitigate the macroeconomic impacts of such uncontrollable events. Could we have performed better than we did in this regard?

As a preliminary exercise to the main task of evaluating the policies of the early 1970's a number of macroeconometric models were used to run the following simulation experiment as a test of the hypothesis that the economic instability and high inflation rates of the early 1970's had their origins in the economic policies of the late 1960's: Federal personal income and corporate profits taxes were increased (permanently) by 10 percent in 1966 (presumably to help finance the sharply increased Vietnam-related defense expenditures). The model outputs were compared to a baseline solution which was made to track the actual behavior of the economy (see below for methodology used to obtain historical tracking). Very small differences resulted; i.e., the models unanimously reject the hypothesis that a more judicious fiscal policy in 1966 could have rescued the economy from its troubles in the 1970's. Thus, in the remainder of this paper, attention is focused on whether policy actions undertaken during the period 1971-75 itself might have improved economic performance.

In Section II we discuss the methodology employed to evaluate macroeconomic policies. We define an optimal control approach to the problem and explain how that procedure is to be applied to seven quarterly macroeconometric models. Section III presents the results obtained by each of the models and begins to address the matter of consensus among the models.

In Section IV we continue the analysis by having all seven models respond to common sets of stabilization policies. The last section of the paper presents conclusions and suggestions for further research on the topic of policy evaluation.

II. Methodology

Obviously, there is no way to replay history in order to discover the characteristics of an optimal stabilization policy. True replication is a tool which is denied both to economic policymakers and to those who would try to evaluate past policies. What we can do to answer important questions about the appropriateness of the economic policies which were applied in a particular historical context is to proceed as any group of scientists might under less than ideal circumstances.

As an analogy, suppose that a physicist has built an apparatus intended to test a number of physical phenomena. Suppose further that he has told his colleagues neither how the apparatus is constructed nor the design of his experimental procedures. Over the course of his experiments he has recorded a number of unexceptional outcomes, mentioned the outcomes and the nature of the work to others in informal conversation, and then turned up a truly surprising result. Following this, an accident in the laboratory takes his life and destroys all but a set of notes which record little more than a listing of the experimental results. How might the physicist's colleagues attempt to recapture the work that was done? Each has some incomplete notions about the apparatus which had been used and the kinds of experiments conducted. Lacking complete agreement among all of them, they might proceed to work in small groups, within each of which all

members have pretty much the same view of what their late colleague
had been up to. In this manner a number of different apparatuses will
be built, each to try and explain the same observed phenomena. Those
groups who succeed in reproducing (explaining) the unexceptional outcomes
will then try for the startling result. No group will ever know whether
it has done the right thing nor, therefore, whether it has produced the
same result and the same understanding that would have derived from the
original experiment.

The hypothetical situation just described bears many similarities
to the problems we face as economists trying to evaluate the adequacy
of economic policies. We have outcomes and incomplete notions about
the mechanism which produced them. There exists, for example, a fair
number of macroeconometric models, each capable of explaining -- with
similar accuracy -- a large number of observed phenomena (the observed
long-run relation between consumption and disposable income, the average
share of profits in GNP, the quarterly change in GNP, etc.) But the
models differ in many ways and thus provide somewhat different charac-
terizations of the real world and, therefore, different answers to some
of the same questions. They do, however, provide a framework within
which to conduct experiments on a set of approximate descriptions
of the economic mechanism generating the observed outcomes of interest.

We propose, therefore, to utilize the results derived from simula-
tion experiments with seven well-known macroeconometric models to address
the following question:

> Do there exist feasible monetary and fiscal policies which would
> have produced macroeconomic results substantially better than those
> which actually occurred in the period 1971-75?

We employ a set of macroeconometric models rather than a single one in order to investigate whether or not the policy-related information implied by the structures of these models is similar. From the point of view of the policy-maker, substantial agreement among the models might greatly increase confidence in them as sources of information on optimal economic policy. The idea then is to search the structure of each of these models for the appropriate (optimal) policy and then to determine whether the policy information implied by the various structures is sufficiently similar to be useful to policymakers.

The foregoing statement of the problem begs a number of critically important issues. What constitutes "feasible" policy? What are the measures of "macroeconomic results"? What defines "better" or "best" macroeconomic results? Are we looking for "real policies" in the sense that they could have been formulated ex ante, and, if so, how often could they have been revised? Or, more simply, are we looking for the existence of a set of better policies whether or not any policymaker could have had sufficient information to adopt such policies? Finally, what of the use of a number of models rather than a single model, and how do we evaluate the differences which are bound to emerge.

One way to begin to get at these issues is to consider the following analytic framework. We define an econometric model as:

$$Y_t = F(G_t, X_t, Y_{t-1}) + \epsilon_t \tag{1}$$

where

Y = Endogenous variable(s)

G = Exogenous policy variable(s)

X = Other exogenous variable(s)

ε = Stochastic error term(s)

t = Time period

The expression in (1) can be thought of as a single- or multi-equation model that may be either linear or non-linear in variables, but the disturbances are additive. Over any calendar time interval, we can define for the model in (1) a set of observed residuals (e_t).

$$e_t = Y_t - f(G_t, X_t, Y_{t-1}) \qquad (2)$$

where f represents the econometrically estimated version of F. We can also (for the moment) assume the existence of a desired, or even optimal, path (Y_t^*) for the endogenous variable(s):

$$Y_t^* = f(G_t^*, X_t, Y_{t-1}^*) + e_t \qquad (3)$$

where

$$Y_o^* = Y_o \qquad (4)$$

If we consider the path Y_t^* to be given ab initio, we can view (3) and (4) as defining G_t^* implicitly if the function f permits the existence of G_t^*. In fact, we proceeded to define G_t^* somewhat differently, as will be discussed in Section III below. The main point here is that the pair (G_t^*, Y_t^*) is defined to be conditioned on the estimated model with X_t and e_t both assumed to be known over the entire policy horizon. In essence, we view

the observed residuals as the realized values of the disturbance term(s) which are considered to represent pure randomness in behavior or other shocks which occur <u>independently</u> of policy actions.[1] The difference $(Y_t - Y_t^*)$ is our measure of the effect of non-optimal policy; i.e., equations (2) and (3) imply

$$Y_t - Y_t^* = f(G_t, X_t, Y_{t-1}) - f(G_t^*, X_t, Y_{t-1}^*) \qquad (5)$$

It should be noted that our approach to defining the effect of non-optimal policy differs importantly from the following alternative procedure. Define dynamic predicted values $(\hat{Y}_t)$ by:

$$\hat{Y}_t = f(G_t, X_t, \hat{Y}_{t-1}) \qquad (6)$$

$$\hat{Y}_o = Y_o \qquad (7)$$

Again considering Y_t^* to be given <u>ab initio</u>, we can regard G_t^{**} as being defined implicitly by:

$$Y_t^* = f(G_t^{**}, X_t, Y_{t-1}^*) \qquad (8)$$

$$Y_o^* = Y_o \qquad (9)$$

The path G_t^{**} will not, in general, coincide with the path G_t^* unless e_t is zero for all t and f is a linear model. But G_t^{**} is an alternative

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[1] That is to say, we permit the residuals to affect policy actions, but policy actions are not permitted to alter the residuals.

optimal policy path and $(\hat{Y}_t - Y_t^*)$ is an alternative measure of the effect of non-optimal policy. Our measure $(Y_t - Y_t^*)$ evaluates the effect of $G_t \neq G_t^*$ in the neighborhood of the historically observed path, Y_t. The alternative measure $(\hat{Y}_t - Y_t^*)$ evaluates the effect of non-optimal policy in the neighborhood of the dynamic simulation path, $\hat{Y}_t$. The two measures of the effect of non-optimal policy will not coincide unless e_t is zero for all t and f is a linear model. Neither of these conditions is satis-fied by the models we are dealing with. If one wishes to determine the extent to which government policies could have produced a path superior to that which actually occurred, it seems most appropriate to evaluate the effect of non-optimal policy in the neighborhood of the path Y_t.

