USE OF OPTIMAL FEEDBACK FOR ECONOMETRIC MODELS

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ABSTRACT

During the last decade, economists have made a great deal of effort in using macroeconometric models for analyzing the behavior of aggregate economic variables. Many such models have been constructed and used for purposes of forecasting and policy analysis, the results of these studies being quite sensitive to the particular method of estimation used.

This thesis introduces Feedback Control Theory ideas to standard macroeconometric models, with the hope that model performance - judged by how well the endogenous variables track the observed historical values - will be improved.

A "new" closed-loop macroeconometric model is obtained by means of incorporating the policy makers' behavior into the original model. This is done by solving the "Finite Horizon Optimal Control Problem" and incorporating the control law into the model, as to obtain the closed-loop version of the model.

Several numerical experiments are presented so as to test the sensitivity of the "new" model to different estimation procedures, and to study its forecasting properties. All of these experiments use Klein's Model I as the original structure. An attempt to study the properties of the "new" model when this is obtained by means of a suboptimal control law, is also presented.

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Introduction

A.- PURPOSE OF THE THESIS

In the past years, there has been an ever increasing interest in the cross fertilization of ideas between economists and control scientists. Experts from both areas feel strongly that that these two fields will benefit from interdisciplinary studies.

This work represents an attempt to continue with this effort, following the outlines given by Athans and Kendrick (1973) {22}, namely, the use of feed back control in a linear-quadratic-gaussian (LQG) framework.

The Thesis introduces feedback control theory ideas to standard macroeconometric models, with the hope that performance -judged by how well the endogenous variables track the observed historical values- will be improved. In this context, the thesis is aimed to stablish new econometric models to be used, in conjunction with stochastic control techniques, for stabilization policy about desired targets for econometric variables.

B.- OVERVIEW

In this section we shall take a brief look at each chapter.

Chapter one begins with a discussion of different applications of control theory in economics, looking at the various difficulties associated with the use of present econometric models. This is followed by an economic interpretation of what would mean to use feeback in econometric models. The chapter then concludes with a discussion of the properties of feedback formulation and new trends in control theory that could be applied in modelling economic systems.

Chapter Two introduces the statement of our problem and the structure of the new macroeconometric model is derived in a LQG context.

Two macroeconometric models, to be used to test the properties of the new structure are introduced in Chapter Three emphasis is placed upon the estimation procedures used to obtain different versions of the model.

Chapter Four presents the numerical results of the experiment aimed to study the sensivity of the "new" model to different estimation procedures and model structures.

The forecasting properties of the new are studied in Chapter Five. In Chapter Six, properties of the "new" model when this is obtained by means of a suboptimal control law are studied in the context of a numerical experiment. Finally, in Chapter Seven, we present the conclusions.

Chapter I

THE USE OF FEEDBACK CONTROL STRATEGIES IN ECONOMETRICS MODELS

1.1 ADVANTAGES OF FEEDBACK FORMULATION. AN OVERVIEW

The United States Economy as any other national economy is a very complex system. Control engineers in tackling complex systems, as an industrial chemical process would be, have been considering highly simplified linear mathematical models instead of large scale non-linear models. How do we explain this seemingly paradox? We can answer the previous question by just using one word: Feedback.

Feedback control has been used in engineering system design because it reduces the sensitivity of the system response to

- o Modelling errors
- o Parameter variations
- o Estimation errors
- o Uncertainties

in the system being controlled. Economic systems have many of the previous properties; therefore, application of control theory seems a rather obvious consequence.

Up to date, most of the application of control theory into economics has been related with the obtention of optimal policies for economic stabilization. But the feedback formulation, the main contribution of control theory, has not been fully utilized in formulating econometric models.

Open and closed loop strategies have been discussed mainly from the point of view of the means by which optimal policies were obtained. But closed loop macroeconomic models, and all their properties, have yet to be considered.

In this chapter we shall justify and interpret the use of a such closed loop macroeconomic models. We will first present a brief summary of the accomplishments of control theory in the economic field as a background for the motivation to use a new formulation of macroeconomic models. Next, a possible economic interpretation of the new formulation will be discussed, afterwards some of the properties of this new formulation will be considered from the control theory point of view. In the final section of this chapter some new ideas in control theory as adaptivity and dual control will be discussed as a brief look to things yet to come.

1.2 BACKGROUND

Economists for long have been interested in the problems of control of recession and inflation. These economic fluctuations may arise either due to inherent cyclical tendencies of economic systems on due to random causes. Whatever the cause may be, there is an increasing awareness on the part of economists for the need of analyzing the impact of alternative types of economic policy for stabilization. One of the tools of policy formulation that has become widely useful, partly as a result of the availability of computers to economists, is the econometric model.

Econometric models have been used to perform computer simulations so as to compare the results of different policies, and eventualy to choose a policy which, though not necessarily optimal, is better, with respect to a given cost functional, than other policies tried. This trial-and-error method, used by Phillips (1954) { 1 }, and others Klein (1950) { 2 }, Simon (1952) { 3 }, is however, an inefficient if not impossible method of arriving at a policy plan that is optimal.

So, new methods have been tried; Theil (1958, 1964) { 4 } ,{ 5 }, and Holt (1960, 1962) { 6 }, { 7 }, looked at the maximization of quadratic and linear objective functions subject to the constraint of an econometric model in its reduced form, and their work has been a precursor to the application of "Optimal Control" theory to stabilization policy.

However, the application of control theory is not new. Tustin (1953) { 8 }, tried to solve the problem of economic stabilization by applying classical control theory. It has been only in recent years that several workers have found the techniques of optimal control theory in particular Pontryagin's minimum principle, to be applicable to problems in economics. Dowell and Ho (1967) { 9 }, Uzawa (1969) {10 }, Iwagaki (1970) {11 }, Applied Optimal Control Theory to Problems in Economic Growth. Stoleru (1965) {12 }, Kendrick (1969) {13 }, and Taylor (1970) {14 } have obtained numerical optimal control solutions for problems concerned with development planning.

