BERNHARD BÖHM, PETER BRANDNER

# Economic Policy Making With An Econometric Decision Model

37

BERNHARD BÖHM, PETER BRANDNER

# Economic Policy Making With An Econometric Decision Model

## Practical Experiences for Austria

March 1990

WIFO Working Papers, 1990, (37)

# ECONOMIC POLICY MAKING WITH AN ECONOMETRIC DECISION MODEL

## Practical Experiences for Austria

Bernhard Böhm
University of Technology
Argentinierstr. 8, A-1040 Vienna, Austria

Peter Brandner
Austrian Institute of Economic Research
A-1103 Vienna, P.O.Box 91, Austria

**Abstract**

This paper presents main features of a nonlinear macroeconometric model for the Austrian economy which serves as an input to derive a set of constraints for macroeconomic policy optimization. Linearized versions of the model are applied to several interactive methods for the optimization of a vector of economic policy targets using a set of mainly fiscal and monetary instruments. The techniques based on linear programming differ from each other in the information requirements and the conduct of the interaction. We consider the Step-Method (Benayoun et al. (1971)), Interactive Multiple Goal Programming (Spronk (1981)), and a method proposed by Zionts and Wallenius (1976). To assess the practical impact of methods and implementation we present results of a comparative evaluation of the techniques together with an implementation of DIDAS (developed and provided to us by the International Institute of Applied Systems Analysis, Laxenburg). People involved in practical economic policy decision making for Austria have been invited to participate. Among the participants were members of the chamber of commerce, the ministry of finance, the national bank and members of the national council. A premiliary survey of the results achieved and a critical comparative evaluation is presented.

**Keywords:** Interactive vector optimization; optimal economic policy making; macroeconometric model.

**Contents**



This is a revised version of the paper "Optimal Economic Policy Making with Interactive Methods of Vector Optimization. Practical Experiences for Austria" presented at the "Second International Conference on Econometric Decision Models" 29.8.-1.9.1989, University of Hagen, FRG. We would like to thank M. Luptáčik and P. Müller for helpful discussions on earlier versions.

## 1 INTRODUCTION

The problem of economic policy making is to search for the joint realization of economic objectives which in most cases are in conflict with each other. There exist numerous attempts by economists to provide solutions to such problems by formulating some kind of decision models (Gruber (1983), Despontin et al. (1984), Hughes Hallett (1984)). A survey about the uses of macroeconometric models for policy formation is given by Klein (1986). By taking a normative approach of decision making the question of how to choose values for the decision variables (instruments) arises. Most approaches use an *a priori* specified preference function to derive an optimal policy. Considering the difficulty of formulating explicit preference or goal functions we intend to draw attention to the potential benefits of interactive optimization techniques for decision making with econometric models. We, therefore, shall not assume knowledge of an objective function but rather show the potential merits of an interactive procedure between the policy maker and some optimization algorithm to reach a subjectively optimal set of target values given the economic conditions in the form of an econometric model. Even for this approach one is confronted with a great number of potential techniques. We shall choose three particular ones and provide evidence with respect to their qualities when applied to a medium sized econometric model.

Most applications of multiple objective decision making (MODM) methods were intended to demonstrate the use of a particular algorithm (e.g. Despontin (1982)). Other studies that compare the performance of MODM procedures use fictitious problems which have to be solved by students, staff members of research departments or managers from industry (Wallenius (1975), Brockhoff (1985), Buchanan and Daellenbach (1987)). As far as we know, a comparative evaluation of MODM methods with a real world problem and active policy makers has not been reported.

The paper is organised as follows: Section two gives a short review of approaches to optimize economic policy with multiple objectives. The third section discusses shortly the interactive optimization techniques used and their implementation in the IAO-program package. The nonlinear econometric model with 72 equations and its properties are discussed in the fourth section. This section also discusses the problem of how to linearize the constraints relevant to policy optimization. We use the final form of the dynamic nonlinear model as a linear approximation. Section five describes the experimental design for the interactive economic policy optimization and gives a preliminary comparative evaluation. Section six concludes.

## 2 ECONOMIC POLICY MAKING WITH MULTIPLE OBJECTIVES

Facing real world economic policy problems, a well known approach is to simulate an econometric model for alternative policies which means to select some values for the instruments and solve for the objectives ("fixed instruments approach"). Obviously, such simulation exercises are a poor tool for finding the best policy. By considering only a small number of *a priori* specified policies, it is an inefficient method. Simulation experiments by trial and error do not exploit all information of the econometric decision model, trade-offs between objectives can not be properly examined. A consequence of the unsystematic search process is the possible consideration of alternatives which are not Pareto optimal. Additionally, no operative framework guides the decision maker to select an optimal policy.

Tinbergen (1952, 1956) adopted the opposite view in order to reach an instrument/objective combination. He suggested to choose some values for the objectives and solve for the instruments ("fixed targets approach"). Generalizations along this line were discussed in Russel (1975), Preston (1974, 1977), and Preston and Sieper (1977).

Theil (1964) introduced explicitly an objective function supposed to represent the decision maker's preferences. He assumed that decision makers are able to express desired values for objectives and instruments. Then a quadratic cost function can be minimized under the restriction of a linear econometric model[1]. Friedman (1975) analysed piecewise quadratic preference functions within this "flexible targets" approach. Further generalizations consider a dynamic objective function which leads to optimal control problems (Chow (1975), Pitchford and Turnovsky (1977), Holly et al. (1979), among others). Preston and Pagan (1982) present a unified treatment of the Tinbergen/Theil approach to the theory of economic policy. Restricted to the linear/quadratic model, the existence, uniquesses and design of policy is analysed in a static as well as dynamic framework. Hughes Hallett and Rees (1983) give an integrated account of these methods of quantitative economic planning in which decision makers play an explicit role through descriptions of their preferences, information, and risk aversion by extending the (dynamic) optimization framework with qualitative properties.

Frisch (1961, 1976) (see also Johansen (1974)) proposed to construct an explicit preference function intended to express the preferences of the decision making authority via interviews. Basically three types of questions have to be raised to policy makers in order to identify parameters of the preference function and points of indifference. The estimation of preference parameters rather than applying interview schemes has also been considered as a tool for constructing an explicit preference function (Ancot et al. (1982), Ancot and Hughes Hallett (1983), among others).

While the explicit knowledge of a preference function is not required for conducting simulation studies, its specification is essential for the traditional optimizing framework starting with Theil's approach. Regardless of how scalar valued preference functions (or cost functions) have been constructed, a policy maker is no longer needed. Optimal policy is the outcome of a mathematical optimization exercise, a decision making process does not evolve. Such a solution to the economic policy problem may satisfy optimality conditions, but aspects concerning the quality of the decision are not taken into account. No decision process takes place. This is at variance with R. Frisch's (1976, p.92) ideas of economic policy making:

> Only through such a cooperation with demonstration of alternatives will it be possible to map out to the authorities the feasible alternatives and to help them to understand which one – or which ones – amongst the feasible alternatives are the most desirable from their own viewpoint. To develop a technique of discussing feasible policy alternatives in such a scientific way is one of the most burning needs in economic policy-making today.

It turns out that interactive methods for solving multiple objective decision models are well suited for economic policy making. The next section highlights the main features of such methods.

[1] Note that Tinbergen implicitly used a quadratic objective function weighting deviations from the target values infinitly high and weighting deviations from the instruments with zero.

## 3 INTERACTIVE OPTIMIZATION WITH MULTIPLE OBJECTIVES

Decision problems are characterized by the interaction of a decision maker, a model, and an optimization technique. Solving decision problems with multiple objectives requires methods which

- help the decision maker to clarify the complex structure of the system and confront him with trade-off choices
- pay attention to psychological and sociological aspects of decision making
- assist the decision maker to find his optimal solution
- take into account for learning effects.

Obviously, methods that first collect all preference information and then solve the problem are not the relevant ones. Decision makers often decide in a stepwise and iterative manner because they are not always able or willing to express their preferences once and for all.

By the use of interactive optimization techniques the decision process is formalized: The decision maker operates from one solution to another, guided by local preferences. Local preferences are those which are formed with respect to a current solution. The decision process is an interactive collection of preference information and iterative calculation of compromise solutions. The nature of including preference information articulated in an interaction differs between methods. The decision maker may determine or judge trade-offs among objectives, define aspiration levels (minimum or maximum values) for one or more objectives, or choose a most preferred solution from a set of (efficient) solutions.

There exists a great number of available techniques to solve multiple objective decision problems (see e.g. Hwang and Masud (1979), Despontin et al. (1983), Grauer and Wierzbicki (1984)). Here we concentrate on four interactive methods which seem to us to possess just the right qualities in order to explain the basic ideas to policy makers[2]. We shall use the Step-Method (STEM) developed by Benayoun et al. (1971), interactive multiple goal programming (IMGP) by Spronk (1981), the method of Zionts and Wallenius (1976)(ZW) and the reference point approach as implemented in DIDAS by Rogowski, Sobczyk, and Wierzbicki (1988). As detailed descriptions of these methods are readily available in the relevant literature we shall only present the basic ideas and point out a few amendments which have been made in our computer application.

### 3.1 Techniques of Interactive Optimization

One can distinguish two principles of interactive techniques. One is based on the assumption of an implicitly available preference function to be optimized. However, details like weights are not explicitly known and have to be retrieved by interacting with the decision maker. The ZW-method belongs to this group. It assumes a linear preference function with unknown weights (for a concave function, see Zionts and Wallenius (1983)). By an iterative procedure which involves asking the decision maker questions concerning his preferred trade-offs between the objectives the unknown weights can be determined. The decision maker is not required to estimate his marginal rates of substitution numerically. After showing a Pareto-optimal solution, the decision maker is only requested to

[2]Obviously other methods also possess such qualities (e. g. Rosinger's algorithm as applied by Streuff and Gruber (1983)). Our selection was determined by easily available PC-software.

answer wether certain trade-offs presented to him are desirable, undesirable or neither. In the case of an underlying concave preference function, the decision maker additionally has to compare efficient solutions. Based on Brandner (1984), the IAO-program package derives new weights for the composite preference function from the answers in a more efficient way than suggested in the original ZW-method.

The second principle corresponds closely to the idea of satisficing. By stating bounds on the values of objectives the decision maker may change the solution space in each iteration until it shrinks to a satisfactory point. Both STEM and IMGP belong to this group of methods.

In STEM the decision maker is always confronted with a compromise solution which has been derived from the ideal (and unfeasible) solution by applying the minimax criterion. By comparing the Payoff-matrix of the initial stage with the compromise solution at each iteration, the decision maker is asked which and how much of the target values may deteriorate in order to improve at least one other objective. Using the minimax criterion as a measure of distance, the efficiency of the compromise solution is not ensured. In the IAO-program package a modified version of STEM has been implemented, so the decision maker is always confronted with an efficient solution.

In the IMGP method the decision maker has to provide his preference information on the basis of a proposed solution and a Potency-matrix which consists of a vector of ideal and a vector of pessimistic (minimum requirement) objective values. It starts from the worst possible point and enables the decision maker to indicate his wishes for improvements and to state aspiration levels. At each iteration the decision maker has to indicate wether a proposal solution is satisfactory or not and wether shifts in this solution are outweighed by shifts in a new Potency-matrix which represents a reduced objective space. A number of features already discussed in Spronk (1981) have been added to the basic IMGP algorithm and are available in the IAO-program package. Based on Müller (1985), it is possible to state aspiration levels at any iteration step. If targets are to be improved simultaneously the decision maker has the opportunity to state a weighting vector via improvement qualifications. Furthermore, an efficient solution can be presented at each iteration step.

A combination of the above mentioned two principles of interactive techniques can be found in the reference point approach as implemented in DIDAS (Rogowski, Sobczyk, Wierzbicki (1988)). The decision maker is assumed to specify aspiration levels for all objective outcomes (the reference point) in order to influence the selection of efficient decisions. A parametric scalarization of the multiobjective problem is then obtained by maximization of an order approximating achievement function where the reference point enters as parameter. As a result the user is confronted with an attainable efficient solution that is uniformly as close to the aspirations as possible. Scanning several representative efficient solutions and outcomes controlled by changing aspirations, the user should learn enough to select either an actual (subjective) decision or an efficient solution proposed by DIDAS as a basis for actual decisions. Further discussion concerning this approach can be found in Olbrisch (1988).

## 4 THE ECONOMETRIC MODEL

Any model is capable of representing reality only in a limited way. It is therefore obvious that also the present model cannot comply with the wishes and ideas of every possible policy maker. The optimization exercise is thus constrained by the structural information contained in the model and its quantitative representation. We assume a constant structure of the model based on annual observations from 1964 until 1984. Recent data revisions and additions until 1987 support this assumption. The 30 stochastic equations of the model have been estimated by the ordinary least squares method where careful attention has been paid to a proper dynamic specification (Hendry (1986))[3]. Thus most behavioural equations exhibit an error correction mechanism. This specification approach captures both short run dynamics as well as long run information of the time series. The basic long run economic theory underlying the model specification is briefly discussed in the following.

### 4.1 The structural form

The macro model is basically Keynesian in spirit but contains neoclassical elements as well. Aggregate demand is the driving force of the economy, production is assumed to adjust. Disequilibrium may occur in the labour market. The fundamental building blocks of the model, which consists of 72 equations, are:

- components of real aggregate demand,
- prices and wages,
- labour market,
- formation of income,
- a small monetary sector,
- the public sector.

A main objective in model building was the explicit consideration of government economic activity with a spectrum of possible instruments. Thus, emphasis is placed on a distinction between private and public sector variables. Public consumption and investment at current prices are treated as exogenous instruments. Private sector behaviour is assumed to be governed by profit and utility maximization. Based on a CES-production technology firms derive their demand for investment goods and labour, consumers solve their consumption and time allocation problem to arrive at functions for consumer demand and supply of labour. The unemployment rate results from the interaction on the labour market. Prices are determined by the mark-up principle. Hourly wage formation is based on an expectations augmented Phillips-curve with additional working time effects. The latter are included to provide a wage compensation rule for a working time reduction policy. Price expectations are derived from the estimated consumer price equation. These expectations are not "rational" in the sense of Muth (1961). The model is not solved for them recursively. The model-generated inflation forecast affects wage increases directly in the short run. In the long run price expectations as well as changes in the legal working time do not matter.