In the context of multiple models, additional considerations argue for the use of our measure $(Y_t - Y_t^*)$ rather than $(\hat{Y}_t - Y_t^*)$. In effect, our measure treats the observed residuals, e_t, as if they were known exogenous variables, whereas the alternative measure ignores the residuals. But the various models with which we deal differ with respect to what is an included exogenous variable and what is left in the residuals. If the effect of non-optimal policy is measured by $(\hat{Y}_t - Y_t^*)$ a model with, say, exogenous petroleum prices will find substantial inflation in the $\hat{Y}_t$ path in 1974 and its optimal policy will have to cope with that inflation. A model which excludes petroleum prices (leaves them in the residual) will likely find much less inflation in its $\hat{Y}_t$ path in 1974 and its optimal policy will have relatively less inflation to deal with. On the other hand, either model's Y_t path contains the same inflation in 1974 whether the

increase in oil prices enters directly through an exogenous variable
or indirectly through the residuals. Indeed, in our procedure, every
model deals with precisely the same Y_t path, namely the observed path.
Thus all models have the same difficulties to overcome and the effect
of non-optimal policy can be evaluated for all models in the neighbor-
hood of the same paths of the endogenous variables. Our procedure thus
provides for some degree of standardization across the models, and is part
of the set of rules intended to assure that disagreements between models
derive as far as possible from differences in the structures of the models.

The major questions of methodology that remain unanswered pertain
to the definition of better or optimal macroeconomic performance, and the
determination of G_t^*, the optimal policy path. We elected to treat these
issues in an optimal control framework. In that framework a choice must
be made between deterministic and stochastic optimal control. We have
ruled out stochastic control by treating the observed residuals as exo-
genous variables and by treating the estimated model, f, as though it
were the true model, F. This treatment of the residuals is justified, as
discussed earlier, by our desire to have all the models reacting to the
same observed events. The decision to treat f as though it were F derives
from financial practicality in dealing with simulation experiments on
large models, with limited computer budgets.

A policymaker has to choose between "open loop" control and "closed
loop" control. In open loop control, policy is set one time for the
entire policy horizon, knowing only those events (Y, G, X, and e) which
have occurred up to the time when policy must be set. In closed loop

control, the policymaker reacts (possibly every period) to the unfolding

of events and revises policies in the light of the latest "surprises"

(exogenous variables turning out different from what was projected, or

$e \neq 0.$) As we have defined the problem in equations (1) - (5), there

can be no surprises; i.e., with everything deterministic, there is no

distinction between open and closed loop control. A G_t^* path which we

derive cannot, therefore, correspond to any policy which a real policy-

maker could have determined ex ante even if he used the same estimated

model. In this study, we are not evaluating actual policy, G_t, against

the best policy which a policymaker could realistically have come up with.

Obviously, our G_t^* is a "full-information" policy and is therefore better

than the best which a real policymaker could have chosen. That is, we

are using much more information than would have been available to any

policymaker using any of the models contained in this study. Recall that

our "policymaker" is assumed to have complete prior knowledge of the val-

ues of the exogenous and other pre-determined variables and the system re-

siduals for every moment in the policy horizon. In contrast, consider even

the best possible situation for a real-world policymaker: (1) the model

in question is perfectly specified and optimally estimated, so that there

is a low degree of uncertainty with respect to model parameters; (2) the

probability distribution of the disturbances and non-policy exogenous var-

iables is known, thus permitting derivation of optimum solutions in an ex-

pectational sense; and (3) forecasts of exogenous variables and solutions

are revised as realized values of the disturbances and other variables be-

come known (closed-loop control). Because substantial uncertainty remains

even in this best-possible case, the (sequential) solution cannot be better

than (i.e., must yield an expected loss at least as large as) that obtained in our deterministic case; and we have no assurance that it closely approximates the latter. Adding the facts of uncertainty with respect to specification and parameters makes the presumption for appropriateness even more doubtful. Although it may seem that we have allowed for an excessive amount of information, this was necessary, as noted above, in order to be able to compare the results from the different models.

The seven models used in the analysis are:

BEA: Bureau of Economic Analysis, U.S. Department of Commerce

DRI: Data Resources, Inc.

FAIR: Ray Fair, Yale University

MPS: MIT-Pennsylvania-SSRC, University of Pennsylvania

MQEM: Michigan Quarterly Econometric Model, University of Michigan

SL: St. Louis Model, Federal Reserve Bank of St. Louis

WQ: Wharton Mark III Quarterly Model, Wharton EFA

The proprietors of the seven models agreed upon the following truncated-quadratic loss function to be applied to each model as the basis for selection of the optimal policy paths:

$$L = \sum_{t=1971.1}^{1975.1} [.75 (100 \frac{Y_t - Y_t^*}{Y_t^*})^2 + .75 (U_t - 4.0)^2$$

$$+ 1.0 (\dot{P}_t - P_t^*)^2 + 1.0 (100 \frac{TB\$_t}{Y\$_t})^2]$$

where

Y_t = GNP in constant dollars (real GNP)

$Y\$_t$ = GNP in current dollars

Y_t^* = Potential real GNP

U_t = Unemployment Rate (in percent) or 4.0, whichever is greater

$\dot{P}_t$ = Annualized rate of inflation (percentage points) or

$\quad\quad P_t^*$, whichever is greater

P_t^* = 3.0 for 1971.1 - 1973.4

$\quad\quad$ = 7.0 for 1974.1 - 1975.1

$TB\$_t$ = Net Exports in current dollars

Quadratic loss functions are by now standard fare in the macroeconomic op-
timal control literature.[2/] It is recognized, however, that the symmetry
inherent in the quadratic loss function may not be the most appropriate
way to quantify macroeconomic gains and losses. It hardly seems reasonable
to penalize a model (or policymaker) for producing "too low" an unemploy-
ment rate if a direct penalty is already being attached to high rates of
inflation. Similarly, lower than targeted rates of inflation would not
be regarded as undesirable. We have therefore elected to truncate the
loss function and charge no penalty for either unemployment or inflation
rates below their target values. Quite natural target values for real GNP,
the trade balance, and the unemployment rate seemed readily available: the
Council of Economic Advisor's Potential real GNP series was selected as the
output target, a four percent unemployment rate was chosen as the employment

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2/ See, for example, Gregory Chow, "An Approach to the Feedback Control of
Nonlinear Econometric Systems," Annals of Economic and Social Measurement,
Summer, 1976; and Robert S. Holbrook, "A Practical Method for Controlling
a Large Nonlinear Stochastic System," Annals of Economic and Social
Measurement, January 1975.

target, and a zero net export balance was selected as the foreign trade
target.