In recent years, formulation of short term stabilization policy has been the most promising field for a realistic application of optimal control. Pindyck (1972) {15} , constructed a small, quartely, linear model of the Post Korean United States Economy to test optimal policies obtained using optimal control theory. Many others have tried the same approach with different types of model. Fair (1974, 1975) {16} ,{17}, Friedman (1972) {18}, Athans, et al. (1975) {19}, Ando, Norman, Palash (1975){20}. A good overview of application of control theory to economics has been given by Kendrick (1976) {21}.

From the foregoing paragraphs, we can conclude, that during the last decade, economists have made increasing use of macroeconometric models for analyzing the behavior of aggregate economic variables. Many such models have been constructed and used for purposes of forecasting and policy analysis. But the results of these studies have shown to be quite sensitive to the particular method of estimation, or the particular model structure used. As Pindyck has pointed out (1972 pg, 146) {15}:

> " THESE RESULTS (OPTIMAL POLICIES) ARE RATHER DISCONCERTING, SINCE THEY SAY THAT A SMALL CHANGE IN A COEFFICIENT VALUE CAN RESULT IN A LARGE CHANGE IN THE OPTIMAL POLICY AND IN THE RESULTING BEHAVIOR OF THE ECONOMY. THIS THROWS SOME DOUBT ON THE USEFULLNESS OF OUR PARTICULAR ECONOMETRIC MODEL FOR POLICY PLANNING."

The previous comment by Pindyck gives us a clear idea of what the problem is all about. Small changes in model structure or changes on the value of model's coefficients produce large changes on the model's multipliers (eigenvalues) and therefore an unpredictable behavior of the model is expected.

If we add to this already weak situation, the well known fact that econometric models behave reasonable well in the period of fit, but they have a very low forecasting accuracy out of the period of fit, we are facing a problem that has to be clearly examined before attempting to apply any optimal stabilization theory.

1.3 Feedback in Econometric Models. An Economic Interpretation

Trying to justify the use of feedback from the point of view of control theory, would be an easy task. Instead, we shall try a rather more difficult approach, namely, an economic approach. Before we start our reasoning we must point out that when we refer to feedback we are excluding the internal feedback relationships of the model, i.e., we are interested in a new feedback relationship among endogenous and exogenous-variables, that is not present in the standard econometric models.

Economic models can be viewed as particular systems describable by a set of simultaneous equations expressing all the interrelationships among the measurable economic variables which guide economic behavior. The variables in this set of equations are classified into two main types: Endogenous and Exogenous. The endogenous variables are those variables which are determined within the system, and they include such familiar quantities as Gross National Product (GNP), employment, profits, rents, etc. The exogenous variables are those which are determined not within the system but rather, by natural, technological, political, sociological or institutional forces which are assumed to be non-economic.

At this point, of course we would like to develop a social theory that would explain all the non-economical variables (i.e., all the exogenous variables) but as far as we know the only known theory today which covers politics, sociology, economics, etc., is the Marxian Theory, which is not applicable to economics based on the free enterprise system.

So, we turn our search back to the exogenous variables. As we said before, exogenous variables are determined by natural, technological, sociological, political, or institutional forces. To try to develop a non-Marxian Theory to explain for all the exogenous variables would be a very difficult task and out of the scope of this thesis research. Rather, we would like to try it just for a few variables. Let us forget about exogenous variables determined by natural, technological, sociological and like forces, and let us concentrate in the ones determined by political or institutional forces, i.e., the variables known as "instrument" or "policy" or "control" variables.

Up to this date economists have formulated no laws of behavior which for example the federal reserve board will obey in making its decision as to the amount of money to be supplied to the market. Similar remarks could be applied to other instrument variables as government spending, taxation, allocation of resources, etc.

On the other hand, economists have, over a period of years, developed theories of economic behavior which are the basis for the determination of the endogenous variables. In this context, firms and households are assumed to behave according to some fundamental rational patterns, which can be often written in the form of mathematical equations.

Neoclassical Economic Theory assumes that firms behave so as to maximize their profits, subject to the constraint that they operate according to the technological possibilities expressed by the production functions. It is also assumed that households behave so as to maximize their satisfactions or utilities, subject to budgetary constraints. It is by using the previous assumptions and equilibrium conditions that the structural equations, that constitute the econometric model, are obtained.

Therefore, it seems reasonable, in a rather intuitive way to assume that policy makers, and among them federal reserve board and government officials, behave in a similar manner, i.e., the policies are choosen so as to optimize certain objective functions subject to the constraints of the economic system.

In fact, it has been this implicit assumption to justify the application of optimal control theory to obtain optimal policies. Furthermore, there is some evidence that shows that policy makers such as federal reserve board officials have been using some kind of optimal control theory to reach, in some extent, conclusions about optimal policies, Athans (1973) {22}. Many people could claim that optimal control theory is such a new development that there is no reason to assume that policy makers behave so as to optimize certain objective function, that policy makers merely follow certain customary rules of thumb. To answer to this claim we can say that the mere fact that policies are obtained by rules of thumb does not mean that they are not optimal. In fact, even if no direct method to choose the optimal policy, among possible policies, is used, at least the policy selected has to be in some way better than the alternative policies and therefore, to a certain extent optimal. For these reasons we should not be misled by the statement that policy makers do not know the meaning of optimal control theory and hence do not behave as to optimize a given objective function.

In other words, the assumption that policy-makers exhibit optimizing behavior, is in principle no more arbitrary than the profit-maximizing or utility-maximizing assumption for firms and households.

1.4 Feedback in Control Theory

In the previous section we have developed a justification for using feedback in econometric models. In this section we shall turn our search to obtain the best way to incorporate the above ideas to the old model from the point of view of control theory. To carry it out, we will begin with a brief survey of the accomplishments on feedback related topics of both classical and modern control theory. Next, we shall present in a rather heuristic way, the statement of our problem. A more formal presentation of our problem will be given in Chapter two. In the last part of this section some properties of this closed loop formulation will be discussed.

A feedback system is one in which the action of an output variable is measured, this measured value is compared with some desired value and the error influences the forces tending to change the output variable. This effect is illustrated in Figure 1.1

Eventhough, applications of feedback can be found in early stages of history, the first definite evidence of an automatic feedback control system carries the date 1750. This is the invention by Meikle to control the turning gear for windmills.