Import and export equations depend on relative prices and an activity variable. The small monetary sector reflects the institutional fact that Austrian interest rate movements depend heavily on the international liquidity situation. The policy of pegging the Austrian shilling to the German mark suggests a close short run relationship of the respective short term rates. The movements of the long term rate are in the long run directly proportional to the short term rate and negatively proportional to real money growth (M3). The stock of the latter is explained via the multiplier mechanism of money creation transmitting the

[3] *PC-GIVE* (Hendry (1987)) was used to carry out the estimation. A listing of the model equations and variables can be found in the appendix C.

indirect effects of current and capital account on base money as well as required reserve and savings policy of the central bank.

In income determination the role of government as redistributor becomes obvious. Indirect taxation and subsidies finally influence the gross price level and thus the nominal value of the income to be distributed. Direct taxation of firms and households as well as the institution of social insurance determine their disposable income. The public sector budget constraint determines the changes in the stock of total public debt which in turn influences the budget via the necessary debt service. The government is assumed to control its expenditures for consumption and investment and the average rates of indirect and direct wage taxation. It also determines the level of subsidies and jointly with the "social partners" (i.e. firms and labour union representatives) the employers' share of social security contributions.

These variables, controlled by the government, will be regarded as instruments for the optimization experiments undertaken. In addition the legal working time per week (under control of the "social partners"), the rate of interest on savings deposits and the (effective) required reserve ratio (essentially controlled by the national bank) will also be considered as a policy instruments. One may also want to include the exchange rate as policy variable. However, under the current foreign exchange regime in Austria this variable can only indicate whether its changes lead to more or less favourable external conditions when compared with the current value which is basically derived from the DM/US$ relation. It cannot be regarded as an instrument in the proper sense but may be set to some level expected by the policy maker before the optimization procedure is started.

### 4.2 The final form

Dynamic properties of the nonlinear model can be assessed by inspecting the final form multipliers. Starting with the last year of our sample observations 1984 a control path for the endogenous variables of the model up to 1995 is generated. For each of the aforementioned exogenous instrument variables the effects of an impulse change have been traced and are graphically displayed in figures 1 to 11. A dominant cyclical adjustment process is recognized. There seems to be evidence for stronger cycles in the adjustment of the unemployment rate. As an explanation could be offered that the dynamic specification of the labour force equation (actually an equation for the labour force participation rate) is of second order. Another feature of the dynamic profiles also catches the eye. Quite often a marked difference between the impact and the first lagged effect can be observed. This is of particular relevance for economic policy optimization as it might happen for a particular policy to have opposite effects in different periods. Thus, optimization over more than one period could prove very difficult for the decision maker and, in fact, might imply radical changes in instrument values. This fact must be borne in mind when interpreting our empirical examples. We restrict the experiment to one period only and leave the intertemporal problem for a different investigation.

A closer examination of public expenditure policy shows stronger impact of investments as compared to transfer payments on $GDP$. After about four periods their total effect is approximately the same. Investment has slight advantages when considering public debt and seems more suitable to fight unemployment than expenditures on transfers to households. Increasing the government wage bill is a relatively short run policy as far as output is concerned but stimulates inflation and increases debts in the long run. Higher subsidies cut prices at least for up to four periods and lead to higher output in turn. This stimulation is thus responsible for the suspension of the unemployment-inflation trade off. However, with an impact multiplier above unity with respect to debts subsidies are a rather costly policy tool even in the short run.

The two types of average tax rates differ markedly with respect to their influence on prices. Raising the indirect tax rate immediately raises prices, too, but affects output only with a lag of one period. It is, therefore, better suited for a debt reduction policy than a raise in direct (wage) taxation. The latter has advantages for fighting unemployment as a fall in disposable real wages deters people from joining or staying in the labour market. The direct damping effect on real disposable wage income is more than twice as strong compared to an indirect tax rate increase. As a consequence $GDP$ drops immediately by some 1.4 bill. A.S. In contrast, under higher indirect taxation $GDP$ is – for the moment – slightly increased resulting from an overcompensation of the drop in private consumption by investment which is stimulated by a large fall in the real interest rate. However, the following periods bring about a much larger drop in $GDP$ than under increased wage taxation so that on balance the latter is less detrimental to the growth target. Indirect taxation contributes a lot to reduce public debts but at the cost of almost all other economic objectives. Direct wage taxation avoids the push in inflation and, apart from contributing to the reduction of debts, brings about even slight advantages for the labour market.

Simulating a shortening of the legal working time seems to lend some evidence in support of such a measure to ease tensions on the labour market. It is assumed that workers receive a 0.5 % compensatory increase in their hourly wage rate for a reduction of 1 % in their working time. Up to four periods after the introduction of a one-hour-less-impulse reduction in the unemployment rate can be observed. There are also no other disadvantages to be noticed immediately. However after two periods prices pick up and output falls substantially. A long cyclical reaction takes place in the course of which inflation helps to reduce some debts. Increasing the share of employers' contributions to social security amounts to a rise in wage costs for firms. Short run effects dominate and are favourable only for government debt.

The effects of a unit change in the interest rate on savings deposits are the expected ones and relatively moderate in size. In practice, this rate plays the role of representing the financial "climate". It basically influences the long term interest rate which functions as the main monetary-real transmission mechanism via investment demand. Changing the (effective) required reserve ratio yields similar results in direction and magnitude as the interest rate change. Both could be regarded as policy substitutes for each other. A final look at the effects of a 5 % devaluation of the Austrian Shilling with respect to the US Dollar shows nothing unexpected. The familiar J-curve effect in the current account ($HDLB$) and $GDP$ is accompanied by an inflation shock due to the increase in import prices and a little bit more uneasy situation on the labour market. One should bear in mind that this simulation actually represents an exercise of the effects of the DM/US$ relation on the Austrian economy keeping the structure of the Austrian exchange rate policy fixed.

### 4.3 Linearization using the final form

Using linear techniques for the optimization requires the constraints to enter in linear form. One way to achieve this is to linearize the structural form of the econometric model. However, we shall not follow this approach here but we propose to use a linear approximation of the final form of the model to represent the model properties in our optimization experiments. We assume that the dynamic multipliers are coefficients of the linearized final form

$$y_t = F(x_t, x_{t-1}, \ldots, x_0; \epsilon_t, \epsilon_{t-1}, \ldots, \epsilon_0)$$

with $y_t$ a vector of endogenous variables, $x_{t-k}$ one of the exogenous variables at period $t-k,\ k=0,\ldots,t)$ and $\epsilon_{t-k}$ the vector of disturbances. Then

$$dy_t = \sum_{j=0}^{t} \frac{\partial F}{\partial x_{t-j}} dx_{t-j} + \sum_{j=0}^{t} \frac{\partial F}{\partial \epsilon_{t-j}} d\epsilon_{t-j}$$

which, approximated by finite differences, yields

$$y_t = \sum D_j x_{t-j} + \text{remainder}$$

where the remainder term includes the approximation error and lags of higher order as well as the error dynamics. For our purposes in the present paper we are going to use the simple model

$$y_t = D_0 x_t + R_t$$

where $D_0$ is the matrix of dynamic multipliers for lag zero. We use the values of $D_0$ given in *Table 1.*

TABLE 1

VALUES OF $D_0$ (TRANSPOSED)

| | *GDP* | *UR* | *PC* | *HDLB* | *DEFQ* |
|---|---|---|---|---|---|
| TRANSV | 0.2597 | 0.0260 | -0.0156 | -0.3380 | 0.0743 |
| OIFS | 0.4595 | -0.0065 | -0.0140 | -0.5649 | 0.0612 |
| FTIV | 0.2333 | 0.0810 | 1.2383 | 0.4189 | -1.4912 |
| NAZ | -0.1396 | 0.0918 | -0.0269 | 0.0947 | 0.0253 |
| FLST | -1.4312 | -0.1430 | 0.0865 | 1.8631 | -0.4117 |
| EXRC | -3.2162 | 0.1321 | 2.2190 | -11.6693 | -0.4634 |
| RSP | -1.7804 | 0.0211 | 0.0552 | 2.1895 | 0.0860 |
| OPAS | 0.4486 | -0.0063 | -0.0136 | -0.5514 | 0.0613 |
| SUBV | 0.0077 | -0.0056 | -0.0928 | -0.0624 | 0.1113 |
| FDBSS | 0.1452 | 0.0751 | 0.0877 | 0.0452 | -0.0358 |
| RRR | -1.6073 | 0.0191 | 0.0498 | 1.9768 | 0.0777 |

The planning horizon can easily be extended to cover more periods. For our practical application we have simplified the problem in order to avoid a too complicated planning issue involving intertemporal substitution effects and only consider one single period.

## 5 THE EXPERIMENTAL SETUP FOR INTERACTIVE ECONOMIC POLICY OPTIMIZATION

### 5.1 Basic data for optimizing economic policy in 1989

The following examples concentrate on achieving an optimal policy for the year 1989 given all data previous to that date. This is certainly the simplest case as it abstracts from any intertemporal considerations but should be sufficient to display relevant features of the approach. We chose as a starting point values for the objectives and instruments which are derived from the economic forecasts (March 1989) for Austria.

TABLE 2

| OBJECTIVES | FORECAST | UNIT | DESCRIPTION |
|---|---|---|---|
| GDP | 968.7 (3.0%) | Bill. A.S. | gross domestic product at constant prices 1976 |
| PC | 169.1 (2.8%) | Indexpoints | deflator of private consumption |
| UR | 4.9 | Percent | unemployment rate |
| DEFQ | 3.9 | Percent | net deficit as percentage of nominal GDP |
| HDLB | 8.0 | Bill. A.S. | balance of goods and services |

TABLE 3

| INSTRUMENTS | LOWER | FORECAST | UPPER | UNIT | DESCRIPTION |
|---|---|---|---|---|---|
| TRANSV | 320.0 (-4.5%) | 350.0 (4.5%) | 360.0 (7.5%) | Bill.A.S. | gov't transfers to private households |
| OIFS | 48.0 (-4.0%) | 51.0 (2.0%) | 53.0 (6.0%) | Bill.A.S. | public investment at current prices |
| FTIV | 15.0 (-5.1%) | 15.8 (0%) | 16.5 (4.4%) | Percent*100 | average rate of indirect taxes |
| FLST | 14.5 (-9.4%) | 15.0 (-6.25%) | 16.0 (0.0%) | Percent*100 | average rate of direct wage tax |
| NAZ | 38.0 (-5.0%) | 40.0 (0%) | 40.0 (0%) | hours/week | legal working time |
| RSP | 2.5 | 2.625 | 4.0 | Percent*100 | interest rate on saving deposits |
| EXRC | 10.0 | 12.8 | 14.0 | A.S./US $ | Shilling/Dollar exchange rate |
| OPAS | 170.0 (2.4%) | 174.0 (4.8%) | 185.0 (11.4%) | Bill.A.S. | government wage bill |
| SUBV | 40.0 (-13.0%) | 46.0 (0%) | 50.0 (8.7%) | Bill.A.S. | subsidies |
| FDBSS | 0.52 (-1.9%) | 0.53 (0%) | 0.54 (1.9%) | Percent | share of employers' contributions to social security |
| RRR | 0.055 (-2.1%) | 0.056 (0%) | 0.057 (1.4%) | Percent | effective required reserve ratio |

For the experiments we assumed that growth of $GDP$ is to be maximized, the inflation rate of $PC$, unemployment rate $UR$, and $DEFQ$ are to be minimized. $HDLB$ should be minimized in absolute terms (see *Table 2*). Since the growth rates of $GDP$ and $PC$ are chosen as targets, whereas the respective columns of $D_0$ in *Table 1* refer to levels, the columns are transformed appropriately.

Example runs are given in the appendix A in a form which is close to the program output.

## 5.2 Some evidence on a comparative evaluation of interactive methods for economic policy optimization

### 5.2.1 The experimental design

In contrast to earlier investigations of comparative evaluations of interactive optimization techniques we have set up a realistic problem of economic policy and not a fictitious one. We also distinguish three groups of participants in the experiment:

- One group consisted of academics and students of economics, mathematics and operations research.
- Economists and members of economic research institutions involved in advisory activity made up the second group.
- Actual economic policy makers in government and industry at the top and the advisory level formed the third group.

Together with a brief model description as above the forecast situation has been presented to the participants in the experimental evaluation. They were asked to attempt a "best" solution to the decision problem with the stated five economic objectives. A little assistance was provided to handle the software but the decisions were taken without any guidance by the operator. Each participant was presented with the same problem and only asked initially if he agreed to the proposed set of objectives and instruments, and to the bounds applied. Generally, the exchange rate was kept fix at a level of 12.5 A.S./US $. If some participants did not agree they were free to choose their own set. The majority, however, accepted the set-up without changes.

The order in which the techniques were applied was always the same: STEM was used first, then followed IMGP and finally ZW. A part of the participants was further confronted with an implementation of DIDAS by Rogowski, Sobczyk and Wierzbicki (1988) to have an opportunity to experience a different software implementation of yet another approach to multiobjective decision support. After experiments with all methods the participants were asked to fill in a questionnaire.

We understand that an assessment of the methods is not independent of how they are implemented. The questions should, therefore, reflect both aspects which are relevant to the user but allow some discrimination as well.

The following criteria were chosen:

1. Ease of use of the method
2. Ease of understanding the logic of the method
3. Ease of providing information required by the method
4. Confidence in the final solution
5. Satisfaction with the implementation of the methods
6. Degree of learning effect
7. Potential for use of interactive MCDM techniques in concrete practical work of the participants.