The setting of an inflation target caused somewhat more difficulty.
A goal of about three percent for inflation seemed roughly justifiable
on the basis of the policy literature of the late 1960's and early 1970's.
By late 1973, however, the economy was being subjected to substantial in-
flationary shocks deriving from world-wide harvest shortfalls and the
OPEC cartelization of crude oil supplies. We chose to raise the target
inflation rate to seven percent beginning in the first quarter of 1974, a
decision representing our perception of how policymakers reset their sights
with respect to an achievable inflation goal at that time.[3/]

The somewhat lower relative weights put on the GNP and unemployment
deviations in the loss function reflect the fact that these two variables
overlap strongly in their meaning and behavior.

It should be noted that the time horizon over which the loss function
is defined coincides with the period for which policies are being analyzed
and evaluated. This raises the obvious possibility that policies selected
as optimal for the period 1971.1-1975.1 might produce highly undesirable
effects -- particularly with respect to inflation -- subsequent to 1975.1.
A number of practical difficulties -- including a total revision of the
national accounts data -- prevented us from adopting an experimental design
which would have dealt adequately with this problem of "terminal hangover."[4/]
However, the results which we present below lead us to believe that the
policy biases resulting from our sub-optimal experimental design are not
severe.

[3/] This decision should not be taken to suggest that targets should be re-
set continually to accommodate changes in the likelihood of their attainment.

[4/] We owe this descriptive phrase to Robert S. Holbrook.

The model proprietors agreed to use as policy instruments Federal Government purchases, Federal personal income taxes, and one monetary variable (either a monetary aggregate or a short-term interest rate).

In the process of solving the optimal control problem, each model proprietor followed his own procedures in deriving the optimal policy settings. Some followed ad-hoc "trial and error" procedures and others used formal optimal control algorithms. In certain cases (e.g., MQEM) both formal and informal procedures were followed and compared, and in others (MPS) alternative formal algorithms and instrument constraints were tried. In most cases researchers found that the failure to place some constraints on the movements of the policy variables led to unacceptable results in the sense that policy instruments displayed "non-believable" rates of change. The actual constraints imposed, however, as well as the method used in developing these constraints, differed from model to model. In one way or another, however, all the constraints imposed a kind of smoothness on the paths of the key policy instruments (see Appendix for a listing of the smoothness constraints).

III. Optimal Policy Results

We first examine the loss function values and the paths of the major target variables for each of the models to determine whether and to what extent a full-information best policy, as defined above, would have produced significantly better macroeconomic results. Second, we turn to the question of whether the models produce any substantial agreement as to the nature of the best full-information policy for the period 1971-75.

Figure 1: Actual and Optimal Loss Function Values,
           FAIR Model
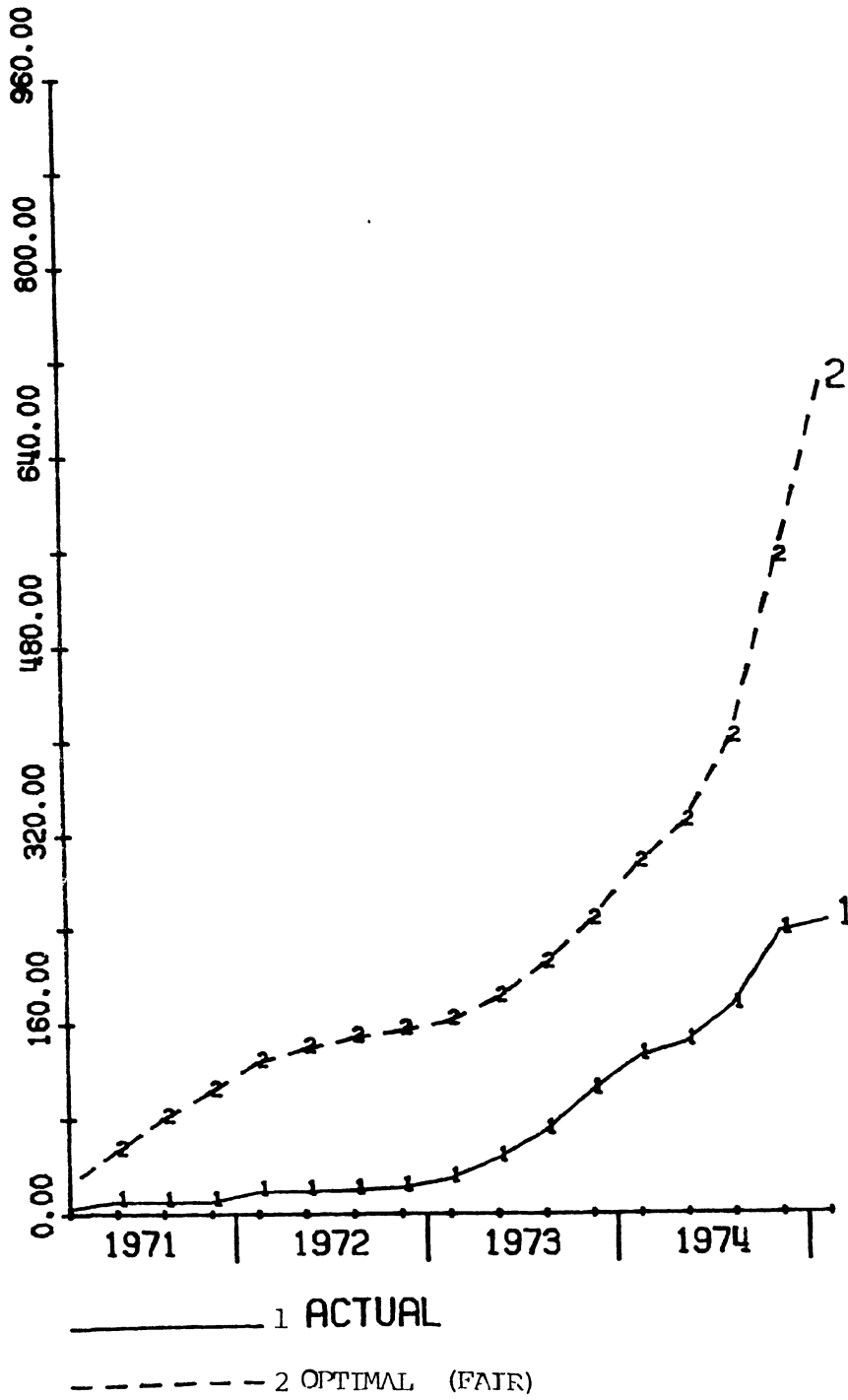
As a general overview of the results consider Table 1 which compares the optimized value of the loss function, as determined by each model, with the historical record and Figure 1 which shows the actual and optimal loss function path for the FAIR model which is quite typical of the results in several of the models. Note first that the value of L corresponding to the actual data for 1971.1-1975.1 amounts to 699.3. Slightly more than half of this loss derives from the last three quarters (1974.3-1975.1) which encompass the worst part of the 1974-75 recession. The gap between actual and potential GNP contributes 443.2 points (63% of the total) to the value of L; 211.3 points (30% of the total) derive from the inflation variable; and the unemployment rate accounts for 41.6 points (6% of the total); the trade balance contributes almost nothing (less than half of 1 percent). All of

Table 1. Actual Value of
Loss Function vs. Constrained Optimum,
by Model

Components of Loss Function	Historical[1]/	Models[2]/							Average of all Models
		BEA	DRI	FAIR	MPS	MQEM	SL	WQ	
GNP	443.2	130.0	34.3	26.0	73.8	59.7	112.4	243.1	97
Unemployment	41.6	19.3	8.5	4.1	12.4	10.9	11.5	36.0	15
Inflation	211.3	215.3	336.8	213.5	207.8	177.7	360.6	161.9	239
Trade balance	3.2	6.3	0.8	6.7	10.4	0.8	N.A.	0.3	4
TOTAL	699.3	371.0	380.5	250.3	304.5	249.0	484.6	441.2	354

[1]/ The value of the loss function and its components with all variables set at their historical values for 1971.1-1975.1.