The mathematical analysis of feedback control systems began in 1868 with Maxwell's paper, "On Governors" (1868) {23}. After a considerable lapse this was followed by three classical papers: Minorsky (1922) {24}, Nyquist (1932){25}, and Hazen's (1934) {26} "Theory of Servomechanism." Many other papers were published in the early 40's in the field of process control and automation. The most comprehensive bibliography, which includes references up to the year 1952, was published by the AIEE (1954) {27}. From the end of the 1940's to early 1950's, the root-locus method in control system design was fully developed.

The frequency-response and the root-locus methods, which are the core of classical control theory, lead to systems that are stable and satisfy a set of more or less arbitrary performance requirements. Such systems are, in general, not optimal in any meaningful sense. Since the late 1950's, the emphasis in control design problems has been shifted to the design of optimal system in some meaningful sense.

As modern plants with many inputs and outputs become more and more complex, the description of a modern control system requires a large number of equations. Classical control theory, which deals

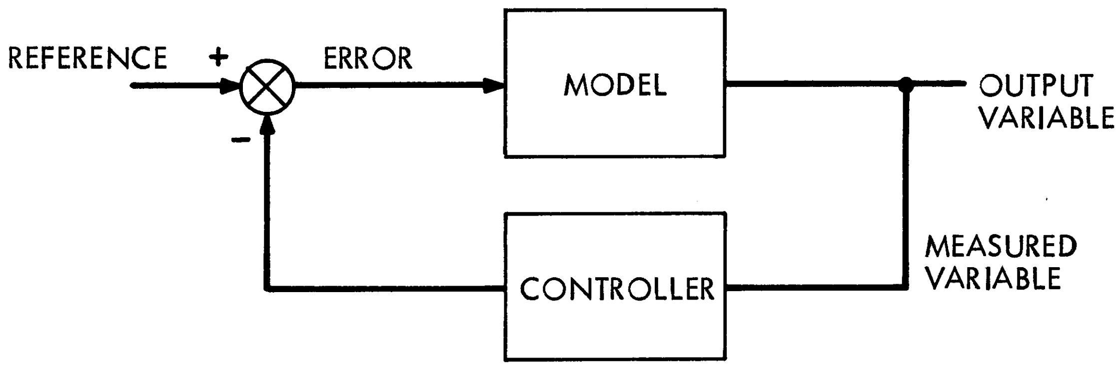


Figure 1.1

Feedback System

only with-single-input-single-output systems, becomes entirely powerless for multiple-input-multiple-output systems. Since about 1960, modern control theory has been developed to cope with the increased complexity of modern plants and the requirements on accuracy and cost in military, space, and industrial applicat- ions.

The most recent developments in modern control theory may be said to be in the direction of the optimal control of both deterministic and stochastic systems as well as the adaptive and learning control of complex systems.

Is in this context, that we approach economic systems. They are a challenging problem for control engineers since they offer most of the properties that constitute a very complex system, and therefore a very good field to try to apply the last discoveries on control theory.

Let us consider the problem of modelling an economic system from the point of view of control theory. The first question that we would like to answer is: What are the properties of an Economic system? in answering this question let us use control theory terminology. First, it is a closed-loop system, and by this expression, we are not reffering to the intrinsic feedback relationships inside the endogenous variables of the economic system, but to the explicit feedback relationship among output variables and instrument variables (i.e., we are reffering to the behavior of policy makers. They observe the situation of the economy, and based up on these measurement they formulate the policies or set the value of the instrument variables). Second, it is an adaptive control system. In other words its dynamic characteristics are evolving over time. This is due to the fact that technological production function are changing constantly, and therefore, the entire economic system is evolving in its structure. Third, it is an automatic regulating system in the sense that society and institutions as government, set targets or objectives in economic variables, and as such the entire system is varying with-time so as to follow the desired values of the targets. Fourth, it is a learning control system in the sense that the controllers ofthe systems (i.e., policy makers) have this ability to learn about the behavior of the system therefore, their policies would be more effective as time goes on.

We can keep on giving properties of the economic system, as; non-linear system, disturbance driven system, etc. But at this point we want to consider the previous properties alone, because these properties are the ones not considered by economists and we are interested on studying what could be the consequences of incorporating these ideas to standard econometric models.

With the above properties in mind, as we said before we want to model an economic system so as to incorporate these ideas. To do this, let us start with a diagram that hopefully will help to clarify our problem. This diagram is illustrated in figure 1.2. Ofcourse that this scheme is, by no meaning, the only way to tackle this problem, see Ogata (1970) {28}, but we consider, that at this