Criteria 1 and 2 were assessed by ranking, 4, 5 and 6 on a point scale of 1 to 10 with higher numbers preferred to lower numbers. Criterion 3 was measured according to a scale from 1 to 6. Criteria 1, 2 and 4 are comparable to some of the criteria used by Wallenius (1975) and Buchanan and Daellenbach (1987).

### 5.2.2 Results

During the first half year of 1989 some fifty people in the categories mentioned above were confronted with the model and the optimization methods as described. Only 23 of them replied to the request to fill in the questionnaire. Even among those were some who did not answer all the questions. Especially many of the participants belonging to the third category of test persons felt rather uneasy about filling the questionnaire. Therefore, only four questionnaires of that latter group could be included in the sample, too few to draw significant conclusions from this batch. Most of them were strongly interested in the properties of the model and were quite indifferent concerning the optimization methods. Also, in view of the time needed to conduct one experiment, it is obvious that participants in top positions afford less time for it than do those in lower ranks. We concluded that we should stretch our experiment over a longer period in order to obtain a larger sample of the third group.

Of the remaining 19 questionnaires 11 were filled by members of the first group and 8 by those of the second one. In view of the sample size we shall not evaluate the results according to groups. We may, however, occasionally indicate if results are strikingly different across groups.

As initial information about the relevance of and the acquaintance with multiple criteria decision making among all responding participants we found that more than 80 % of the participants are facing problems with multiple criteria but only about 20 % actually use appropriate optimization techniques. Approximately 86 % of the participants think that interactive optimization techniques can sensibly be applied to their multicriteria problems.

TABLE 4

CRITERIONS 1 & 2 — AVERAGE RANKS

| | STEM | IMGP | ZW | DIDAS |
|---|---|---|---|---|
| Criterion 1: Ease of use | 1.8 | 2.4 | 3.0 | 2.2 |
| Criterion 2: Understanding the logic | 1.7 | 2.0 | 2.5 | 3.2 |

Ranking the four methods under scrutiny produced *Table 4*. It contains the average of the ranks achieved. STEM and DIDAS are the easiest to use – probably the implementation in IAC-DIDAS-L is partially responsible for this good result – but participants had problems to understand the logic of the reference point method. It turned out that most of the participants did not see how their result varied with variations in the reference point. In contrast the guiding principle of STEM was the easiest to understand and also easy to use. The term "ease of use" was often misunderstood by the participants as "user friendly implementation".

Providing the required information (criterion 3) was generally found relatively easy, sometimes with some need to think. Most participants did not find much difference across methods but for STEM and IMGP answering deemed a little easier than for the other two methods.

Considering aspects of the implementation *Table 5* gives point averages from a scale of 1 to 10 (higher figures preferred to lower figures):

TABLE 5

CRITERION 5 — AVERAGE POINTS

| | STEM | IMGP | ZW | DIDAS |
|---|---|---|---|---|
| understanding interaction | 7.8 | 6.6 | 6.6 | 6.4 |
| clarity of information | 6.7 | 6.5 | 5.5 | 7.5 |
| speed | 7.9 | 7.6 | 6.7 | 8.3 |
| flexibility | 6.5 | 7.3 | 5.0 | 6.3 |
| sum | 29.0 | 28.1 | 23.9 | 28.4 |

Concerning the sum of points all methods except ZW seem to do equally well. This may be due to the fact that we present the tradeoffs in terms of a tradeoff vector and not in terms of adjacent efficient solutions. The marginal (but not significant) dominance of STEM might be explained by the fact that the participant is confronted with this method first.

Turning finally to criteria 4 and 6, the degree of confidence in the solution and the degree of learning experienced, we find a higher point average for the learning effect (7.7) than for the degree of confidence (5.9). Both criteria are measured on a scale of 1 (no confidence or nothing learned from the experiment) to 10 points. It is interesting to note that academic participants varied much more in their answers than did participants of the other groups. This does not seem surprising because the number of available methods itself and the varying results associated with them makes participants suspicious about the relevance of the achieved results. In most cases, however, heated debates started about the econometric model, its properties and the consequences traced in the optimization experiments. Learning about the problem at issue was then straightforward.

## 6 CONCLUSIONS

This paper has presented some main features of a macroeconomic model for the Austrian economy which serves as an input to derive a set of constraints for macroeconomic policy optimization. The model does not only provide a well structured representation of the Austrian economy but also a useful and practical linkage between objectives and instruments.

Utilizing all advantages of an optimization framework for actual decision making but without the requirement of a preference function, interactive methods for solving multiple objective decision models are well suited for economic policy making. The policy maker is closely involved in the solution process. Consequently, decision quality is considerably improved because interactive optimization methods allow to pay attention to psychological and sociological aspects of decision making. Important learning effects may be induced.

Three of these optimization techniques based on linear programming are implemented in the InterActive Optimization program package IAO (Brandner and Böhm (1989)). Together with a PC-version of DIDAS they are applied to the econometric model of Austria in the context of an experiment in economic policy optimization. Example runs on economic policy optimization for a single period presented in the appendix A permit quick comparisons between the methods which differ from each other in the information requirements and the conduct of the interaction. The example runs clearly demonstrate how decision makers gain insight into the restrictions of their problem implied by the model structure and the trade-off choices to find an optimal solution. An evaluation of questionnaires returned by the participants in the experiments permitted to draw comparisons between the methods. It is certainly not easily possible to convey in written form the process of learning – experienced by the decision maker and the model builder too – associated with real life-use of an interactive software. Therefore, the second purpose of the experiment was to assess the practical usefulness of interactive procedures for people involved in actual economic policy decision making in Austria. A survey of the results achieved so far and a critical comparative evaluation has been presented. There is clear evidence for a demand for easily accessible techniques to solve multicriteria decision problems.

There remain a number of problems most of which are too complex to be considered here, e.g. group decisions, model specification problems. Two problems seem to be immediately relevant. First, applying a nonlinear model requires certain approximations which are not always satisfactory. Nonlinear optimization techniques will doubtlessly help provided the model possesses the appropriate curvature properties. Earlier experiments of the authors indicated that this is quite often not the case (cf. Brandner 1985). Second, a dynamic model demands intertemporal considerations in decision making. Even in simple cases this amounts to a multiple of one-period-target-vectors with the consequence of a very large number of targets and correspondingly a larger number of tradeoff possibilities. Aspects of this question have been investigated already (e.g. Deissenberg (1983)) and shall be pursued with the present model-setup at a different place.

## References


Ancot J. P., A. J. Hughes Hallett, J. H. P. Paelinck, *The determination of implicit preferences - Possible approaches compared*, European Economic Review **18** (1982), 267–289.

Ancot J. P., A. J. Hughes Hallett, *Collective preferences in economic decision models: With an application to Soviet economic policy*, in "Gruber, J. (ed.), Econometric Decision Models," Lecture Notes in Economics and Mathematical Systems, Vol. 208, Springer-Verlag, 1983, pp. 263–304.

Benayoun R., J. de Montgolfier, J. Tergny, O. Larichev, *Linear programming with multiple objective functions: Step method (STEM)*, Mathematical Programming **1 (3)** (1971), 366–375.

Brandner P., *Interaktive Verfahren für Optimierungsprobleme bei mehrfacher Zielsetzung - eine Anwendung in der Wirtschaftspolitik*, Master Thesis, Institute for Econometrics and Operations Research, University of Technology, Vienna (1984).

Brandner P., *Interaktive Vektoroptimierung zur Unterstützung der Entscheidungsfindung in der Wirtschaftspolitik*, mimeo, Institute for Advanced Studies, Vienna (1985).

Brandner P., B. Böhm, *Interactive Optimization. Manual for the IAO-Program Package*, Research Report No. 95, Institute for Econometrics and Operations Research, University of Technology, Vienna (1989).

Brockhoff K., *Experimental test of MODM algorithms in a modular approach*, European Journal of Operational Research **22** (1985), 159–166.

Buchanan J. T., H. G. Daellenbach, *A comperative evaluation of interactive solution methods for multiple objective decision models*, European Journal of Operational Research **29** (1987), 353–359.

Chow G. C., "Analysis and Control of Dynamic Economic Systems," Wiley, New York, 1975.

Deissenberg C., *Interactive solution of multiple objective dynamic, macroeconomic stabilization problems. A comparative study*, in "Gruber, J. (ed.), Econometric Decision Models," Lecture Notes in Economics and Mathematical Systems Vol. 208, Springer-Verlag, 1983, pp. 305–309.

Despontin M., *Regional multiple objective quantitative economic policy: a Belgian model*, European Journal of Operational Research **10** (1982), 82–89.

Despontin M., J. Moscarola, J. Spronk, *A User-oriented listing of multiple criteria decision methods*, The Belgian Journal of Statistics, Computer Science and Operation Research **23 (4)** (1983).

Despontin M., P. Nijkamp, J. Spronk, "Macro-Economic Planning with Conflicting Goals," Lecture Notes in Economics and Mathematical Systems Vol. 230, Springer-Verlag, 1984.

Friedman B. M., "Economic Stabilization Policy: Methods in Optimization," North Holland, 1975.

Frisch R., *Numerical determination of a quadratic preference function for use in macroeconomic programming*, Giornale Degli Economisti a Annali Di Economia (1961).

Frisch R., "Economic Planning Studies," International Studies in Economics and Econometrics Vol. 8, edited by F. Long, D. Reidel Publishing Company, Dordrecht, 1976.

Grauer M., A. P. Wierzbicki, "Interactive Decision Analysis," Lecture Notes in Economics and Mathematical Systems Vol. 229, Springer-Verlag, 1984.

Gruber J. (ed.), "Econometric Decision Models," Lecture Notes in Economics and Mathematical Systems Vol. 208, Springer-Verlag, 1983.

Hendry D. F., "The Econometrics of PC-GIVE," Version 5.0, Oxford, 1987.

Hendry D. F., A. R. Pagan, J. D. Sargan, *Dynamic specification*, chapter 18, in "Z. Griliches and M.D. Intriligator (eds.), Handbook of Econometrics Vol. II," Amsterdam, 1986, pp. 1025–1100.

Holly S., B. Rüstem, M. Zarrop (eds.), "Optimal Control for Econometric Models: An Approach to Economic Policy Formation," Macmillan, London, 1979.

Hughes Hallett A., "Applied Decision Analysis and Economic Behaviour," Advanced Studies in Theoretical and Applied Econometrics 3, Martinus Nijhoff Publishers, Dordrecht, 1984.

Hughes Hallett A., H. Rees, "Quantitative Economic Policies and Interactive Planning," Cambridge University Press, 1983.

Hwang C. L., A. S. M. Masud, "Multiple Objective Decision Making - Methods and Applications. A State-of-the-Art Survey," Lecture Notes in Economics and Mathematical Systems Vol. 164, Springer-Verlag, 1979.

Johansen L., *Establishing preference functions for macroeconomic decision models*, European Economic Review **5** (1974), 41–66.

Klein L. R., *Economic policy formation: Theory and implementation (Applied econometrics in the public sector)*, chapter 35, in "Z. Griliches and M.D. Intriligator (eds.), Handbook of Econometrics Vol. III," Amsterdam, 1986, pp. 2057–2093.

Muth J. F., *Rational expectations and the theory of price movements*, Econometrica **29** (1961), 315–335.

Müller P., *Interactive Multiple Goal Programming (Pascal-Programm)*, Master Thesis, Institute for Econometrics and Operations Research, University of Technology, Vienna (1985).

Olbrisch, M., "Das interaktive Referenzpunktverfahren als Lösungsmöglichkeit ökonometrischer Entscheidungsmodelle – Darstellung und Einordnung der Theorie und praktische Anwendungen," Bochumer Wirtschaftswissenschaftliche Studien Nr. 121, Studienverlag Brockmeyer, Bochum, 1988.

Pitchford J. D., S. J. Turnovsky (eds.), "Application of Control Theory to Economic Analysis," North Holland, Amsterdam, 1977.

Preston A. J., *A dynamic generalization of Tinbergen's theory of policy*, Review of Economic Studies **41 (1)** (1974), 65–74.

Preston A. J., *Existence, uniqueness and stability of linear optimal stabilisation policies*, in "J. D. Pitchford, S. J. Turnovsky (eds.), Application of Control Theory to Economic Analysis," North Holland, Amsterdam, 1977, pp. 255–292.

Preston A. J., A. R. Pagan, "The Theory of Economic Policy," Cambridge University Press, 1982.

Preston A. J., E. Sieper, *Policy objectives and instrument requirements for a dynamic theory of policy*, in "J. D. Pitchford, S. J. Turnovsky (eds.), Application of Control Theory to Economic Analysis," North Holland, Amsterdam, 1977, pp. 215–254.

Rogowski T., J. Sobczyk, A. P. Wierzbicki, *IAC-DIDAS-L Dynamic Interactive Decision Analysis and support System Linear Version*, Working Paper WP-88-110, IIASA, Laxenburg (1988).

Russel C. S., V. K. Smith, *Targets, instruments and generalized inverses*, European Economic Review **6** (1975), 143–153.

Spronk J., "Interactive Multiple Goal Programming for Capital Budgeting and Financial Planing," Martinus Nijhoff Publishing, Boston, 1981.

Streuff, H., J. Gruber, *The interactive multiobjective optimization method by Elemer E. Rosinger: A computer program and Aspects of Applications*, in "Gruber, J. (ed.), Econometric Decision Models," Lecture Notes in Economics and Mathematical Systems Vol. 208, Springer-Verlag, 1983, pp. 334–364.

Theil H., "Optimal Decision Rules for Government and Industry," North Holland, 1964.

Tinbergen J., "On the Theory of Economic Policy," North Holland, 1952.

Tinbergen J., "Economic Policy, Principles and Design," North Holland, 1956.