[2]/ For each model, the optimized value of the loss function and its components, with the optimization constrained by instrument smoothness requirements specified by the model proprietor (see Appendix).

the optimal policies which were selected succeeded in producing sub-
stantial reductions in L. The FAIR and MQEM policies produced the most
dramatic improvements, dropping the loss from 699.3 to about 250 -- or
a 64 percent reduction in the loss. The SL and WQ policies produced the
smallest relative decreases -- 31 percent and 37 percent, respectively.
The remaining models -- BEA, DRI, and MPS -- ranked between these extremes,
generating relative decreases in the neighborhood of 50 percent.

Six of the seven model proprietors found it possible to generate
dramatic reductions -- amounting to 80-90 percent -- in the loss due to
the GNP component.[5] In the case of BEA, FAIR, MPS, and MQEM these im-
provements in the performance of GNP (and, correspondingly, employment)
were accompanied by no significant difference between the optimal and ac-
tual loss due to inflation. This is confirmed by the closeness of the
actual and optimal paths of the price deflators in these models. In con-
trast, the DRI and SL models' policies, which produced the same kind of
improvements in GNP and employment, did so at the cost of substantially
higher inflation, i.e., 60-70 percent increases in the inflation compon-
ent of the loss function. To summarize, six of the model proprietors found
that instrument manipulation could produce far better performance with
respect to GNP; none of the six found it possible to improve on the
aggregate loss measure by significantly reducing the loss due to inflation;

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[5] We use the clause "... model proprietors found it possible..." ad-
visedly. Recall that each of the model proprietors was free to con-
strain the optimal control solution by imposing some form of "smooth-
ness" requirement on the instruments. The results in Table 1 there-
fore reflect not only model differences, but constraint differences
as well. We shall remove these elements of inhomogeneity in the sec-
tion of the paper which discusses common-policy simulations.

and two of the six had to accept some worsening of inflation as the price for the improved performance of GNP and employment.

The WQ model proprietors seem to be telling a story somewhat different from that just summarized. The WQ policies did improve on both GNP and inflation. But the reduction of the loss due to inflation was modest indeed -- about 25% -- and was accompanied by a mere 45% reduction in the loss due to the GNP component -- by far the smallest GNP improvement shown in Table 1. This atypical result derives from the fact that the WQ model proprietors imposed far more severe smoothness constraints on their federal spending and tax instruments than did the other model proprietors. In particular, WQ imposed penalties on deviations between the optimal and historical values of instruments, whereas most other models constrained the quarterly variations in the instruments along their optimal path (see Appendix).

Further insight into the optimal control results can be gained by considering the optimal paths obtained for unemployment and inflation. Figure 2 presents the optimal unemployment path as determined in the DRI Model which is typical of the kind of result found in six of the seven models. In general, the policy manipulations produced unemployment rates well below actual levels in 1971 and 1972, held unemployment close to actual levels in 1973, and again produced unemployment well below actual in 1974 and early 1975. Only the WQ Model produced an unemployment path substantially different from that shown in Figure 2. The WQ path has a shape similar to that shown for DRI, but the average level of the unemployment rate for the WQ Model is very much closer to the average actual unemployment rate.
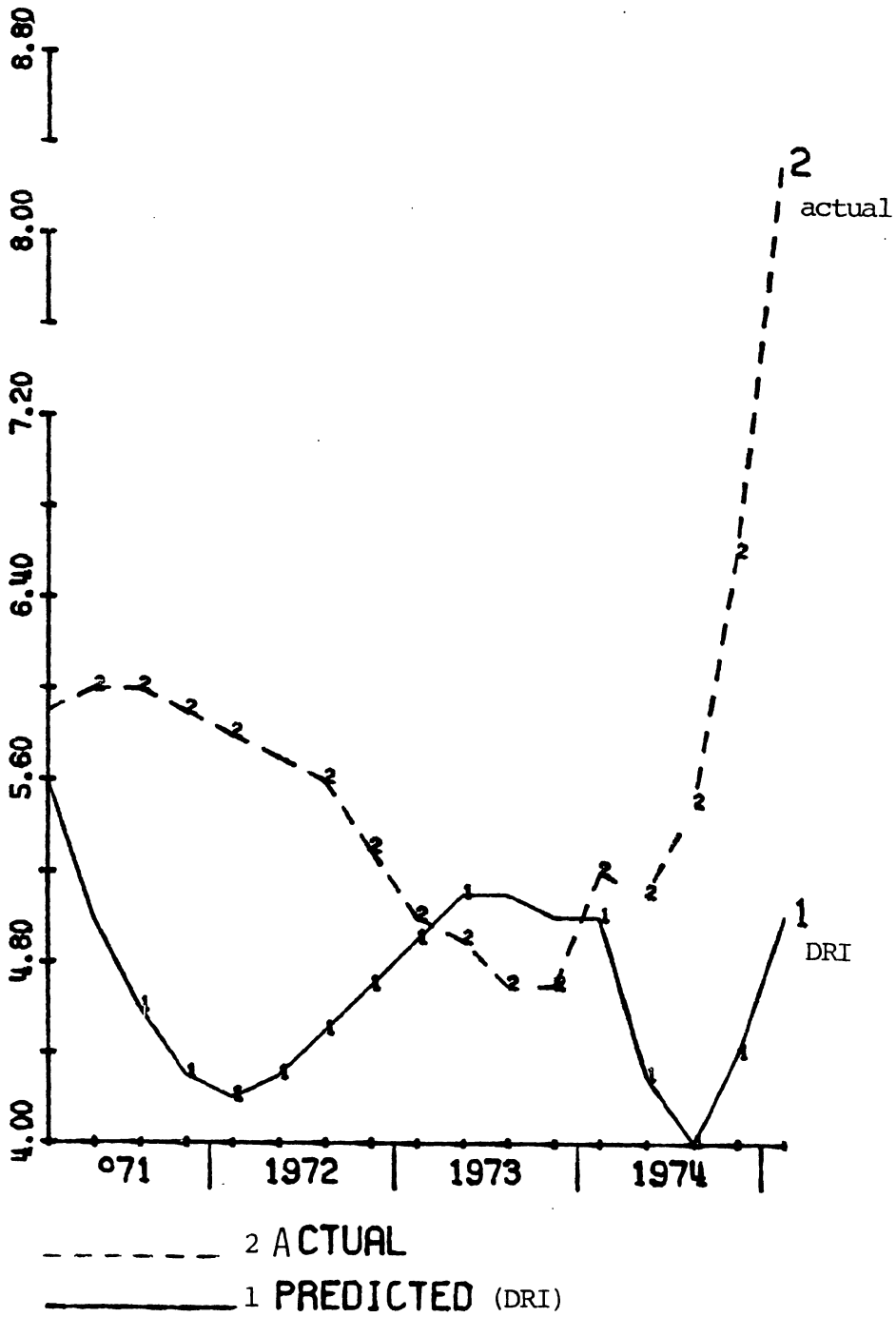
Fig. 2
Unemployment Rate

The typical result with respect to inflation is a time path virtually indistinguishable from the path of the actual inflation rate, as was already noted above. The two exceptions involve the SL and WQ Models. The result for the SL Model is shown in Figure 3. The SL Model pays some noticeable price in higher inflation for its improvement in output (and employment). Roughly, the SL Model produces an inflation rate about 50 basis points above actual in 1971-72 and about 150 basis points above actual in 1974-75. The WQ Model produces an inflation rate similar to that of SL during 1971-72, but then runs inflation some 100-150 basis points below actual during the double-digit inflation period in 1974. It is precisely these results occurring in 1974-75 which account for the differences between the inflation components of the loss function for SL, WQ, and the other five models as a group.