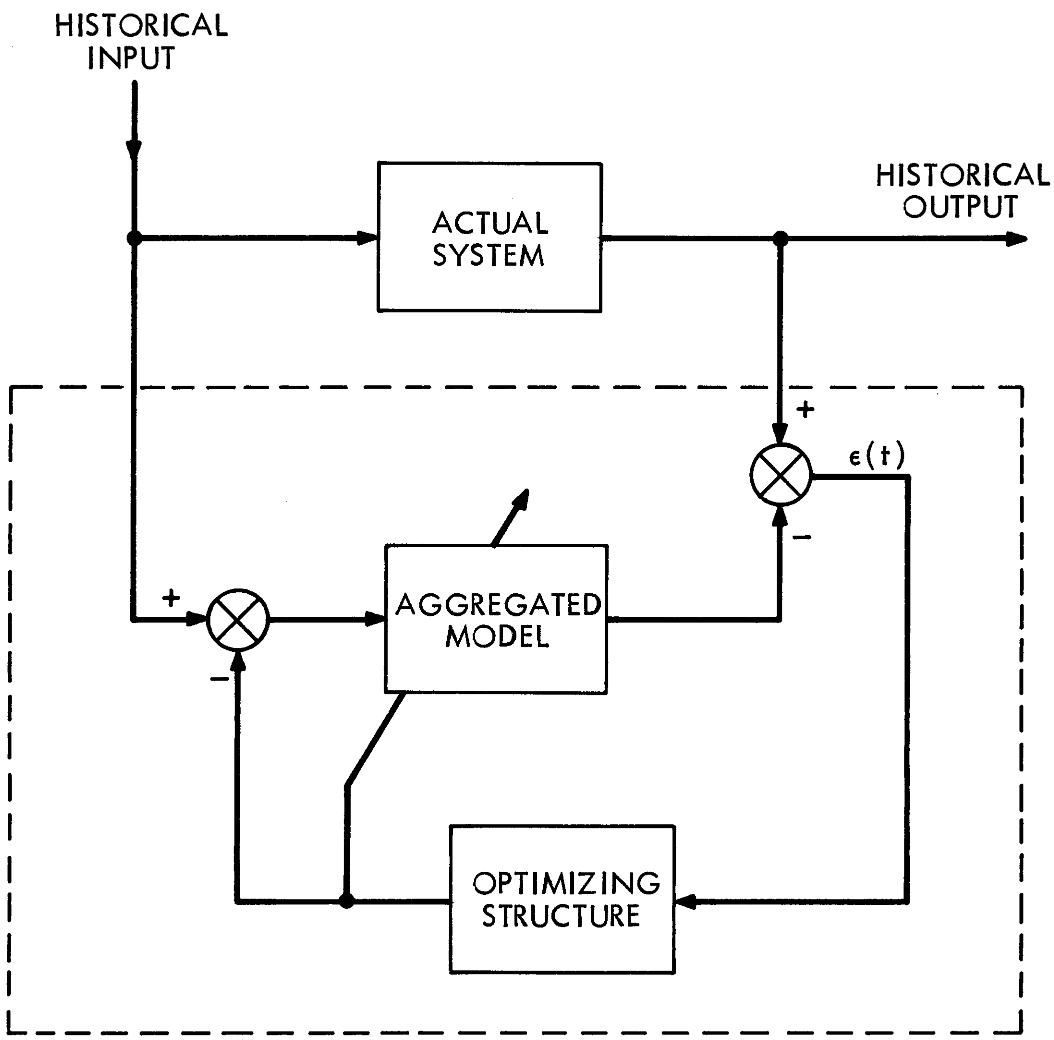


Figure 1.2

A Possible Way To Model Economic Systems point, our diagram is a good starting point for this day to day improvement in the interplay between economy and control theory.

Schemes like the one shown in figure 2.1 have been studied extensively in the control field. See for example Landau (1975) {29}. It is the same approach with a different philosophy the one used to solve the optimal tracking problem. See for exmaple in a linear-quadratic-caussian context, Athans (1971) {30}. The difference in philosophy basically consists in that the first is aimed to included the optimizing behavior inside the model. Meanwhile, the second approach is concerned only with obtaining the optimal controls. We shall use the second approach because its derivation is simpler but we will keep the former philosophy so as to incorporate the optimizaing behavior into the old model. In other words, once we obtain the explicit closed loop form for the optimal control, we will contruct the closed loop structure so as to arrive to the new model.

Now, let us discuss some properties of this structures from what we already know in control theory. We hope that by doing this we will gain some insight in the characteristics of this new structure.

The main property of closed-loop model is the capability of reducing the sensitivity of the model to modelling errors and uncertainties. This means that even if the original aggregated model is not a good representation of the original system. The closed-loop structure of the new configuration is going to help to overcome the original difficulties. This property is very important since it says that a perfect knowledge of the actual system is no longer needed.

Another property of this close-loop formulation is that the feedback relationship permits to exhibit "hidden" relationships among the original variables. This is due to the fact that the closed loop is going to modify the values-of the coefficients of the original model. This can be illustrated by a very simple example. Let us suppose the following linear system.

$$x(t+1) = A\, x(t) + B\, \mu(t) \tag{1.1}$$

in this particular case the matric "A" gives stability and behavior characteristic to the particular system (1.1). If we introduce a closed-loop formulation to a system (1.1) as for example:

$$\mu = -G\, x\, (t)$$

the system described by (1.1) becomes

$$x(t+1) = (A-BG)\, x(t) \tag{1.2}$$

and now, the stability and behavior characteristics would be given by the matrix (A-BG).

In a linear systems context, the position on the "s" plane of the Eigenvalues of Matrix "A" determines the stability and behavior characteristics of continous systems, this has its equivalence for discrete systems, to the position of Eigenvalues on the plane "z". See for example, Free man (1965) {31}. It is obvious that for different aggregated models, the positions of their Eigenvalues on the "z" plane are going to be different and therefore forecasting properties of these models are going to differ widely. The use of closed-loop formulation gurantees to certain extent the uniformization of behavior of different aggregated models, i.e., the positions of the Eigenvalues for the closed-loop systems are going to be similar independently of the aggregated model used.

Up to this point, we have formulated and discussed some properties of the closed-loop systems, before we enter specifically in the details of the formulation of our problem, let us first discuss some of the ideas that in the near future economists can obtain from control theory. This will be done in the next section.

1.5 Feedback and Adaptivity. Use of Aggregated Models For Control

Different adaptive control methods have been applied to macroeconometric models, Prescott (1967) {32}, Chow (1975) {33}, and Upadhyay (1975) {34}. It is not yet clear which of these approaches (or others still untried) will prove to be superior in application to macroeconometric models. However, so far none of the applications of adaptive control to macroeconomic models have included the errors in measurement of the Endogenous variables. The updating of macroeconomic time series would indicate that the first date reported are indeed noisy so that the use of this procedure could help in modelling the economic system.

Though macroeconomic policy at least in the U.S. is definitely characterized by decentralization in decision making, there has so far been relatively few efforts to model this phenomenon. Among them, Kydland (1975) {35}, Pau (1973) {36}, Pindyck (1975) {37}. In such studies the policy makers can be viewed as having the same or different objectives and as having access to the same or different information.

Another interesting idea is the use of aggregated models for control. As is well-known to control engineers a model required for pure prediction purposes will have different characteristics to one used as a reference for control purposes. It is a point which economists find difficult to appreciate, since their thinking has been mainly in terms of open-loop correction of output variables. The powerful stiffening effect that feedback control has is unfamiliar to them. It is for this reason that a convincing demonstration of this effect in credible terms assumes such importance. In this context, our thesis research is aimed to stress such an idea.

Chapter 2 PROBLEM STATEMENT.-

2.1 OVERVIEW.-

In this chapter we shall interpret and extend, from a mathematical point of view, the ideas presented in Chapter One. On the following paragraphs we present a brief overview of the sections contained in this chapter. In the first section a short discussion of how we arrive to the mathematical formulation of the problem is presented. Next, mathematical symbols and definitions, to be used in formulating the problem, are introduced along with the formulation of the problem. In section three, highlights of the solution of the finite time optimal control problem are presented. Section four introduces the "new" model as a result of the interplay between the econometric model and the infinite time optimal control solution. The last section gives some remarks about the "new" structure.