Wallenius H., *Optimizing macroeconomic policy: A review of approaches and applications*, European Journal of Operations Research **10** (1982), 221–228.

Wallenius J., *Comparative evaluation of some interactive approaches to multicriteria optimization*, Management Science **21** (1975), 1387–1396.

Zionts S., J. Wallenius, *An interactive programming method for solving the multiple criteria problem*, Management Science **22 (6)** (1976), 652–663.

Zionts S., J. Wallenius, *An interactive multiple linear programming method for a class of underlying nonlinear utility function*, Management Science **29 (5)** (1983), 519–529.

## APPENDIX A

### A1.1 Interactive Economic Policy Optimization using STEM

```
     *** S T E M ***
Optimize Problem        -> P
Print Objectives        -> O
Print Instruments       -> I
E N D                   -> *
->p
```

*At this stage it is assumed that the model equations, a selection of objectives and instruments as well as bounds for the latter are already in memory. The optimization menu has been chosen. The other entries may be used to inform the decision maker about the current values of objectives and instruments.*

```
 ** O P T I M I Z E **
PayOff Matrix           -> P
Compromise              -> C
E N D                   -> *
->p
```

*To get an overview of the possible range of objective values that can be achieved. Each line of the matrix represents a single target optimization.*

```
                          PAY-OFF  MATRIX
                gdp-%      ur         pc-%       |L.Bil.|   defq
max: gdp-%      4.1161     5.2901     2.7513      4.8491     4.9529
min: ur         2.7463     3.9126     2.0840     10.8362     3.6009
min: pc-%       4.0490     5.3507     1.5927      5.2890     7.2410
min: |L.Bil.    3.6171     4.9438     1.7413      0.0000     6.0784
min: defq       1.8158     4.2186     3.9411     23.1849    -0.9752
```

```
 ** O P T I M I Z E **
PayOff Matrix           -> P
Compromise              -> C
E N D                   -> *
->c
```

*Now a compromise solution is asked for.*

```
Taking the compromise-solution:
Objective 1   gdp-%         3.50295
Objective 2   ur            4.77670
Objective 3   pc-%          3.52382
Objective 4   |L.Bil.|      3.18328
Objective 5   defq          2.20812

Would you accept a deterioration of one of the objectives
in order to improve at least one other  y / n  ... y
Objective 1   gdp-%     is allowed to deteriorate about  ... *
Objective 2   ur        is allowed to deteriorate about  ... *
Objective 3   pc-%      is allowed to deteriorate about  ... *
Objective 4   |L.Bil.|  is allowed to deteriorate about  ... *
Objective 5   defq      is allowed to deteriorate about  ... 0.8    ok !


Taking the compromise-solution:
Objective 1   gdp-%         3.60925
Objective 2   ur            4.84580
Objective 3   pc-%          3.22263
Objective 4   |L.Bil.|      1.62991
Objective 5   defq          3.00812
```

```
Would you accept a deterioration of one of the objectives
in order to improve at least one other  y / n  ... y
Objective 1   gdp-%      is allowed to deteriorate about  ... *
Objective 2   ur         is allowed to deteriorate about  ... *
Objective 3   pc-%       is allowed to deteriorate about  ... 0.3   ok !
Objective 4   |L.Bil.|   is allowed to deteriorate about  ... 8.0   ok !
Objective 5   defq       is allowed to deteriorate about   ...0.8
If you want to change this, enter a new value  ... 0.0   ok !


Taking the compromise-solution:
Objective 1   gdp-%        3.40625
Objective 2   ur           4.62236
Objective 3   pc-%         3.01284
Objective 4   |L.Bil.|     3.85525
Objective 5   defq         3.00812
Would you accept a deterioration of one of the objectives
in order to improve at least one other  y / n  ... n
```

*The optimal set of instrument values providing this solution is:*

```
Optimal solution found !
 I N S T R U M E N T S
transv        334.30487
oifs           53.00000
ftiv           16.50000
naz            38.00000
flst           14.50000
exrc           12.50000
rsp             2.50000
opas          185.00000
subv           49.67354
fdbss           0.52000
rrr             0.05500
```

## A1.2 Interactive Economic Policy Optimization using IMGP

*The first payoff-matrix is the same as in the previous example. As a first step the program presents*

```
     *** I M G P ***
Optimize Problem      -> P
Print Objectives      -> O
Print Instruments     -> I
E N D                 -> *
->p

Iteration No.    1
                       POTENCY-MATRIX  for  PROPOSAL SOLUTION
                  Ideal solution  Pessimistic sol.  Solution
gdp-%     (max)      4.11616          1.81586         1.81586
ur        (min)      3.91260          5.35070         5.35070
pc-%      (min)      1.59272          3.94114         3.94114
|L.Bil.|  (min)      0.00000         23.18498        23.18498
defq      (min)     -0.97516          7.24101         7.24101
Do you accept this solution as final ?
Y = yes / N = no / L = Potency-matrix / P = Payoff-matrix /
S = Efficient solution
-> n
```

*At each interactive stage the decisionmaker has access to information about the Potency - matrix, the Payoff - matrix, and an efficient solution.*

```
Do you want to set aspiration levels ?
N = no / Y = yes
-> y
Are there aspiration levels for objective gdp-%?
N = no / Y = yes / L = Potency-matrix / P = Payoff-matrix /
S = Efficient solution
-> y
Aspiration level ...   3.4   ok !
Are there aspiration levels for objective ur?  -> n
Are there aspiration levels for objective pc-%?  -> n
Are there aspiration levels for objective |L.Bil.|?  -> n
Are there aspiration levels for objective defq?  -> y
Aspiration level ...    3.5   ok !

Shall gdp-% be improved?
Y = yes / W = yes (weakly) / N = no / P = Payoff-matrix /
L = Potency-matrix / S = Efficient solution
-> y
Shall ur be improved? -> y
Shall pc-% be improved? -> y
Shall |L.Bil.| be improved? -> w
Shall defq  be improved? -> y

Iteration No.    2
                      POTENCY-MATRIX  for  TRIAL SOLUTION
                  Ideal solution  Pessimistic sol.   Solution
gdp-%     (max)       3.40193          3.40000          3.40000
ur        (min)       4.59689          4.59936          4.59936
pc-%      (min)       2.76507          2.76693          2.76693
|L.Bil.|  (min)       3.67144         17.38873         17.38873
defq      (min)       3.49618          3.50000          3.50000

Are the changes in the Potency-matrix justified ?
Y = yes / N = no / V = New trial sol. / Q = New Payoff-mat. /
L = Previous proposal sol. / P = Previous Payoff-mat. /
S = Efficient solution / J = Jump back
-> y
```

*The trial solution becomes the new proposal solution.*

```
Do you accept this solution as final ?
Y = yes / N = no / L = Potency-matrix / P = Payoff-matrix /
S = Efficient solution / R = Repeat
-> p

Do you want to set aspiration levels ?
N = no / Y = yes
-> n

Shall gdp-% be improved?
Y = yes / W = yes (weakly) / N = no / P = Payoff-matrix /
L = Potency-matrix / S = Efficient solution
-> n
Shall ur be improved? -> w
Shall pc-% be improved? -> y
Shall |L.Bil.| be improved? -> w
Shall defq  be improved? -> n
```

*Further interaction leads to*

```
Iteration No.    4
                     POTENCY-MATRIX  for  PROPOSAL SOLUTION
                  Ideal solution   Pessimistic sol.   Solution
gdp-%      (max)     3.40096           3.40000         3.40000
ur         (min)     4.59702           4.59835         4.59835
pc-%       (min)     2.76507           2.76600         2.76600
|L.Bil.|   (min)     3.68204          13.95941        13.95941
defq       (min)     3.49809           3.50000         3.50000
Do you accept this solution as final ?
Y = yes / N = no / L = Potency-matrix / P = Payoff-matrix /
S = Efficient solution / R = Repeat
-> y

Optimal Solution found !


              EFFICIENT  SOLUTION
O B J E C T I V E S
gdp-%     (max)     Value      3.40000
ur        (min)     Value      4.59742
pc-%      (min)     Value      2.76600
|L.Bil.|  (min)     Value      3.69352
defq      (min)     Value      3.49809

 I N S T R U M E N T S
transv          342.61415
oifs             53.00000
ftiv             16.19568
naz              38.00000
flst             16.00000
exrc             12.50000
rsp               2.50000
opas            185.00000
subv             50.00000
fdbss             0.52000
rrr               0.05500
```

*The corresponding efficient solution is inspected*

## A1.3 Interactive Economic Policy Optimization using ZW

```
     *** Z W ***
Optimize Problem        -> P
Print Instruments       -> I
Print Weights           -> W
->p

Choose a set of starting weights  y / n  ... n


 O B J E C T I V E S
gdp-%     (max)    Value      3.76251
ur        (min)    Value      5.01999
pc-%      (min)    Value      3.43331
|L.Bil.|  (min)    Value      0.00000
defq      (min)    Value      2.90840
```

*The first solution is proposed by assuming equal weights in the objective function. The decision maker could have stated his preferred weighting pattern.*

```
Would you accept
a change of   0.00267  in  gdp-%     (       3.76251 )  and
a change of  -0.04872  in  ur        (       5.01999 )  and
a change of   0.00720  in  pc-%      (       3.43331 )  and
a change of   0.00000  in  |L.Bil.|  (       0.00000 )  and
a change of  -0.05991  in  defq      (       2.90840 )
---> y / n / ?    ... y

Would you accept
a change of  -0.00429  in  gdp-%     (       3.76251 )  and
a change of  -0.01040  in  ur        (       5.01999 )  and
a change of  -0.05465  in  pc-%      (       3.43331 )  and
a change of   0.00000  in  |L.Bil.|  (       0.00000 )  and
a change of   0.09758  in  defq      (       2.90840 )
---> y / n / ?    ... ?

Would you accept
a change of   0.01909  in  gdp-%     (       3.76251 )  and
a change of   0.07858  in  ur        (       5.01999 )  and
a change of   0.05203  in  pc-%      (       3.43331 )  and
a change of   0.00000  in  |L.Bil.|  (       0.00000 )  and
a change of  -0.02586  in  defq      (       2.90840 )
---> y / n / ?    ... n

 O B J E C T I V E S
gdp-%     (max)   Value     3.71965
ur        (min)   Value     4.91552
pc-%      (min)   Value     2.88665
|L.Bil.|  (min)   Value     0.00000
defq      (min)   Value     3.88745
```

*The decisions result in these values*

```
Would you accept
a change of   0.05900  in  gdp-%     (       3.71965 )  and
a change of   0.11322  in  ur        (       4.91552 )  and
a change of   0.73823  in  pc-%      (       2.88665 )  and
a change of   0.00000  in  |L.Bil.|  (       0.00000 )  and
a change of  -1.39912  in  defq      (       3.88745 )
---> y / n / ?    ... ?

Would you accept
a change of  -0.00429  in  gdp-%     (       3.71965 )  and
a change of  -0.01040  in  ur        (       4.91552 )  and
a change of  -0.05465  in  pc-%      (       2.88665 )  and
a change of   0.00000  in  |L.Bil.|  (       0.00000 )  and
a change of   0.09758  in  defq      (       3.88745 )
---> y / n / ?    ... ?


 O B J E C T I V E S
gdp-%     (max)   Value     3.71965
ur        (min)   Value     4.91552
pc-%      (min)   Value     2.88665
|L.Bil.|  (min)   Value     0.00000
defq      (min)   Value     3.88745


Optimal solution found !
```

```
    *** Z W ***
Optimize Problem       -> P
Print Instruments      -> I
Print Weights          -> W
->i

 I N S T R U M E N T S
transv            345.65067
oifs               53.00000
ftiv               16.50000
naz                38.00000
flst               14.50000
exrc               12.50000
rsp                 2.50000
opas              185.00000
subv               50.00000
fdbss               0.52000
rrr                 0.05500
```

```
    *** Z W ***
Optimize Problem       -> P
Print Instruments      -> I
Print Weights          -> W
->w

 W E I G H T S
gdp-%             0.52822
ur                0.40484
pc-%              0.02231
|L.Bil.|          0.02231
defq              0.02231
```

## A1.4 Screen of the Interaction Phase in DIDAS

| IAC - DIDAS - L2<br>V 5.4<br>Interaction | Names | flst | exrc | rsp | opas | subv |
|---|---|---|---|---|---|---|
| | Upper bound | 16. | 12.5 | 4. | 185. | 50. |
| | Value | 16. | 12.5 | 2.5 | 185. | 50. |
| | Lower bound | 14.5 | 12.5 | 2.5 | 170. | 40. |

| | D89D | 1 | 1 | Neutral solution |
|---|---|---|---|---|

| Names | Sta tus | Lower bound | Utopia | Value | Reference point | Nadir | Upper bound | Automatic scale |
|---|---|---|---|---|---|---|---|---|
| GDP | Max | ... | 4.12 | 3.03 | 3.03 | 1.82 | ... | 2.3 |
| UR | Min | ... | 3.91 | 4.24 | 4.24 | 5.35 | ... | 1.44 |
| PC | Min | ... | 1.59 | 2.7 | 2.7 | 3.94 | ... | 2.35 |
| HDLBx | | 0. | | 3.1e-15 | ... | | 0. | ... |
| DEFQ | Min | -1.000e7 | -0.98 | 2.9 | 2.9 | 7.24 | 1.000e5 | 8.22 |
| LBx | | 0. | | -4.4e-15 | ... | | 0. | ... |
| abs(LB) | Min | ... | 0. | 8.03 | 8.03 | 23.19 | ... | 23.19 |