We turn attention now to the main policy manipulations which produced the loss function improvements discussed above. Qualitatively, all of the models tell a similar story regarding the ways in which monetary and fiscal policies should have been conducted during 1971-75.

In attempting to optimize the loss function, all models selected a more expansionary fiscal policy than that actually pursued for the period 1971.1 to mid-1972. The models judged fiscal policy to have been "about right" from mid-1972 to mid-1973, and then opted for a very much more expansive policy than that actually pursued after mid-1973. Figure 4 illustrates this general finding using the results from the BEA Model. In the figure, the actual path of total Federal Government purchases is compared with the optimal path as determined by the BEA Model.
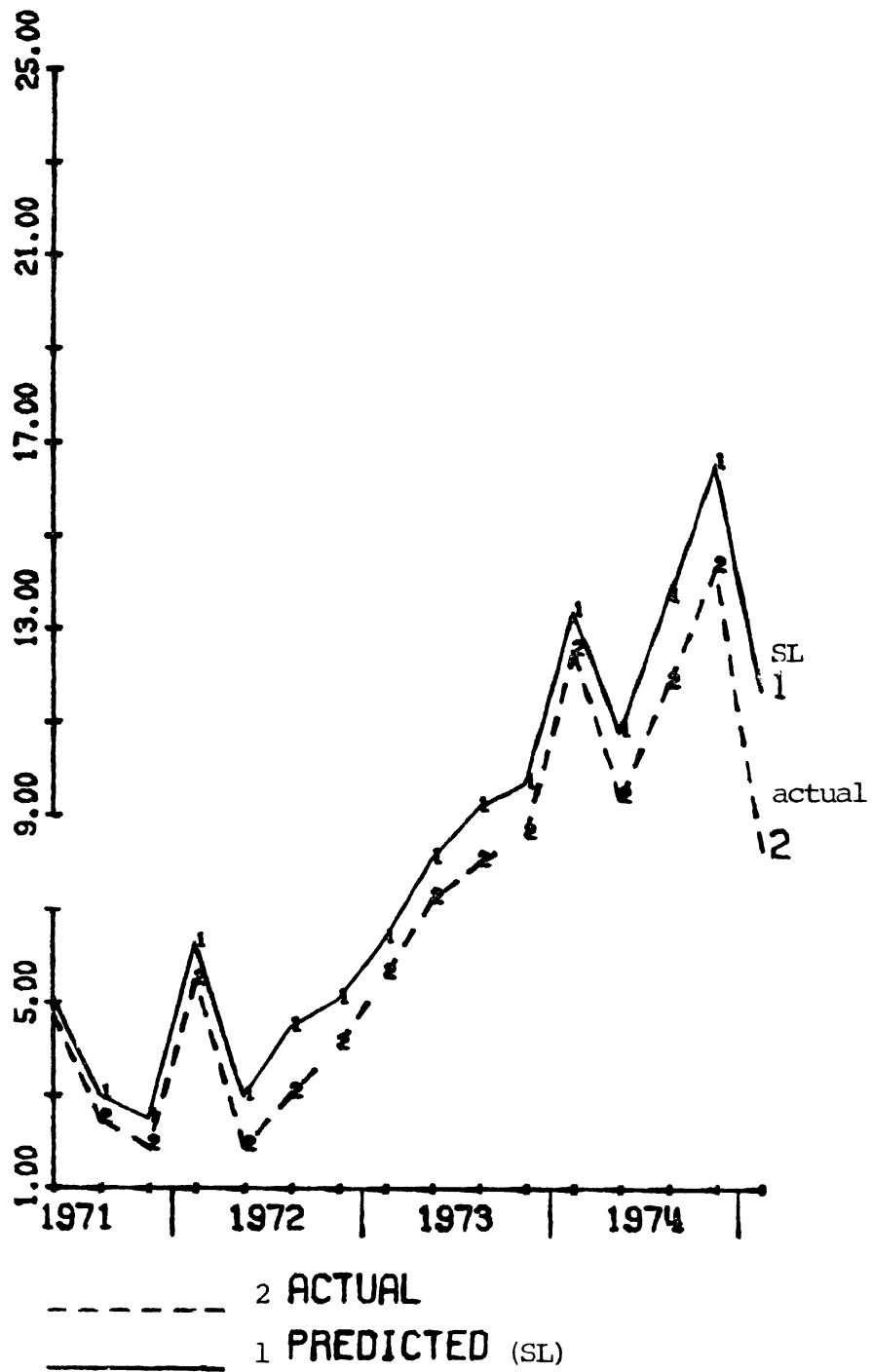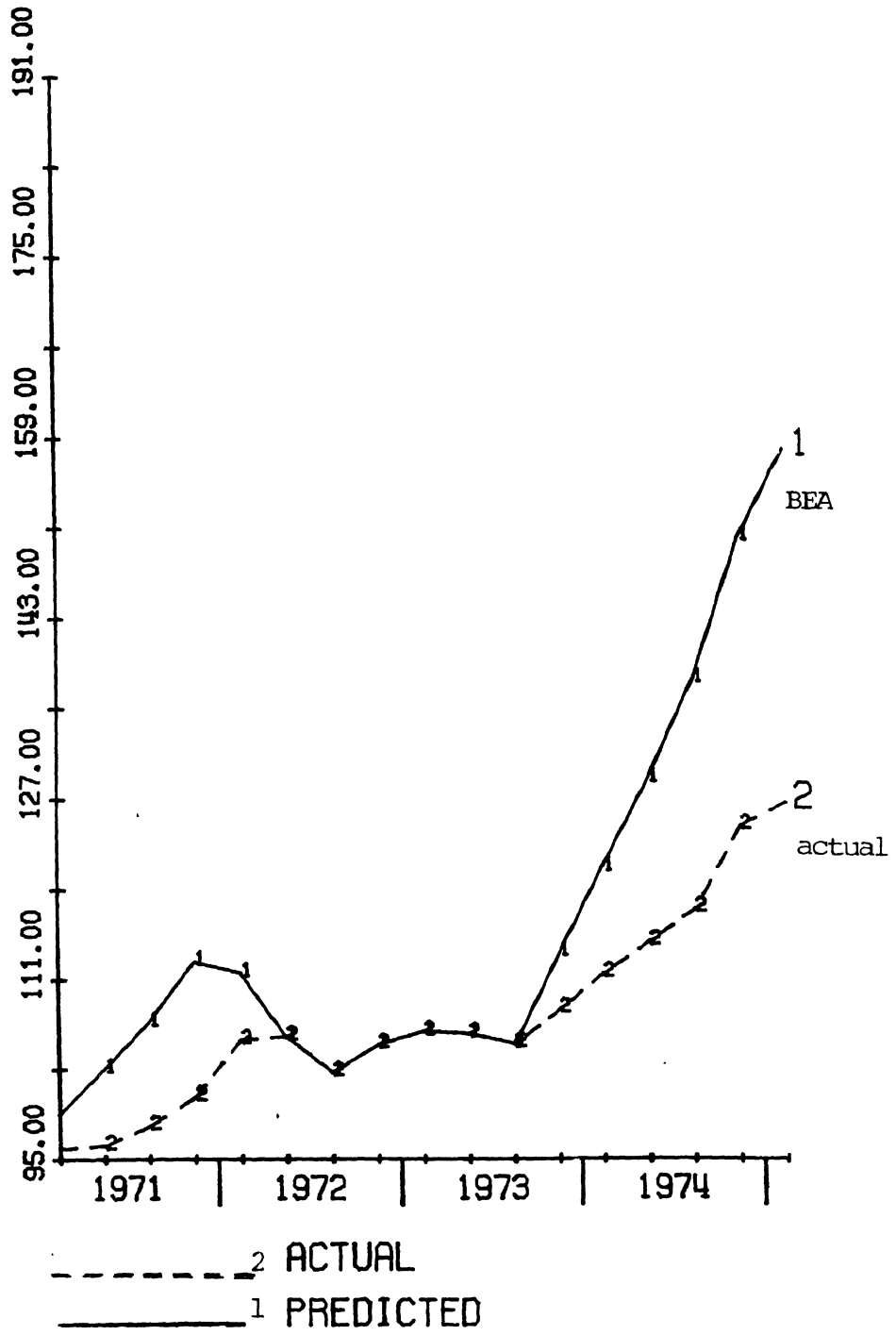
Fig. 3
Inflation Rate