2.2 Necessity of a Better Mathematical Formulation of Our Problem.

Standard econometric models are obtained by estimating the parameters of simultaneous difference equations using historical data. Economic behavior is very difficult to model. Even large scale econometric models are not able to predict accurately economic variables. Considering the previous facts we can state that standard intermediate econometric models are highly simplified models of the economy, and therefore, optimal control policies and forecasts obtained with these models are not necessarily too reliable.

In obtaining optimal policies we consider: future desired target paths for endogenous and instrument variables (observed and control variables), an objective function, and tradeoff parameters to weigh the importance of different variables. These facts are not considered in obtaining standard econometric models. Therefore, the need of a new mathematical formulation is clear.

In Chapter One we presented an economic interpretation of the necessity of a new formulation. In this Chapter we shall consider a mathematical formulation that incorporates all the facts that are missing in the standard econometric model. In this context, we can state our problem; we need to construct a "new" mathematical model to be used for future stabilization policies such that it allows us to:

- Improve the forecasting accuracy of standard Econometric models
- Reduce sensitivity to modelling errors
- Reduce sensitivity to uncertainties
- Include the desired paths or targets for endogenous and instrument variables
- Include the objective function to be optimized by policy makers
- Include the dynamics of standard models
- Blend behavior theories of firms, households and policy makers

The structure of this "new" econometric model is presented in Figure 2.1.

In the diagram of Figure 2.1 we observe that the key step in the formulation of the "new" model is the solution of the finite

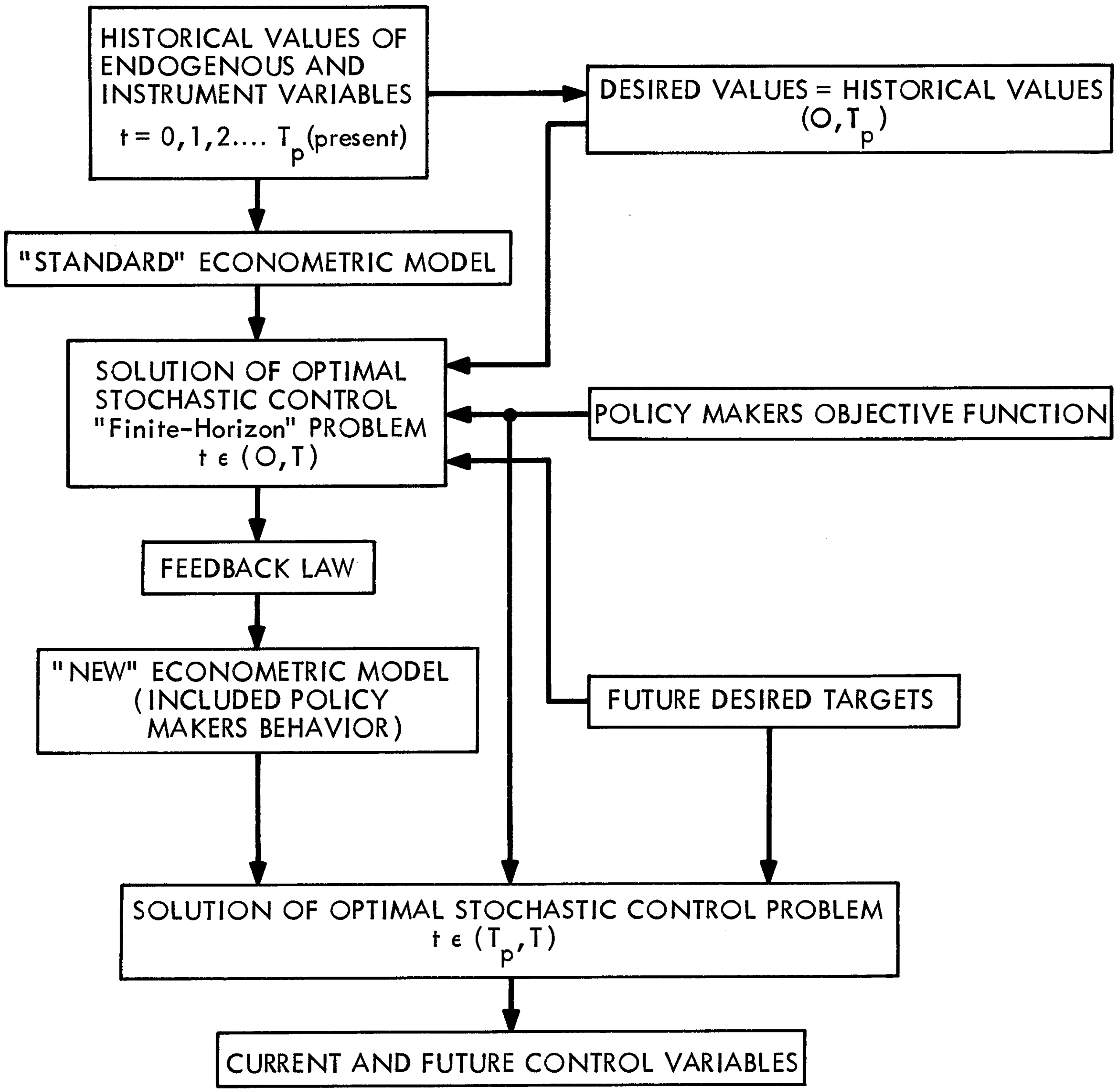


Figure 2.1

Finite Horizon Optimal Control Problem

time optimal stochastic control problem (i.e., the optimal tracking problem). It is by meaning of the solution of this optimal control problem that we are able to include the desired paths for endogenous and instrument variables (historical and future values), the objective function that reflect the behavior of the policy makers, and the dynamics of the "old" model that reflects the behavior of the firms and households. Furthermore, the nature of the optimal control problem (closed loop form) allows us to reduce the sensitivity to modelling errors and uncertainties inherent to the "old" model.