F1 - Help F9 - Exit

| IAC - DIDAS - L2<br>V 5.4<br>Interaction | Names | flst | exrc | rsp | opas | subv |
|---|---|---|---|---|---|---|
| | Upper bound | 16. | 12.5 | 4. | 185. | 50. |
| | Value | 14.5 | 12.5 | 2.5 | 185. | 50. |
| | Lower bound | 14.5 | 12.5 | 2.5 | 170. | 40. |

| | D89D | 1 | 2 | Example after two attempts |
|---|---|---|---|---|

| Names | Sta tus | Lower bound | Utopia | Value | Reference point | Nadir | Upper bound | Automatic scale |
|---|---|---|---|---|---|---|---|---|
| GDP | Max | ... | 4.12 | 3.4 | 3.5 | 1.82 | ... | 0.62 |
| UR | Min | ... | 3.91 | 4.59 | 4.5 | 5.35 | ... | 0.59 |
| PC | Min | ... | 1.59 | 2.7 | 2.7 | 3.94 | ... | 1.11 |
| HDLBx | | 0. | | 3.1e-15 | ... | | 0. | ... |
| DEFQ | Min | -1.000e7 | -0.98 | 3.63 | 3. | 7.24 | 1.000e5 | 3.98 |
| LBx | | 0. | | -8.8e-15 | ... | | 0. | ... |
| abs(LB) | Min | ... | 0. | 3.62 | 4. | 23.19 | ... | 4.02 |

F1 - Help F9 - Exit

## APPENDIX B

FIGURE 1

Dynamic effects of an increase in public transfers to private households

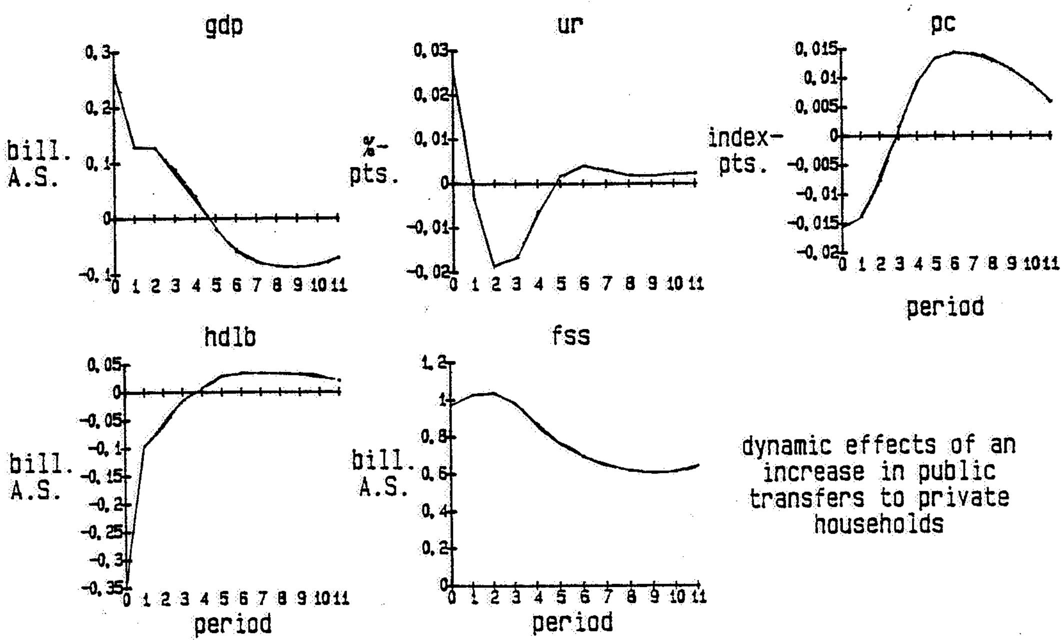



FIGURE 2

Dynamic effects of an increase in public investment expenditures

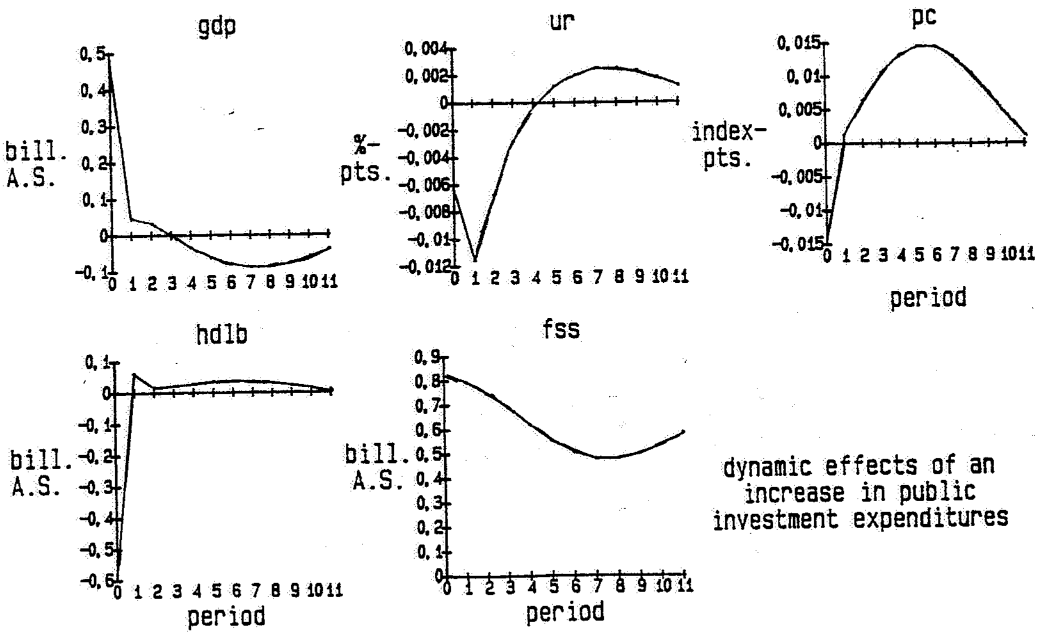


FIGURE 3

Dynamic effects of an increase in the average direct wage tax rate

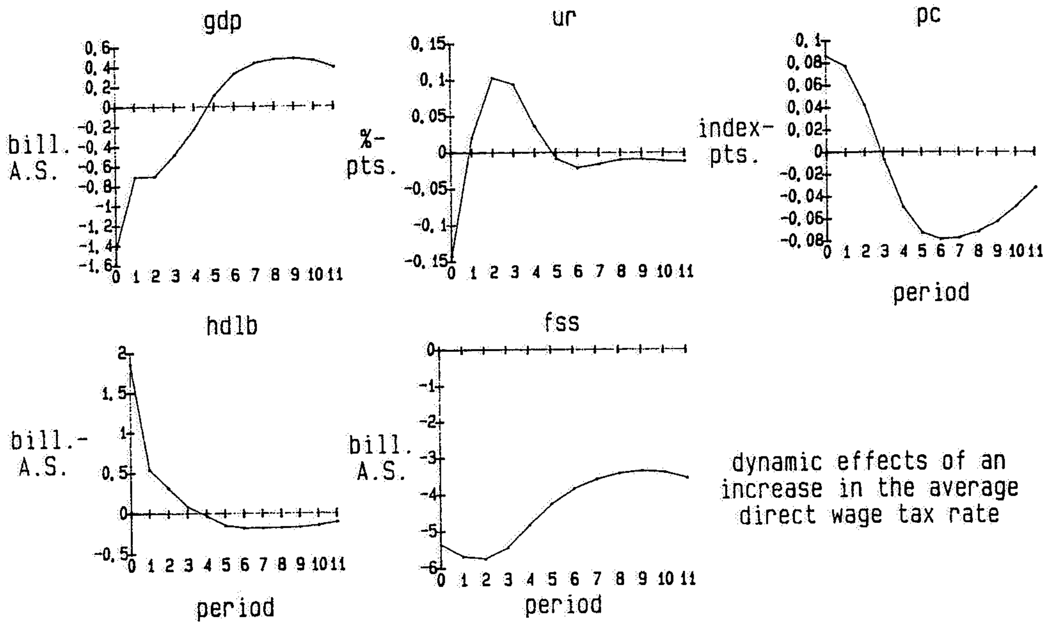



FIGURE 4

Dynamic effects of an increase in the average indirect tax rate

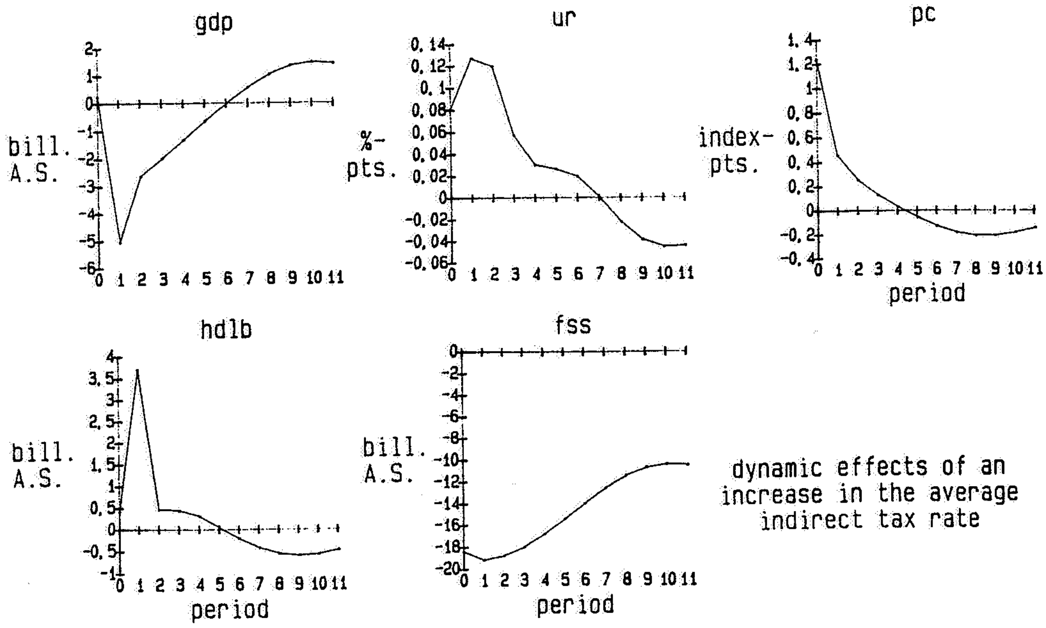


FIGURE 5

Dynamic effects of an increase in legal working hours

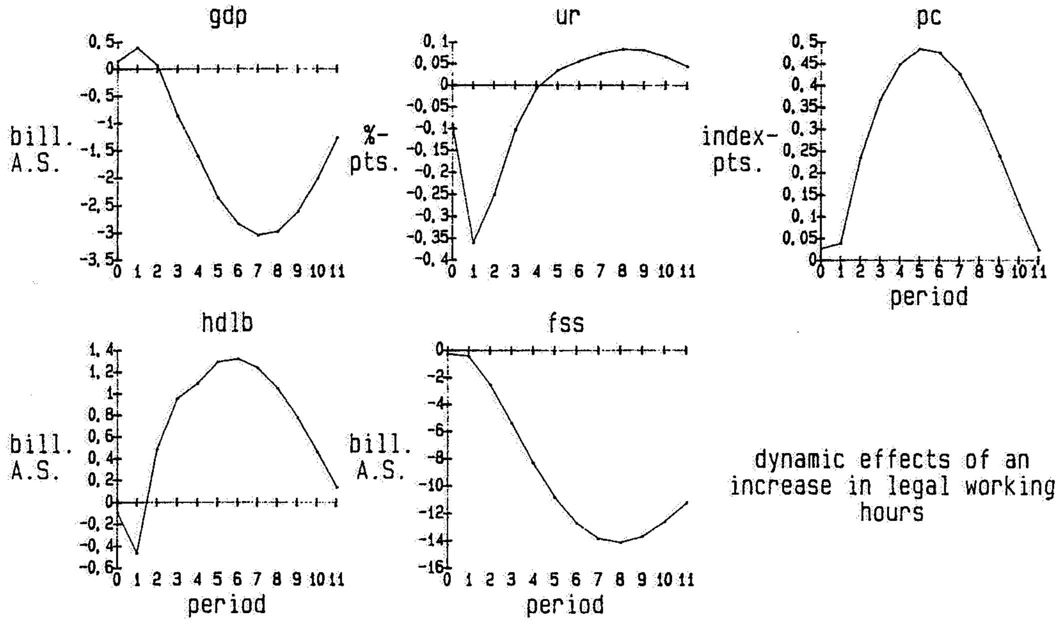
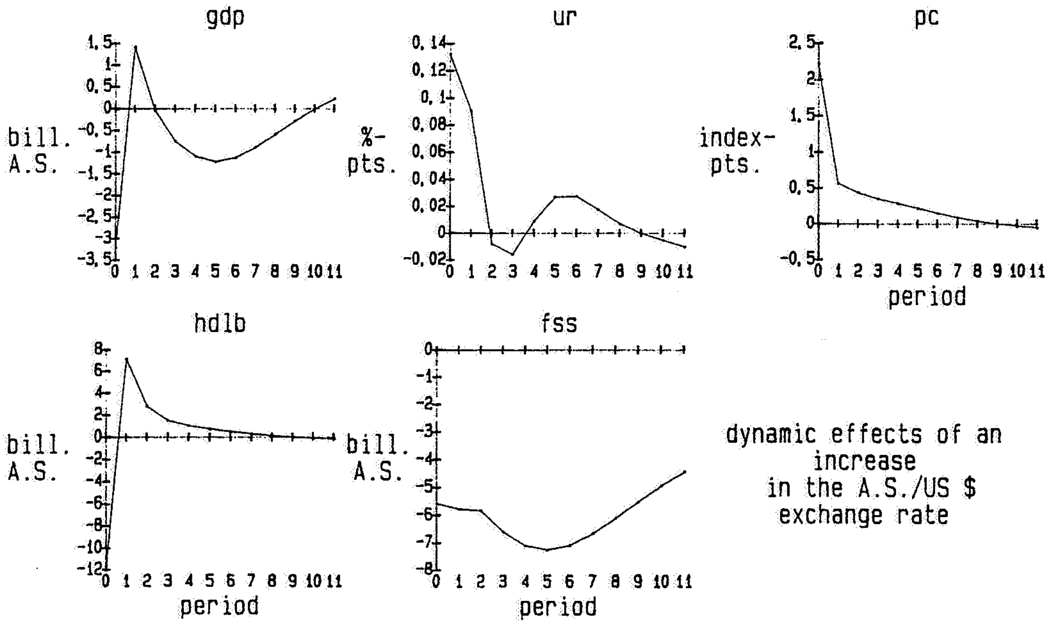