Fig. 4
Federal Government
Purchases

With respect to monetary policy -- whether measured by unborrowed reserves or M1 -- all the models agree that the monetary aggregates were "about right" for 1971-72 and that much greater monetary expansion was required in 1974-75. The models show minor disagreements regarding 1973, with DRI MQEM, and SL turning to more expansionary monetary policy in early or mid-1973 and the other models waiting until late 1973 or early 1974.

IV. Model Results for Common Policies

The results given so far indicate a rather strong qualitative consensus about policies that would have ameliorated the overall conditions of the economy over the 1971-75 period. However, because the optimal control framework permitted the paths and combinations of the instrument variables to vary among models -- due both to differences in model structures and the lack of consistent constraints on the policy instruments -- a consistent (ex-post) recommendation for policymakers does not really emerge.

One possible approach to finding a consensus policy in a quantitative sense would have been a global search across models for the instrument paths that minimize the average value of the loss function. This approach would have been difficult to implement at a reasonable cost, however, and might not even have been useful since a minimum average value of L could be associated with a wide dispersion of values among the models.

In lieu of anything obviously superior, participants were asked to submit simulations for selected common paths of the policy instruments. The results of these simulations, while not representing optimal paths, have value as supplementary information to the optimal control results because they remove the elements of differences in policy mixes and constraints.

Results from two sets of common policy runs are reported. In the first set (policy 1) two instruments are used: Federal Government purchases and unborrowed reserves. The paths chosen are the mean paths from the optimal control runs (see Table 2). In policy 1, Government purchases are substantially above historical levels from 1971.1 to mid-1972, decrease to 1973.1, then rise sharply -- indeed, perhaps unrealistically -- above actual by 1975.1. Unborrowed reserves are close to actual until the end of 1972, then rise substantially more rapidly.

The second common policy simulations (policy 2) use smoother, and accordingly, more realistic paths of Government purchases and unborrowed reserves, especially the former (Table 2).[6] Although the paths of both Government purchases and unborrowed reserves in policy 2 are almost uniformly higher than the historical paths, the movements are much less countercyclical than in policy 1. To compensate for the lesser degree of countercyclical movement of these instruments, the following temporary cuts in Federal individual income taxes are introduced in addition:[7]

1971.1 - 1971.4:	$25 billion
1972.1 - 1973.4:	0
1974.1 - 1974.3:	$25 billion
1974.4 - 1975.1:	$50 billion

Table 3 shows for policies 1 and 2 the value of the loss function and its major components for each model and

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[6] In setting values for unborrowed reserves allowance is made for reductions in reserve requirements in 1972.4 and 1975.1.

[7] The SL model is not included in these experiments since it does not contain personal taxes as a variable.

Table 2. Federal Government Purchases and Unborrowed Reserves
Used in Common Policy Simulations

	Federal Purchases			Unborrowed Reserves		
	Actual	Policy 1	Policy 2	Actual	Policy 1	Policy 2
1970.4	94.8	94.8	94.8	28.2	28.2	28.2
1971.1	95.9	116.7	104.7	29.7	29.5	28.0
2	96.3	116.1	106.1	30.1	30.1	29.0
3	97.9	117.1	108.0	30.1	30.2	30.0
4	100.6	113.1	109.2	30.5	30.6	31.8
1972.1	105.6	120.1	111.4	32.1	31.7	32.6
2	105.9	112.9	112.1	32.7	32.4	33.0
3	102.7	111.2	114.8	32.9	32.8	33.2
4	105.2	108.3	116.3	31.3	32.0	32.7
1973.1	106.4	104.4	118.7	30.6	32.0	32.6
2	106.2	111.0	119.6	30.7	32.6	33.0
3	105.3	112.2	121.2	32.1	34.4	34.0
4	108.4	112.3	123.4	33.2	36.4	34.8
1974.1	111.5	132.9	124.8	34.3	37.5	35.6
2	114.3	133.3	127.2	34.2	37.8	36.6
3	117.2	133.4	128.9	34.2	38.8	37.6
4	124.6	164.8	131.8	35.4	40.0	38.6
1975.1	126.5	193.4	132.3	35.6	40.3	39.0

Table 3. Value of Loss Function Under Common Policies

Components of Loss Function	Historical	BEA	DRI	FAIR	MPS	MQEM	WQ	Average of all models
				Policy 1				
GNP	443.2	200.4	93.6	94.8	252.5	151.0	24.7	136
Unemployment	41.6	24.1	16.6	16.7	28.8	17.7	15.2	20
Inflation	211.3	254.4	243.6	176.0	240.6	214.8	498.2	271
Trade balance	3.2	3.5	4.0	4.0	6.8	4.9	6.5	5
Total	699.3	482.4	357.8	291.5	528.7	388.4	544.5	432
				Policy 2				
GNP	443.2	164.9	122.1	219.2	149.0	151.6	105.1	152
Unemployment	41.6	21.2	12.4	25.2	9.3	14.8	18.0	17
Inflation	211.3	223.7	320.2	225.5	471.0	208.1	912.0	393
Trade balance	3.2	5.4	5.4	3.5	29.2	5.4	7.2	9
Total	699.3	415.2	460.1	473.4	658.5	379.9	1,042.3	572

The column headers BEA, DRI, FAIR, MPS, MQEM, WQ fall under the heading "Models".

for the average of all the included models. The loss is reduced for all models compared to its historical value, and for most models, quite substantially so. However, for all but the DRI model, L is larger than the corresponding value in the optimal control simulation -- a not unexpected result since the common (averaged) policy instrument paths are for no model identical to the optimal paths, and some models used the personal tax instrument in addition.[8/] The WQ model shows only a 22 percent reduction (relative to actual) compared with a 30 percent drop in the optimal case. At the other extreme, the FAIR model shows nearly as large a decrease as before. As in the optimal control solutions, improvement is achieved primarily through reductions in the GNP and unemployment terms. The inflation component deteriorates for five of the six models, though substantially so only for the WQ model.