In the next pages we shall derive the "new" econometric model according to the structure of figure 2.1. As we pointed out in the introduction of this thesis report, the derivation of this "new" model will be done in a "Linear-Quadratic-Gaussian" framework.

In order to derive the "new" model, first a mathematical formulation of the problem in the LQG context is given, next a concise derivation of the finite horizon optimal control is presented following the theory developed in Athans and Falb (1966) {38} , and more specifically in Athans (1974) {39}. Once the optimal control law is calculated, the "new" econometric model is obtained by constructing the closed loop system from the optimal control law and by rearrenging the matrices of the "old" model so as to arrive to a new structure.

Eventhough, only highlights of the finite horizon optimal control are given in this chapter, the reader is referred to

Appendix A, in which a complete derivation of the finite horizon problem is presented.

2.3 Mathematical Formulation Of the Problem In a Linear-Quadratic-Gaussian Context.-

Standard linear econometric modesl can be represented by the following relationships:

$$\underline{A1}\ \underline{x}(t+1) = \underline{A0}\ \underline{x}(t) + \underline{B0}\ \underline{u}(t) + \underline{D0}\ \underline{v}(t) + \underline{L0}\ \underline{\xi}(t) \tag{2.1}$$

$$\underline{y}\ (t) = \underline{C}\ \underline{x}(t) + \underline{N}\ \underline{u}\ (t) \tag{2.2}$$

where:

x(t): State vector

v(t): Exogenous deterministic disturbance vector

u(t): Control vector (instruments)

y(t): Output vector of endogenous variables

ξ(t): Time-uncorrelated (white-noise) disturbance vector

Let us assume that the matrix as is invertible then we can rewrite our system in an standard state space form:

$$\underline{x}(t) = \underline{A}\ \underline{x}(t) + \underline{B}\ \underline{u}(t) + \underline{D}\ \underline{v}(t) + \underline{L}\ \underline{\xi}(t) \tag{2.3}$$

$$\underline{y}(t) = \underline{C}\ \underline{x}(t) + \underline{N}\ \underline{u}(t) \tag{2.4}$$

Now, let us consider the objective function introduced in Chapter One:

$$\begin{aligned} J = E\ \{ & [\underline{y}(T) - \underline{y}_d(T)]^T\ \underline{Q}(T)\ [\underline{y}(T) - \underline{y}_d(T)] + \\ & \sum^{T-1} [[\underline{y}(t) - \underline{y}_d(t)]^T\ \underline{Q}(t)\ [\underline{y}(t) - \underline{y}_d(t)] + \\ & [\underline{u}(t) - \underline{u}_d(t)]^T\ \underline{R}(t)\ [\underline{u}(t) - \underline{u}_d(t)]\ ]\ \} \end{aligned} \tag{2.5}$$

We want to obtain the control sequence:

$$\{\underline{u}^*(t) = f(\underline{x}(t),\ \underline{y}_d(t),\ \underline{u}_d(t),\ \underline{v}(t)\quad t = 1,2,\ldots T\} \qquad (2.6)$$

Such that the objective function (2.5) would be minimized

Note:

$y_d(t)$: Sequence of desired targets for selected endogeneous variables

$u_d(t)$: Sequence of desired targets for instrument variables

$Q(t)$: Matrix of trade-off parameter values for endogenous variables

$R(t)$: Matrix of trade-off parameter values for instrument variables

T: Horizon planning time.

Once the sequence of instrument variables of (2.6) is obtained (i.e., we need to solve the finite time optimal control, given by equations (2.5) and (2.6) subject to the constraint given by the econometric system (2.3) and (2.4), we want to arrange equations (2.3), (2.4) and (2.6) so as to obtain a closed loop system. This is better understood from Figures 2.2 and 2.3.

In Figure 2.2 we see that the input variables for the "old" model are the instrument variables and the purely exogenous variables. Meanwhile in Figure 2.3 we see that for the "new" model (dotted lines) the input variables are the desired targets of selected endogenous variables, the desired targets for the instrument variables and the purely exogenous variables.

So, in order to obtain the "new" structure we must first solve the finite time optimal control problem and afterwards reorder the