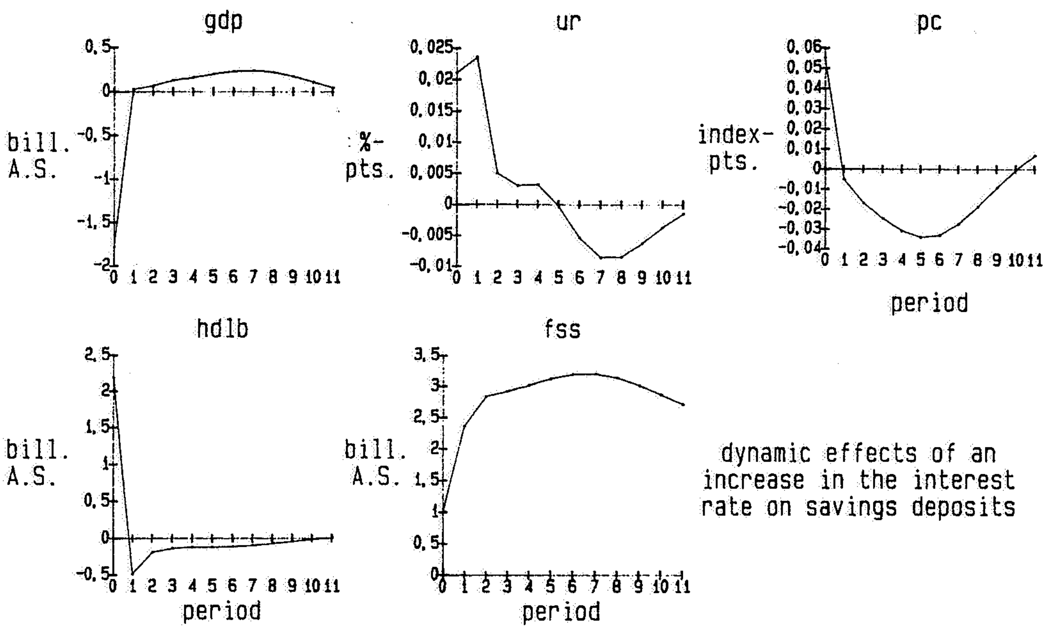

FIGURE 6

Dynamic effects of an increase in the A.S./US$ exchange rate



## FIGURE 7

Dynamic effects of an increase in the interest rate on savings deposits




## FIGURE 8

Dynamic effects of an increase in salaries of civil servants

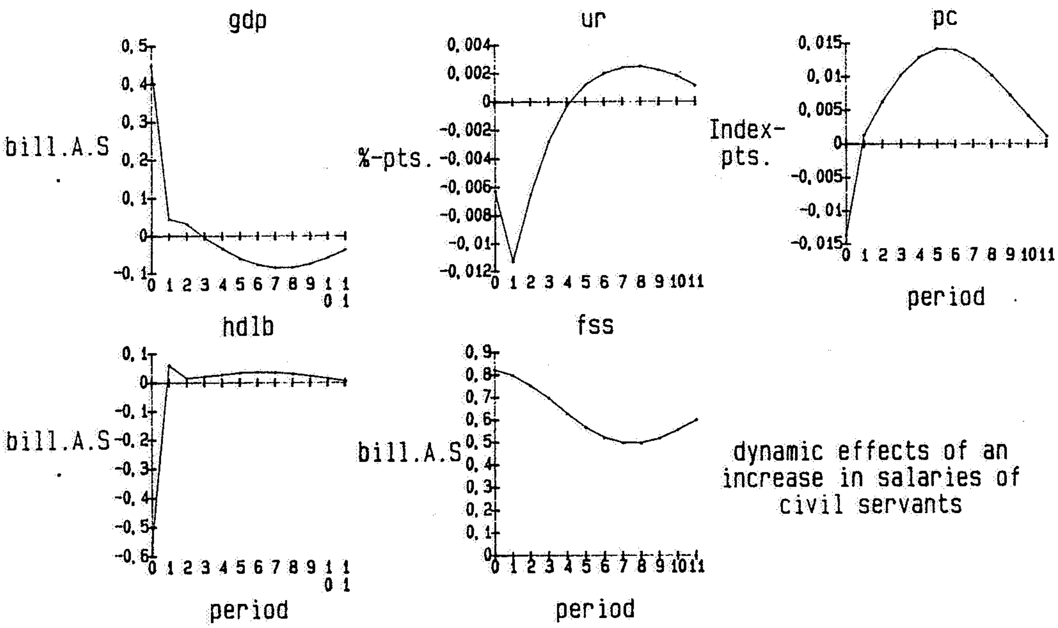


FIGURE 9

Dynamic effects of an increase in subsidies

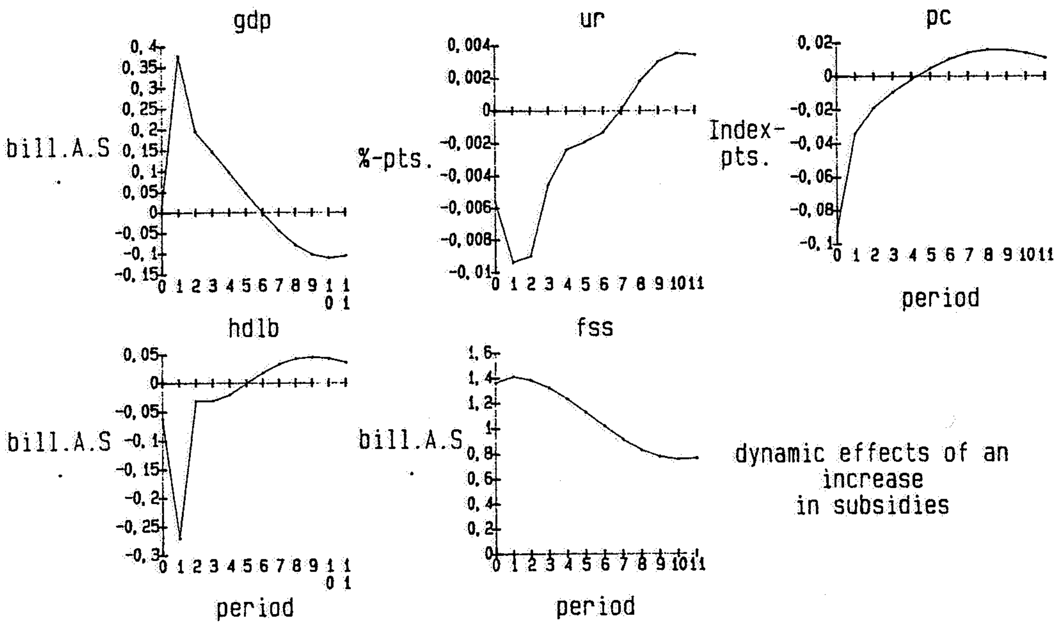
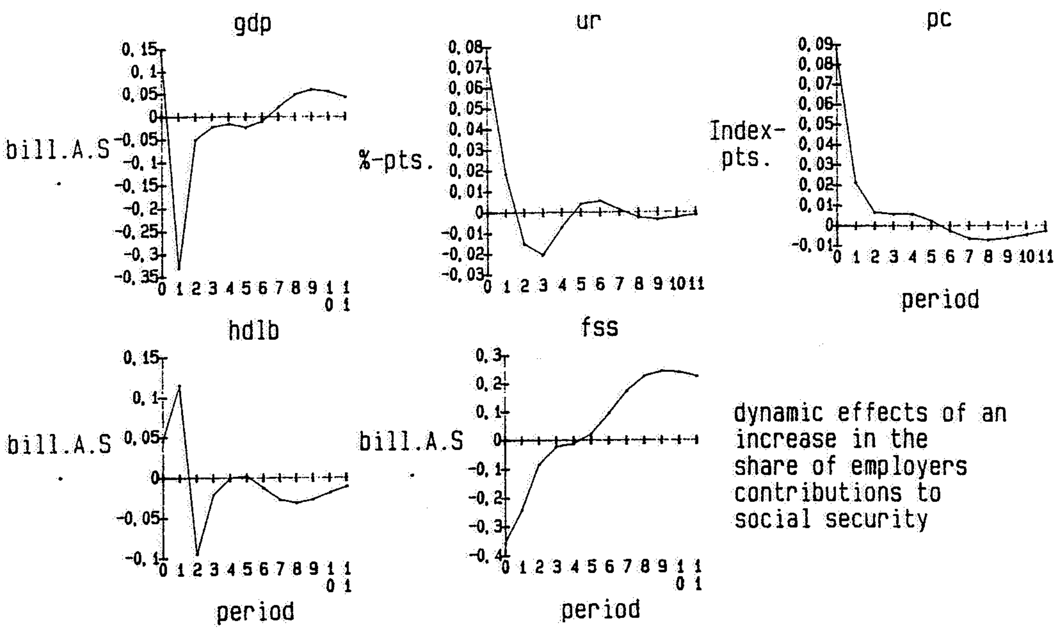


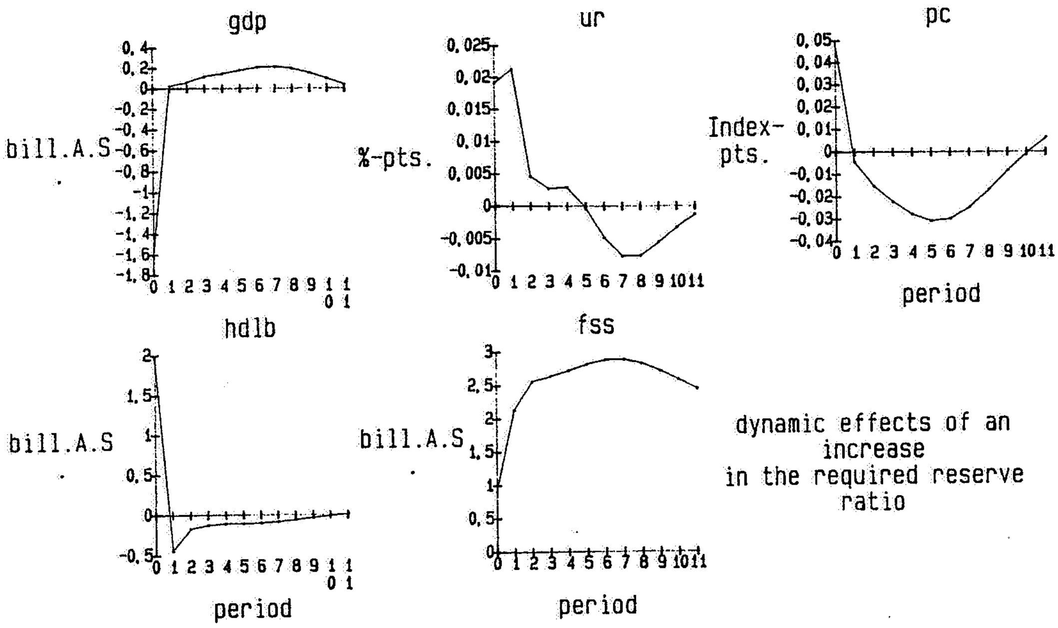

FIGURE 10

Dynamic effects of an increase in the share of emloyers contributions to social security



## FIGURE 11

Dynamic effects of an increase in the required reserve ratio



# APPENDIX C

**Model MAXOPT (E)** **Version 7/87**

## A. ENDOGENEOUS VARIABLES[1)]

| | |
|---|---|
| ALVB | contributions to unemployment insurance |
| BIFP | present value of private tax-depreciations allowances |
| C | private consumption expenditures, at 1976 prices |
| CP | public consumption expenditures, at 1976 prices |
| CPS | public consumption expenditures, at current prices |
| CS | private consumption expenditures, at current prices |
| DBSS | employers contributions to social insurance |
| DEF | net deficit/surplus of public sector |
| DEFQ | deficit ratio |
| DEPS | depreciations (nat. acc.), at current prices |
| EBU | total income from profits and property |
| EBUS | residual income from profits and property |
| EBUST | government income from profits and property |
| EGK | retained profits from corporate enterprises |
| FITS | mark-up factor for indirect taxation minus subsidies |
| FSS | stock of public sector debt |
| GDP | Gross domestic product at 1976 market prices |
| GDPS | Gross domestic product, at current prices |
| HBU | average weekly working time |
| HDLB | XS - MS (balance of trade and services) |
| IFO | gross fixed investment, at 1976 prices |
| IFP | private gross fixed investment, at 1976 prices |
| IFS | gross fixed investment, at current prices |
| KP | private stock of fixed capital, at 1976 prices |
| LEO | employment |
| LF | labour supply |
| LST | direct taxes on wage income |
| M | imports of goods and services, at 1976 prices |
| M3 | money stock (currency, demand- and savings deposits) |
| MS | imports of goods and services, at current prices |
| MU3 | money multiplier for M3 |
| OESP | public savings (nat. acc.) |
| PC | deflator of private consumption |
| PCP | deflator of public consumption |
| PDEP | deflator of depreciations (nat. acc.) |
| PGDP | deflator of gross domestic product |
| PIF | deflator of gross fixed investment |
| PM | deflator of imports of goods and services |
| PMS | deflator of imports of goods and services (in US-$) |
| PVD | deflator of domestic demand |
| PVDN | deflator of domestic demand, (netto ind.St-Subv.) |
| PX | deflator of exports of goods and services |
| PXST | deflator of tourism exports |
| RPI | rental price of private capital |
| RSECL | effective interest rate on newly issued bonds |
| RTG | call money rate |
| SVB | contributions to social insurance |
| TDHV | direct taxes of private households (nat. acc.) |
| TDHVR | other direct taxes of private households |
| TDKV | direct taxes of corporations |
| TIV | indirect taxes (nat. acc.) |
| TRANSH | transferincome, gross |
| ULC | unit labour costs |
| UR | unemployment rate |
| VDS | domestic demand, at current prices |
| WBFB | contributions to construction programs |
| XS | exports of goods and services, at current prices |
| XSTS | tourism exports, at current prices |