Policy 2 yields similarly improved performance (compared to historical behavior) for the BEA, DRI, and MQEM models: L is smaller under policy 2 than under policy 1 for the BEA and MQEM models and about 140 points larger for the DRI model -- the latter reflecting principally moderately worsened performance in the inflation component. The MPS and, most notably, the WQ models have substantially worsened inflation components under policy 2. As a result, the L value for MPS is only 6 percent below that for historical target variables and for WQ, it is 49 percent higher! For the FAIR model, L is about 180 points higher under policy 2 than under policy 1, but in this case the increase reflects principally higher GNP and unemployment components.

8/   Apparently, DRI's trial-and-error solution procedure failed to determine a true minimum for L subject to the DRI model.

It is interesting to note that the spread of L values among models is larger for both sets of common policies than for the optimal policies. The range of values (from largest to smallest) is 252 under policy 1 compared with 236 under the optimal policies. Under policy 2, the range increases to 662, and even with the extreme WQ result omitted, the range is 279. Such results are to be expected since the constraint of a common policy deprives each model proprietor of the flexibility of optimizing the mix of instruments. This deprivation will inevitably be more constraining for some models than for others.

We turn now from loss function values to direct examination of economic performance, as measured by the unemployment and inflation rates. Figure 5 displays the results for two of the models.

Results for the DRI model may be taken as roughly representative of those models for which both common policies reduced the value of L more than 30 percent -- BEA, DRI, FAIR, and MQEM. Under policy 1, the unemployment rate is substantially below actual levels before mid-1972 and again after 1974, while the inflation rate is generally close to actual levels. Under policy 2, the unemployment rate is continuously below actual, even dropping below 3-1/2 percent in late 1973; and the inflation rate is moderately higher in certain periods -- mainly in 1973 and 1974. The inflation rates for the other models in this group exhibit little difference from actual rates under either policy.
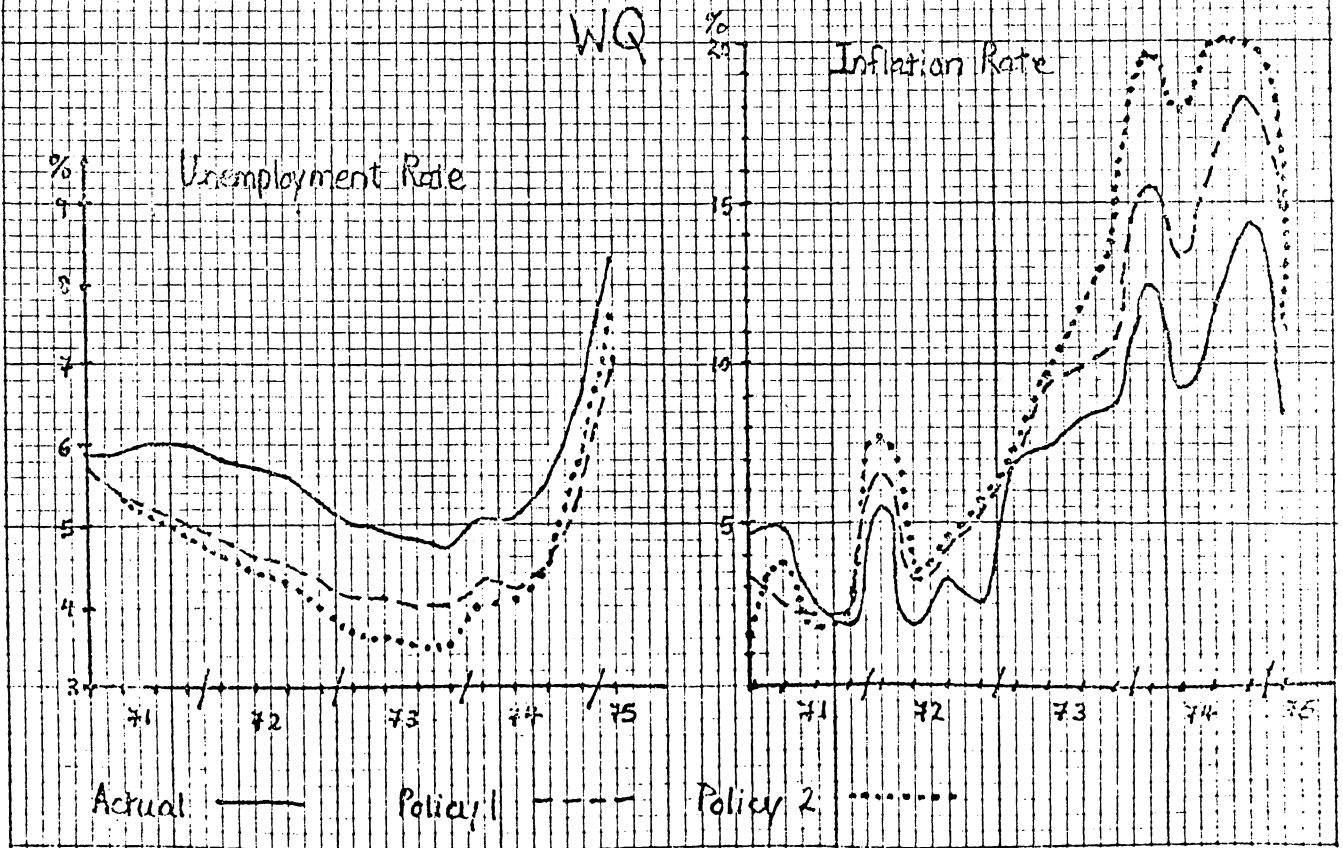
The WQ model simulations represent the extreme case of strong price responses to both common policies, but especially to policy 2 during the 1974-75 period, when the average inflation rate was 17.7 percent compared to 11.3 percent for the actual rate (see Figure 5). To be sure, the unemployment rate is lower in WQ's policy 2 simulation than in DRI's during