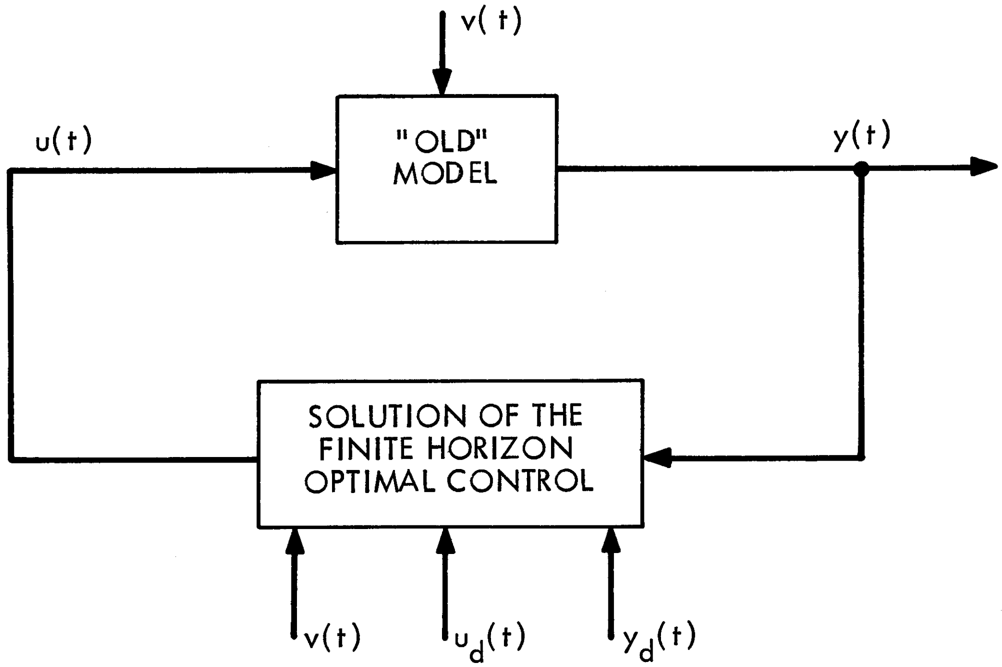


Figure 2.2

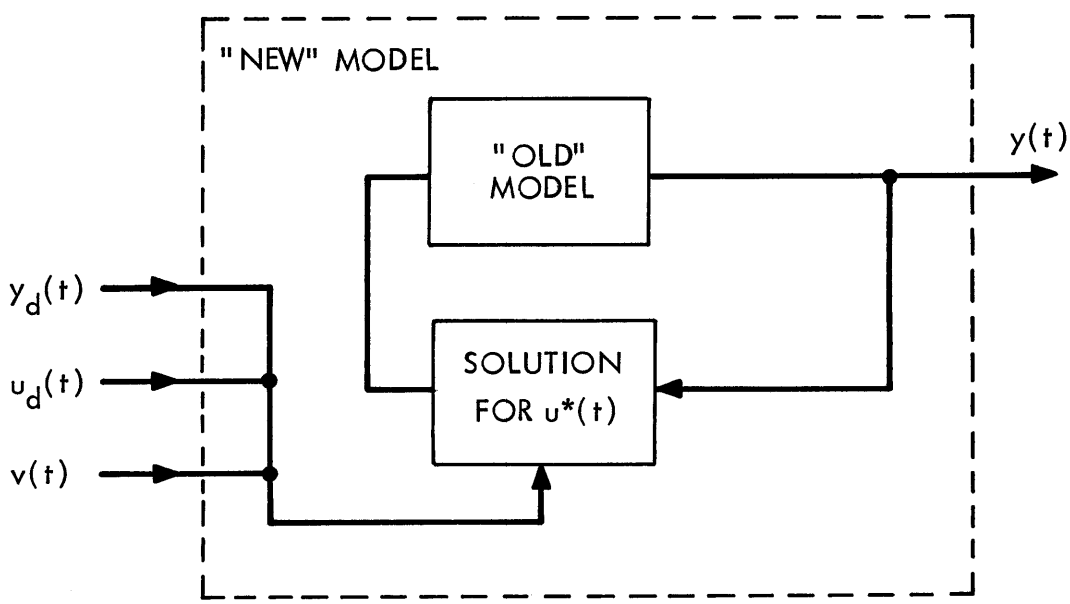


Figure 2.3

equations of the solution so as to obtain the desired structure. This is done in the next sections.

2.4 Finite Time Optimal Control Problem

We will first restate the particular problem. We want to obtain the control sequence:

$$\{\underline{u}^*(t) \qquad t = 1,2,3.... T\} \tag{2.6}$$

such that:

$$J = E\{ [\underline{y}(T) - \underline{y}_d(T)]^T \underline{Q}(t) [\underline{y}(T) - \underline{y}_d(T)] + \sum_{t=0}^{T-1} ([\underline{y}(t) - \underline{y}_d(t)] \underline{Q}(t) [\underline{y}(t) - \underline{y}_d(t)] + [\underline{u}(t) - \underline{u}_d(t)]^T \underline{R}(t) [\underline{u}(t) - \underline{u}_d(t)])\} \tag{2.5}$$

would be minimized.

In this section only highlights of the derivation will be given; for a complete proof the reader is referred to Appendix A.

Using dynamic programming, we obtain the following functional equation:

$$V(x,t) = \min E\{[\underline{y}(t) - \underline{y}_d(t)]^T \underline{Q}(t) [\underline{y}(t) - \underline{y}_d(t)] + [\underline{u}(t) - \underline{u}_d(t)]^T \underline{R}(t) [\underline{u}(t) - \underline{u}_d(t)] + V (x_1 t+1)/x\} \tag{2.7}$$

$$+ [\underline{u}(t) - \underline{u}_d(t)]^t \underline{R}(t) [\underline{u}(t) - \underline{u}_d(t)] \} + E\{V(x,t+1)/x\} \tag{2.8}$$

Solution of the functional equation for t = T gives us the structure of the general solution.

$$V(x,t) = \underline{x}^T(t)\ \underline{P}(t)\ \underline{x}(t) + \underline{x}^T(t)\ \underline{f}(t) + \underline{g}(t) \tag{2.9}$$

Proceeding by induction we obtain the control law:

$$\underline{u}^*(t) = -\ \underline{G}(t)\ \underline{x}(t) + \underline{h}(t) \quad t = 0,1,\ T-1 \tag{2.10}$$

where:

G(t): Deterministic control gain matrix

h(t): Deterministic control correction vector

with:

$$\underline{G}(t) = \underline{M}(t)\ \left\{\underline{N}^T\underline{Q}(t)\underline{C} + \underline{B}^T\underline{P}(t+1)\ \underline{A}\right\} \tag{2.11}$$

$$\underline{M}(t) = \left[\underline{N}^T\underline{Q}(t)\ \underline{N} + \underline{R}(t) + \underline{B}^T\ P(t+1)\ \underline{B}\right]^{-1} \tag{2.12}$$

where:

P(t+1): Solution of the discrete time Riccati equation:

$$\underline{P}(t) = \underline{A}^T\ P(t+1)\ \underline{A} + \underline{C}^T\underline{Q}(t)\ \underline{C} - \underline{G}^T(t)\ \underline{M}^{-1}(t)\ \underline{G}(t) \tag{2.13}$$

subject to the boundary condition:

$$P(T) = \underline{C}^T\underline{Q}(T)\ \underline{C} - \underline{C}^T\ \underline{Q}(T)\ \underline{N}\left[\underline{N}^T\ \underline{Q}(T)\ \underline{N}\right]^{-1}\underline{N}^T\underline{Q}(T)\underline{C} \tag{2.14}$$

and:

$$\underline{h}(t) = \underline{M}(t)\quad \underline{N}^T\underline{Q}(t)\ \underline{y}_d(t) + \underline{R}(t)\ \underline{u}_d(t) - \underline{B}^T P\ (t+1)\ \underline{D}\ \underline{v}(t) - \tfrac{1}{2}\ \underline{B}^T\ \underline{f}(t+1) \tag{2.15}$$

where:

$$\underline{f}(t) = 2\ \underline{G}^T(t)\ \underline{M}^{-1}(t)\ \underline{h}(t) - 2\underline{C}^T\underline{Q}(t)\ \underline{y}_d(t) + 2\ \underline{A}^T\underline{P}(t+1)\ \underline{D}\ \underline{v}(t) + \underline{A}^T\underline{f}(t+1) \tag{2.16}$$

subject to the boundary condition:

$$\underline{f}(T) = 2\underline{C}^T\ \underline{Q}(T)\ \underline{N}\ [\underline{N}^T\ \underline{Q}\ (T)\ \underline{N}]^{-1}\ \underline{N}^T\ \underline{Q}\ (T)\ \underline{y}_d(T)$$
$$- 2\ \underline{C}^T\ \underline{Q}(T)\ \underline{y}_d(T) \qquad (2.17)$$

If we assume that our system is stable and that cost matrices Q(t) and R(t) are constant, we can use the solution of the finite time optimal control to arrive at the steady state solution for the Ricatti equation. This solution will help us in anlyzing the structure of the model, therefore, it is included here for sake of completness.