1) Note: Quantities are measured in billions of Austrian Shillings, all prices are 100 in 1976.

| | |
|---|---|
| XX | exports of goods and services, at 1976 prices |
| YDS | disposable income, at current prices |
| YDSG | disposable nonwage income, at current prices |
| YDSW | disposable wage income, at current prices |
| YG | disposable nonwage income, at 1976 prices |
| YS | national income at factor costs, at current prices |
| YW | disposable wage income, at 1976 prices |
| YWGGLE | gross wage rate (incl. social wage) |
| YWGGS | gross wages and salaries (incl. social wage) |
| YWGH | hourly wage rate |
| YWGS | gross wages and salaries (excl. social wage) |
| ZG | base money |
| ZKSV | interest on consumer debt |
| ZSSV | interest on public debt |

## B. EXOGENEOUS VARIABLES

| | |
|---|---|
| D7390 | Dummy 1973 - 1990 |
| D77 | Dummy 1977 |
| D78 | Dummy 1978 |
| D8384 | Dummy 1983:1.0, 1984:-1.0 |
| DD | normal depreciation rate |
| DDV | advanced depreciation rate |
| DEFR | difference between changes in public debt and deficit of all public households |
| DIFII | inventory changes and statistical discrepancy, at 1976 prices |
| DP | average depreciation rate (nat. acc.) |
| EWBC | population in working age |
| EXRC | exchange rate AS/US$ |
| FDBSS | average rate for employers contributions to social insurance |
| FIFMS | share of value added tax for public investment |
| FIMP | share of imputed pensions of public sector |
| FLST | average wage tax rate |
| FODEP | share of depreciations of the public sector |
| FOTIV | share of indirect taxes of public sector |
| FTIV | average indirect tax rate |
| FXST | share of tourism exports ot total exports of goods and services, at 1976 prices |
| GDPOECD | gross domestic product of OECD-countries, at 1976 prices |
| GUS | public fees and penalties |
| IFMS | value added tax of not-exempted investors |
| IMPPS | imputed contributions to public pensions |
| NAZ | legal working time |
| NP | years of normal depreciation |
| OIFS | public investment expenditures, at current prices |
| OIMVS | intermediary consumption of public sector |
| OKES | refunds for certain public sector costs |
| OKTRN | capital transfers of public sector, net |
| OLIEGN | public acquisition of land, net |
| OPAS | expenditures on civil servants |
| OTRAN | current transfer receipts of public sector, net |
| PGDPOECD | deflator of gross domestic product of total OECD |
| PHHV | contributions to federal government pensions |
| RDISK | discount rate |
| REU3 | 3-month eurodollar rate |
| RRR | effective required reserve ratio |
| RSP | basic interest rate on savings deposits |
| RTGDM | call money rate, FR Germany |
| SUBV | subsidies (nat. acc.) |
| T1 | time trend |
| TRANSV | domestic transfer income of private households |
| U | marginal corporate tax rate |
| YDREST | net foreign transfers of private households |
| YFS | factor income from abroad, net |

## C. RESIDUALS

| | |
|---|---|
| PCR | difference between observed and estimated consumer price inflation |
| R2 | (transh-equation) |
| R8 | (c-equation) |
| R10 | (kp-equation) |
| R13 | (m-equation) |
| R14 | (xx-equation) |
| R16 | (rtg-equation) |
| R18 | (rsecl-equation) |
| R20 | (hbu-equation) |
| R21 | (le0-equation) |
| R22 | (lf-equation) |
| R24 | (svb-equation) |
| R25 | (alvb-equation) |
| R26 | (wbfb-equation) |
| R35 | (pvdn-equation) |
| R38 | (ywgh-equation) |
| R40 | (pif-equation) |
| R42 | (pdep-equation) |
| R43 | (pcp-equation) |
| R44 | (px-equation) |
| R45 | (pxst-equation) |
| R59 | (zksv-equation) |
| R60 | (zssv-equation) |
| R62 | (egk-equation) |
| R63 | (ebust-equation) |
| R65 | (tdkv-equation) |
| R67 | (tdhvr-equation) |
| RMU3 | (mu3-equation) |
| RN4 | (ydsw-equation) |
| RPMS | (pms-equation) |
| RZG | (zg-equation) |

## D. EQUATION SYSTEM OF THE MACRO MODEL MAXOPT (E) VERSION 7/87

```
EQUATION  1: YDS         DISPOSABLE INCOME, AT CURRENT PRICES

YDS = YWGGS + EBUS - ZKSV + TRANSV
      - TDHV -SVB -IMPPS - GUS - YDREST


EQUATION  2: TRANSH      TRANSFER INCOME, GROSS

TRANSH = EXP(LN(TRANSH1) + .9913*LN(TRANSV/TRANSV1) +
                          (.00313)
        .25607*LN(TRANSV1) -.25697*LN(TRANSH1) +.00881 +R2)
       (.19399)            (.19465)            (.00608)
     R2=.999  DW=1.699  SE=.0003  (1965-84)


EQUATION  3: CPS         PUBLIC CONSUMPTION, AT CURRENT PRICES

CPS = OPAS+(FIMP*IMPPS)+(FODEP*DEPS)+(FOTIV*TIV/100)
      +OIMVS-OKES


EQUATION  4: YDSW        DISPOSABLE WAGE INCOME, CURRENT PRICES

YDSW = YWGS + TRANSH - LST - PHHV
       -(1-FDBSS)*(SVB-PHHV+ALVB+WBFB) +RN4


EQUATION  5: YDSG        DISPOSABLE NONWAGE INCOME, CURR. PRICES

YDSG = YDS-YDSW
```

```
EQUATION  6: YW          DISPOSABLE WAGE INCOME,AT 1976 PRICES

YW = YDSW/PC*100


EQUATION  7: YG          DISPOSABLE NONWAGE INCOME, 1976 PRICES

YG = YDSG/PC*100


EQUATION   8: C          PRIVATE CONSUMPTION, AT 1976 PRICES

C = EXP(LN(C1) +.51688*(LN(YW/YW1)) +.05658*(LN(YG/YG1)) +
             (.09356)           (.02080)
   .32815*(LN(YW1)) +.07954*(LN(YG1)) -.41685*LN(C1) +
  (.12005)          (.02372)          (.15021)
   .02705*(D77-D78) +.01707*(D8384) +.22928 + R8)
  (.00565)          (.00574)        (.13536)
      R2=.928  DW=1.668  SE=.0074  (1965-84)


EQUATION   9: CP         PUBLIC CONSUMPTION, AT 1976 PRICES

CP = CPS*100/PCP


EQUATION   10: KP        PRIVATE STOCK OF CAPITAL, AT 1976 PRICES

KP= EXP(LN(KP1) +.09117*LN(GDP/GDP1) +.03808*LN(GDP1/KP1) -
              (.03898)           (.00925)
     .00741*LN(RPI/PGDP) +.05179 + R10)
    (.00192)            (.01347)
        R2=.990  DW=1.010  SE=.0027  (1965-84)
        AR1(F1,15)=3.22    ARCH (F1,14)=15.57


EQUATION   11: IFP       PRIVATE GROSS FIXED INVESTMENT,
                         AT 1976 PRICES

IFP = KP - (1-DP)*KP1 + IFMS*(1-FIFMS)


EQUATION   12: IFO       GROSS FIXED INVESTMENT,AT 1976 PRICES

IFO= IFP + OIFS/PIF*100


EQUATION   13: M         IMPORTS OF GOODS AND SERVICES,
                         AT 1976 PRICES

M = EXP(LN(M1) +2.02832*LN(GDP/GDP1) + 1.06213*LN(GDP1/M1)
              (.38382)           (.35554)
   -.43756*(LN(PM1/(PGDP1*M1)) -3.56724 + R13)
   (.14389)                  (1.17220)
      R2=.837  DW=1.46   SE=.0249  (1965-84)


EQUATION   14: XX        EXPORTS OF GOODS AND SERVICES,
                         AT 1976 PRICES

XX = EXP(LN(XX1) +.67772*LN(GDPOECD/GDPOECD1)
              (.44650)
    +1.93926*LN(GDPOECD1) +.13664*LN(PGDPOECD*EXRC) -
     (.44662)            (.09866)
     .38542*LN(PX) -.73986*LN(XX1) -12.21234 + R14)
    (.20802)       (.19911)       (2.92150)
        R2=.706  DW=2.41   SE=.0289  (1966-84)


EQUATION   15: GDP       GROSS DOMESTIC PRODUCT, AT 1976 PRICES

GDP = C + CP + IFO + XX + DIFII - M
```

```
EQUATION   16: RTG        CALL MONEY RATE

RTG = EXP(LN(RTG1) +.17764*LN(RTGDM) -.21369*LN(RTGDM1)
                   (.11022)          (.11366)
        +.97618*LN(RDISK) -.57498*LN(RDISK1)
        (.22200)           (.25491)
        -.31992*LN(RTG1) + R16)
        (.20905)
           R2=.767  DW=1.810  SE=.1451  (1965-84)


EQUATION   17: MU3        MONEY MULTIPLIER FOR M3

MU3 = EXP(.36428*LN(GDPS) -.23449*LN(RRR) -.17808*LN(RSP)
         (.01718)          (.05655)        (.04587)
         -1.23761 + RMU3)
          (.07945)
              R2=.993  DW=1.66   SE=.0207  (1964-84)


EQUATION   18: ZG        BASE MONEY

ZG = EXP(LN(ZG1) +.62897*(LN(XS)-LN(MS)) +.10885*LN(RTG/REU3)
                 (.27757)                (.04132)
        +.11143 + RZG)
        (.04132)
              R2=.317  DW=1.88   SE=.0358  (1965-84)


EQUATION   19: M3        MONEY STOCK M3

M3 = MU3*ZG


EQUATION   20: RSECL     YIELD OF NEWLY ISSUED BONDS

RSECL = EXP(LN(RSECL1)+ .14863*LN(RTG/RTG1)+.16419*LN(RTG1)
                       (.04013)            (.04833)
         -.14431*LN(RSECL1)-1.96900*LN((M3/PC)/(M31/PC1))
         (.11624)          (.34633)
         -.16873*LN(M31/PC1)+.34969 + R18)
         (.04534)           (.17632)
              R2=.910  DW=2.130  SE=.0307  (1966-84)


EQUATION   21: BIFP      PRESENT VALUE OF PRIVATE DEPRECIATIONS
                         OF TAX ALLOWANCES

BIFP = ((1/(1+RSECL/100))^.5)*(DDV+DD+DD*(1/(1+RSECL/100))
      *((1/(1+RSECL/100))^NP-1)/((1/(1+RSECL/100))-1)+
       (1-DDV-DD-NP*DD)*((1/(1+RSECL/100))^(NP+1)))


EQUATION   22: HBU       AVERAGE WEEKLY WORKING TIME

HBU = EXP(LN(HBU1) +.54748*LN(NAZ/NAZ1) +.49318*LN(NAZ1)
                   (.08225)             (.12096)
      +.13041*LN(GDP/GDP1) -.53745*LN(HBU1) + .12282 + R20)
      (.07162)             (.12502)           (.10195)
           R2=.830  DW=1.848  SE.0052  (1965-84)


EQUATION   23: LEO        EMPLOYMENT

LEO = EXP(LN(LE1) +.19798*LN((GDP/GDP1)/(HBU/HBU1))
                  (.09213)
     +.38355*LN(GDP1/(HBU1*LE1)) -.12239*LN((YWGGLE/(HBU*PGDP)))
     (.07347)                    (.04937)
     -.00794*T1 +1.61687 + R21)
     (.00168)   (.48672)
          R2=.849  DW=1.43   SE=.0067  (1965-84)
```

```
EQUATION  24: LF        LABOUR SUPPLY

LF = EXP(LN(EWBC) + LN(LF1/EWBC1) -.05448 *(LN(LF1/EWBC1))
                                  (.17275)
   -.52453*(LN(LF2/EWBC2))+.24205*LN(YW/YW1)+.10481*LN(YW1)
   (.13131)              (.05999)          (.02216)
   -.02766*LN(YG/YG1)-.02445*LN(YG1) -.81652 + R22)
   (.01128)          (.01247)        (.15593)
        R2=.898  DW=2.04  SE=.0039  (1966-84)
```

```
EQUATION  25: UR        UNEMPLOYMENT RATE

UR = (LF-LEO)/LF * 100.
```

```
EQUATION  26: SVB       CONTRIBUTIONS TO SOCIAL INSURANCE

SVB = EXP(LN(SVB1) +.6447*(LN(YWGS/YWGS1)) +.29959*LN(YWGS1)
                   (.12295)                (.10563)
     -.26257*LN(SVB1) +.06652*D78 -.54019 + R24)
     (.09041)         (.01588)    (.21192)
         R2=.891  DW=1.602  SE=.0143  (1965-84)
```

```
EQUATION  27: ALVB      CONTRIBUTIONS TO UNEMPLOYMENT INSURANCE

ALVB = EXP(LN(YWGS) + LN(ALVB1/YWGS1) +.26745*LN(UR/UR1)
                                      (.06236)
      +.01486*T1 +.24511*LN(UR1*YWGS1/ALVB1) -1.40207 + R25)
      (.00233)   (.06559)                    (.35732)
          R2=.853  DW=2.839  SE=.0382  (1966-84)
```

```
EQUATION  28: WBFB      CONTRIBUTIONS TO CONSTRUCTION PROGRAMS

WBFB = EXP(LN(WBFB1) +.4837*(LN(YWGS/YWGS1)) +.50138*LN(YWGS1)
                     (.24517)                (.14798)
      -.45521*LN(WBFB1) -2.52922 + R26)
      (.13989)          (.74849)
           R2=.666  DW=2.449  SE=.0284  (1965-84)
```

```
EQUATION  29: DBSS      EMPLOYERS CONTRIBUTIONS TO SOCIAL INSUR.

DBSS = FDBSS*(ALVB+WBFB+SVB-PHHV)
```

```
EQUATION  30: YWGGS     GROSS WAGES AND SALARIES
                        (INCL. SOCIAL WAGE)

YWGGS = YWGS + IMPPS + DBSS
```

```
EQUATION  31: ULC       UNIT LABOUR COSTS(YWGGS/GDP)

ULC = YWGGS/GDP
```

```
EQUATION  32: YWGGLE    GROSS WAGE RATE (INCL. SOCIAL WAGE)

YWGGLE = YWGGS/LEO*1000
```

```
EQUATION  33: TIV       INDIRECT TAXES (NAT. ACC.)

 TIV = (FTIV/100)*(CS+CPS+XSTS+IFS)
```

```
EQUATION  34: PMS     DEFLATOR IMPORTS OF GOODS AND SERVICES
                       (BASED ON US$)

PMS = EXP(LN(PMS1) + 1.81228*LN(PGDPOECD/PGDPOCD1) +
                      (.15481)
          .14093*LN(PGDPOCD1/PMS1) - .00004 + RPMS)
         (.07845)                  (.03038)
              R2=.890  DW=2.606  SE=.0316  (1965-84)


EQUATION  35: PM       DEFLATOR IMPORTS OF GOODS AND SERVICES
                        (BASED ON A.S.)

PM = PMS*EXRC/17.93925


EQUATION  36: FITS     MARK-UP FACTOR FOR IND.TAXES & SUBSIDIES

FITS = (TIV-SUBV)/(CS+CPS+XSTS+IFS)


EQUATION  37: PVDN     NET PRICE DEFLATOR OF DOMESTIC DEMAND

PVDN = EXP(LN(PVDN1) + .34162*(LN(ULC/ULC1))
                       (.07123)
      +.31499*(LN(PM/PM1)) + .13727*LN(ULC1/PVDN1)
      (.06224)             (.08399)
      +.09875*LN(PM1/PVDN1) + .73921 + R35)
      (.07756)              (.43919)
          R2=.982  DW=1.780  SE=.0089  (1965-84)


EQUATION  38: PVD      DEFLATOR DOMESTIC DEMAND

PVD = (1+FITS)*PVDN/1.1262199


EQUATION  39: PC       DEFLATOR OF PRIVATE CONSUMPTION

PC = EXP(LN(PC1) +.69868*(LN(PVD/PVD1)) +.34734*(LN(PVD1/PC1))
                 (.08862)°               (.08870)
     .01729  + PCR)
    (.00536)
          R2=.896  DW=2.145  SE=.0062  (1965-84)


EQUATION  40: YWGH     GROSS HOURLY WAGE RATE

YWGH = EXP(LN(YWGH1) +1.02478*(LN(PC/PC1)-PCR) +
                      (.28648)
       .07763* LN(PC1/YWGH1) -.03299*LN(UR) +
      (.01592)              (.01346)
       -.50820*LN(NAZ/NAZ1) +.01134 + R38)
       (.20752)             (.03190)
             R2=.856  DW=2.524  SE=.0131  (1965-84)


EQUATION  41: YWGS     GROSS WAGES AND SALARIES
                       (EXCL. SOCIAL WAGE)

YWGS = (YWGH*(HBU*52)/1000)*LEO/1000


EQUATION  42: PIF      DEFLATOR OF GROSS FIXED INVESTMENT

PIF = EXP(LN(PIF1) +.99472*(LN(PVD/PVD1)) +.36003*LN(PVD1)
                   (.17976)                (.18738)
      -.39277*LN(PIF1) + .15537 + R40)
      (.20451)         (.09698)
          R2=.730  DW=1.491  SE=.0140  (1965-84)
```

```
EQUATION  43: PDEP     DEFLATOR DEPRECIATION (NAT. ACC.)

PDEP = EXP(LN(PDEP1) +.86433*LN(PIF/PIF1)
                      (.11962)
        +.19831*LN(PIF1/PDEP1)+.00652 + R42)
        (.17337)              (.00674)
           R2=.784  DW=1.821  SE=.0110  (1965-84)


EQUATION  44: PCP      DEFLATOR PUBLIC CONSUMPTION

PCP = EXP(LN(PCP1) +.94832*(LN(YWGGLE/YWGGLE1)) +
                    (.13287)
     .49227*LN(YWGGLE1)-.57614*LN(PCP1) +.17915 + R43)
    (.18932)          (.22208)         (.08148)
         R2=.809  DW=1.841  SE=.0122  (1965-84)


EQUATION  45: PX       DEFLATOR EXPORTS OF GOODS AND SERVICES

PX = EXP(LN(PX1) +.89831*LN(PVDN/PVDN1) +.54423*LN(PVDN1)
                  (.13088)              (.17316)
    -.71578*LN(PX1)+ .79371 + R44)
    (.22852)        (.26030)
         R2=.765  DW=1.702  SE=.0117  (1965-84)


EQUATION  46: PXST     DEFLATOR TOURISM EXPORTS

PXST= EXP(LN(PXST1) +1.11775*LN(PC/PC1) +.10155*LN(PC1/PXST1)
                     (.13613)           (.05881)
      -.00278 + R45)
      (.00808)
          R2=.819  DW=2.083  SE=.0096  (1966-84)


EQUATION  47: CS       PRIVATE CONSUMPTION, CURRENT PRICES

CS = PC*C/100


EQUATION  48: IFS      GROSS FIXED INVESTMENT, CURRENT PRICES

IFS = (IFP*PIF/100)+ OIFS


EQUATION  49: VDS      DOMESTIC DEMAND, CURRENT PRICES

VDS = (C+CP+IFO+DIFII)*PVD/100


EQUATION  50: MS       IMPORTS OF GOODS AND SERVICES,
                       AT CURRENT PRICES

MS = M*PM/100


EQUATION  51: XS        EXPORTS OF GOODS AND SERVICES,
                        AT CURRENT PRICES

XS = XX*PX/100


EQUATION  52: HDLB     TRADE AND SERVICE BALANCE

HDLB = XS - MS


EQUATION  53: XSTS     TOURISM EXPORTS, CURRENT PRICES

XSTS = (FXST*XX/100)*PXST/100
```