Figure 5
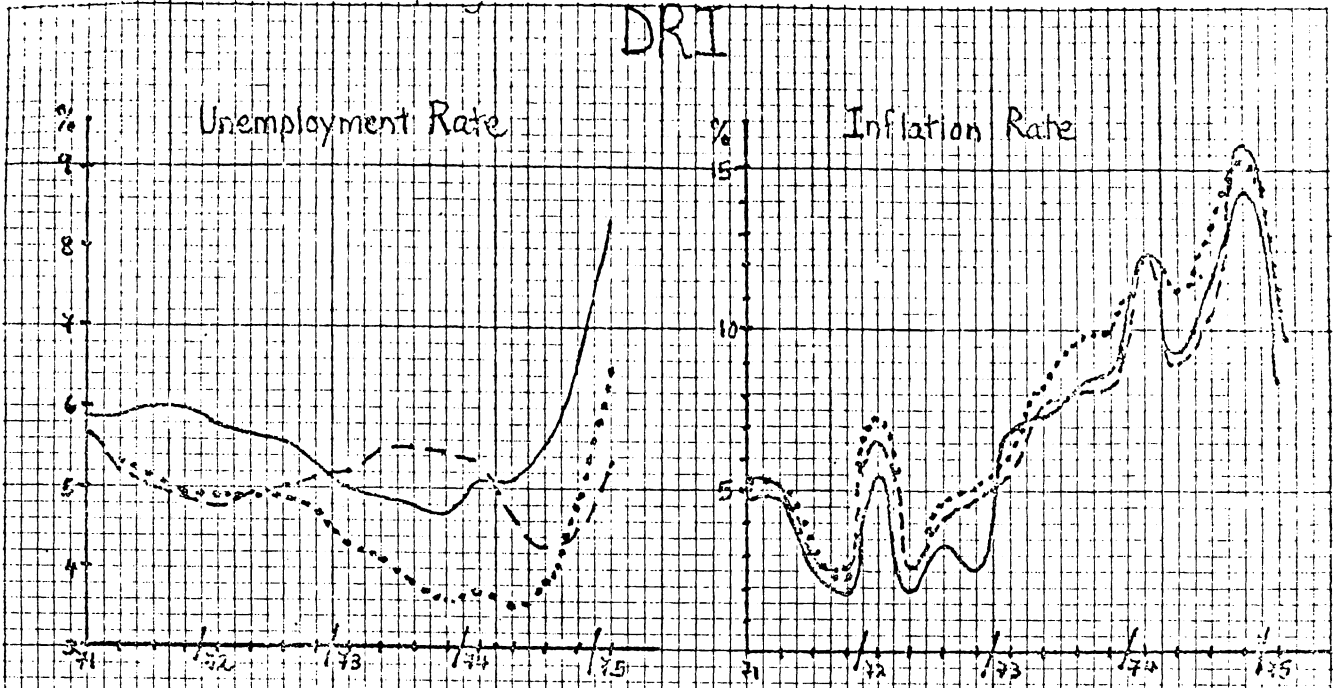
1972 and 1973. However, it is similar to FAIR's after 1973.2 and does not drop as low as MPS's. Yet the inflation rate for FAIR during 1974-75 is virtually the same as the actual and that for MPS is only 3 percentage points higher than actual. It is thus clear that the WQ model has extreme price sensitivity with respect to the unemployment rate -- at least for unemployment rates well below 5 percent -- compared to the other models.[9]/

Despite the substantial differences in performance among models shown in this section -- differences that were obscured in the previous section by the differences in instrument paths -- the main findings of the optimal control simulation experiments is reconfirmed by most of the models: namely that more expansive fiscal and monetary policies, especially in 1974-75, could have improved the output/employment situation with little probable damange on the inflation front. The "minority report" (by MPS and WQ) of strong inflationary responses under policy 2 may be taken as indicative that a somewhat more moderate stimulus than was introduced under that policy during the latter part of the period would have been in order.

9/ Apparently, the strength of this characteristic in the WQ model was partly hidden by the severe instrument constraints applied when the optimal control calculation was performed.

V. Summary and Conclusions

We have reported on the results of experimenting with seven econometric models in order to investigate the potential for improved performance of the U.S. economy in the early 1970's through alternatives to historical policy actions (i.e., different paths for conventional fiscal and monetary policy instruments). The consensus findings may be summarized as follows: (1) A more restrictive fiscal policy before 1970 (specifically, higher taxes beginning in 1966) would not have rescued the economy from instability and excessive inflation in the early 1970's; (2) instability in output and employment could have been reduced by more expansive fiscal policy during 1971 and early 1972 and during 1974-75, along with a more expansionary monetary policy beginning, at the latest, early in 1974.

The models disagreed about the inflationary effects of much more expansionary fiscal and monetary policies in 1974-75: most models showed little inflationary cost, while two models (MPS and WQ) showed considerable sensitivity in this regard. This difference was more clearly revealed in the common policy simulations than in the optimal control experiments.

A principal value of the approach to historical analysis utilized in this study lies in its highly disciplined nature. Even though the loss function used was necessarily arbitrary, it provided a common and consistent basis for analysis. Moreover, the conclusions resulting from the chosen loss function seem to us to be similar in meaning to those that would have emerged from a large number of modest perturbations to the loss function.[10]

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[10] Obviously, this conjecture could be tested. Further studies along the same lines as ours should probably include loss function perturbation.

At the same time, close examination of the findings reveals the substantial quantitative differences existing in the response mechanisms of the different models. This is consistent with earlier studies which turned up differences among the policy multipliers in early versions of these models.[11/] Seen from the standpoint of scientific adequacy, these are disconcerting differences. Yet such differences should come as no surprise to the practitioners of econometric modelling; they are to be expected from differences in model structures and the weakness of our current base of knowledge when it comes to formal criteria for the comparative evaluation of large and complex macroeconometric models. The lesson to be derived, given the present stage of model development, is that while analyses of the type performed in this study can be useful and perhaps even important to policymakers, the latter are well advised to examine the results of more than one model and to combine these results with the evidence from other analytical approaches.

[11/] See Carl F. Christ, "Judging the Performance of Econometric Models of the U.S. Economy" and Gary Fromm and Lawrence R. Klein, "The NBER/NSF Model Comparison Seminar: An Analysis of Results," in Lawrence R. Klein and E. Burmeister, (eds.), Econometric Model Performance (University of Pennsylvania Press, 1976).

APPENDIX

Smoothness Constraints Applied
in the Optimal Control Calculations

BEA

Constraints were applied to limit the <u>quarterly changes</u> in instrument variables as follows .

1) Federal purchases: $\leq$ $7 billion

2) Unborrowed reserves: < $2 billion
   (plus a limit of $3.5 billion and $4.5 billion over 2 and 3 successive quarters)

3) Federal personal tax rate: $\leq$ 6 percentage points

DRI

No constraints applied.

FAIR

Constraint applied to 90 day treasury bill rate as follows:

1971.1 - 1973.1: bill rate constrained to historical value

1973.2 - 1975.1: bill rate set at 6%

MPS

Minimum value constraints applied to the 90 day treasury bill rate and to the tax rate applied to quarterly changes in the aggregate federal personal tax base, as follows:

bill rate $\leq$ 0.5%

marginal tax rate $\leq$ 0.5%

MQEM

The optimal control problem was first solved without constraints and then cubic time trends were fit to the resulting instrument values. Smoothed instrument values were read off the cubic time trends and applied to produce the results contained in this paper.

SL

No constraints applied.

WQ

The following terms were added to the Loss function to penalize deviations from the historical paths of the instruments:

$$(100 \frac{GF\$_t - GF\$_t^a}{GF\$_t^a})^2 + (100 \frac{FPTR\%_t - FPTR\%_t^a}{FPTR\%_t^a})^2$$

$$+ .05(100 \frac{UR\$_t - UR\$_t^a}{UR\$_t^a})^2$$

where

$GF\$_t$ = federal purchases in quarter t (billions of $'s).

$FPTR\%_t$ = effective federal personal income tax rate in % in in quarter t

$UR\$$ = unborrowed reserves in quarter t (billions of $'s).

and the superscript "a" denotes the actual or historical value of a given variable.