EQUATION 54: GDPS GROSS DOMESTIC PRODUCT, CURRENT PRICES

```
GDPS = VDS + XS - MS
```

EQUATION 55: PGDP DEFLATOR OF GROSS DOMESTIC PRODUCT

```
PGDP = GDPS/GDP*100
```

EQUATION 56: RPI RENTAL PRICE OF PRIVATE CAPITAL

```
RPI = PIF*(DP+RSECL/100-(PGDP/PGDP1-1))*(1-U*BIFP)/(1-U)
```

EQUATION 57: DEPS DEPRECIATIONS (NAT. ACC.), CURRENT PRICES

```
DEPS = ((DP*KP1)*PDEP/100)/(1-FODEP)
```

EQUATION 58: YS NET NATIONAL PRODUCT AT FACTOR COSTS

```
YS = GDPS  - DEPS - TIV + SUBV - YFS
```

EQUATION 59: ZKSV INTEREST ON CONSUMER DEBT

```
ZKSV = EXP(LN(ZKSV1) + .22263*LN(RSECL/RSECL1)
                      (.20051)
      +1.51081*LN(CS/CS1) -.03606*LN(ZKSV1) +.06245 + R59)
       (.64625)           (.01705)          (.06377)
           R2=.453  DW=1.622  SE=.0735  (1965-84)
```

EQUATION 60: ZSSV INTEREST ON PUBLIC DEBT

```
ZSSV = EXP(LN(ZSSV1)+.30797*LN((RSECL*FSS)/(RSECL1*FSS1)) +
                    (.09256)
      .62858*LN(RSECL1*FSS1) -.60503*LN(ZSSV1) -3.02905 + R60)
     (.10153)               (.09983)          (.50213)
          R2=.781  DW=1.667  SE=.0399  (1965-84)
```

EQUATION 61: EBU TOTAL INCOME FROM PROFITS AND PROPERTY

```
EBU = YS -YWGGS + ZSSV + ZKSV
```

EQUATION 62: EGK RETAINED EARNINGS OF CORPORATIONS (NAT. ACC.)

```
EGK = EXP(LN(EGK1) +5.03564*LN(GDPS/GDPS1)
                   (.63089)
      +.82678*LN(GDPS1/EGK1) -2.68173 + R62)
      (.12801)               (.38632)
           R2=.816  DW=1.505  SE=.0619  (1965-84)
```

EQUATION 63: EBUST GOVERNMENT INCOME FROM PROFITS AND PROPERTY (NAT. ACC.)

```
EBUST = EXP(.46932*LN(RSECL) +.41229*LN(GDPS)
           (.27243)          (.19819)
         + .63014*LN(EBUST1) -2.73539 + R63)
          (.13969)            (.83770)
              R2=.986  DW=1.961  SE=.0921  (1965-84)
```

EQUATION 64: EBUS RESIDUAL INCOME FROM PROFITS AND PROPERTY

```
EBUS = EBU - EGK - EBUST
```

EQUATION 65: TDKV DIRECT TAXES OF CORPORATIONS

```
TDKV = EXP(LN(TDKV1) +.45659*(LN(EGK1/EGK2)) +.70434*LN(EGK2)
                    (.11837)               (.15231)
      -.63434*(LN(TDKV1)) -.17693*D7390 -.79313 + R65)
      (.14615)           (.07106)      (.22531)
            R2=.655  DW=2.047  SE=.0585  (1966-84)
```

EQUATION 66: LST DIRECT WAGE TAX

LST = (FLST/100)*YWGS

EQUATION 67: TDHVR OTHER DIRECT TAXES OF PRIVATE HOUSEHOLDS

```
TDHVR = EXP(LN(TDHVR1) +1.65510*LN(YWGS/YWGS1)
                       (.28086)
        +.19703*LN(YWGS1/TDHVR1) +.42363*LN(EBUS2/EBUS3) +
        (.08784)                (.12596)
         .28171*LN(EBUS3/TDHVR1)-.87802 + R67)
        (.07179)               (.26807)
             R2=.835  DW=2.812  SE=.0275  (1967-84)
```

EQUATION 68: TDHV TOTAL DIRECT TAXES OF PRIVATE HOUSEHOLDS

TDHV = LST +ALVB + WBFB + TDHVR

EQUATION 69: OESP SAVINGS OF THE PUBLIC SECTOR (NAT. ACC.)

OESP = EBUST + TIV + TDHV + TDKV + SVB + IMPPS + GUS + OTRAN -
CPS - ZSSV - SUBV - TRANSV

EQUATION 70: DEF NET DEFICIT/SURPLUS OF PUBLIC SECTOR

DEF = OESP + (FODEP*DEPS) + OKTRN - OIFS - OLIEGN

EQUATION 71: FSS STOCK OF PUBLIC SECTOR DEBT

FSS = FSS1 -DEF +DEFR

EQUATION 72: DEFQ DEFICIT RATIO

DEFQ = (FSS-FSS1)/GDPS*100

# FRAGEBOGEN ZUR BEWERTUNG VON INTERAKTIVEN OPTIMIERUNGSMETHODEN

**1. Treten Entscheidungsprobleme bei mehrfacher Zielsetzung in Ihrem Arbeitsbereich auf?**

a) nie b) selten c) oft d) fast immer — Bitte ankreuzen!

falls nicht a): **1b. Verwenden Sie Optimierungsverfahren bei mehrfacher Zielsetzung für Ihre Entscheidungsprobleme ?** ja / nein

**2. Welches Verfahren ist für Sie am leichtesten verwendbar?**

STEM ____ IMGP ____ ZW ____ DIDAS ____ — Bitte Rangordnung angeben!

**3. Welches Verfahren ist für Sie am ehesten verständlich?**

STEM ____ IMGP ____ ZW ____ DIDAS ____ — Bitte Rangordnung angeben!

**4. Können Sie die vom Verfahren von Ihnen verlangte Information**

1 sehr leicht
2 leicht
3 mit Nachdenken
4 mit Nachrechnen
5 schwer
6 nur durch "Raten" geben?

[ ] STEM
[ ] IMGP
[ ] ZW
[ ] DIDAS

Bitte Nummer angeben!

**5. Wie groß ist Ihr Vertrauen in die gewonnene Lösung?**

Punkteskala 1---2---3---4---5---6---7---8---9---10 — Bitte Nummer ankreuzen!
(1 = kein Vertrauen, 10 = volles Vertrauen)

**6. Wie sind Sie mit der Implementation der Verfahren zufrieden?**

| | STEM | IMGP | ZW | DIDAS |
|---|---|---|---|---|
| Verständnis der Interaktion | | | | |
| Übersichtlichkeit der Information | | | | |
| Schnelligkeit | | | | |
| Flexibilität | | | | |

Bitte bewerten Sie mit einer Punkte-skala von 1 (nicht) bis 10 (sehr).

**7. Haben Sie durch die Verwendung von interaktiven Methoden den Eindruck erhalten, über das Problem etwas dazugelernt zu haben?**

Punkteskala 1---2---3---4---5---6---7---8---9---10 — Bitte Nummer ankreuzen!
(1 = nichts, 10 = viel)

**8. Können interaktive Optimierungsverfahren für Ihre Entscheidungsprobleme sinnvoll eingesetzt werden?** ja / nein — Bitte ankreuzen!