By assuming steady state solution we are saying that:

$P(t+1) = P(t)$

$G(t+1) = G(t)$

$M(t+1) = M(t)$

Therefore, from equations (2.11), (2.12) and (2.13) we obtain:

$$G_{s.s.} = M(NQC + B^T PA) \qquad (2.18)$$

$$M_{s.s} = (N^T QN + R + B^T PB)^{-1} \qquad (2.19)$$

$$P_{s.s.} = A^T PA + C^T QC - G^T M^{-1} G \qquad (2.20)$$

SUMMARY OF EQUATIONS FOR THE FINITE TIME PROBLEM

o Optimal Control Law:

$$u^*(t) = -G(t)x(t) + h(t) \qquad (2.21)$$

o Control Gain Matrix G(t)

$$G(t) = M(t)\ [N^T Q(t)\ C + B^T P(t+1)A] \qquad (2.22)$$

where:

$$M(t) = \{N^T Q(t)\ N + R(t) + B^T P\ (t+1)\ B\}^{-1} \qquad (2.23)$$

$$P(t) = A^TP(t+1)\ A + C^TQ(t)C - G^T(t)M^{-1}(t)G(t) \qquad (2.24)$$

subject to the boundary condition:

$$P(T) = C^TQ(T)C - C^TQ(T)N \quad N^TQ(T)N \quad {}^{-1}N^TQ(T)C \qquad (2.25)$$

o Control Correction h(t):

$$h(t) = M(t) \quad N^TQ(t)\ y_d(t) + R(t)\ u_d(t) -$$
$$B^TP(t+1)\ Dv(t) - \tfrac{1}{2}\ B^tf(t+1) \qquad (2.26)$$

where:

$$f(t) = 2G^T(t)\ M^{-1}(t)h(t) - 2C^TQ(t)\ y_d(t)$$
$$+ 2A^TP(t+1)\ Dv(t) + A^Tf(t+1) \qquad (2.27)$$

subject to the boundary condition:

$$f(T) = 2C^TQ(T)\ N \quad N^TQ(T)\ N \quad {}^{-1}\ N^TQ(T)y_d(T)$$
$$- 2C^TQ(T)\ y_d(T) \qquad (2.28)$$

2.5 Construction of the "New" Model

In the previous section we have obtained the control law that describes the policy makers behavior. Now, we shall introduce this control law into the model so as to obtain the "new" structure.

We start with the original structure of the econometric model in its control form given by equation (2.3)

$$\underline{X}(t+1) = \underline{A}\ \underline{x}(t) + \underline{B}\ \underline{u}(t) + \underline{D}\ \underline{v}(t) + \underline{L}\ \underline{\xi}(t) \qquad (2.3)'$$

From the previous sections the control law is given by:

$$\underline{u}(t) = -\underline{G}(t)\underline{x}(t) + \underline{h}(t) \qquad (2.10)'$$

By substituting (2.10)' into (2.3)' we obtain the following closed-loop form:

$$\underline{x}(t+1) = [\underline{A} - \underline{B}\ \underline{G}(t)]\ \underline{x}(t) + \underline{B}\ \underline{h}(t) + \underline{D}\ \underline{v}(t)$$
$$+ \underline{L}\ \xi(t) \qquad (2.29)$$

Replacing the value of h(t) we obtain:

$$\underline{X}(t+1) = \left[\underline{A}-\underline{B}\ \underline{G}(t)\right]\ \underline{X}(t) + \underline{B}\ \underline{M}(t)\ \ \underline{N}^T\ \underline{Q}(t)\ \underline{y}_d(t)+\underline{R}(t)\underline{u}_d(t)$$
$$- \underline{B}^T\underline{P}(t)\ \underline{D}\ \underline{v}(t) - \tfrac{1}{2}\ \underline{B}^T\underline{f}(t+1) + \underline{D}\ \underline{v}(t)$$
$$+ \underline{L}\ \underline{\xi}(t) \qquad (2.30)$$

Grouping term in (2.28):

$$\underline{X}(t+1) = \left[\underline{A} - \underline{B}\ \underline{G}(t)\right]\ \underline{X}(t) + \underline{B}\ \underline{M}(t)\ \underline{N}^T\ \underline{Q}(t)$$
$$\underline{y}_d(t) + \underline{B}\ \underline{M}(t)\ \underline{R}(t)\ \underline{u}_d(t) - \underline{B}\ \underline{M}(t)$$
$$\underline{B}^T\ \underline{P}(t)\ \underline{D}\ \underline{v}(t) - \tfrac{1}{2}\ \underline{B}\ \underline{M}(t)\underline{B}^T\underline{f}(t+1)$$
$$+ \ \underline{D}\ \underline{v}(t) + \underline{L}\ \underline{\xi}(t) \qquad (2.31)$$

Finally:

$$\underline{X}(t+1) = \left[\underline{A}-\underline{B}\ \underline{G}(t)\right]\ \underline{X}(t) + \underline{B}\ \underline{M}(t)\ \underline{R}(t)\ \underline{u}_d(t)$$
$$+ \left[\underline{D}-\underline{B}\ \underline{M}(t)\ \underline{B}^T\underline{P}(t+1)\underline{D}\right]\ \underline{v}(t) + \underline{B}\ \underline{M}(t)$$
$$\underline{N}^T\underline{Q}(t)\ \underline{y}_d(t) - \tfrac{1}{2}\ \underline{B}\ \underline{M}(t)\ \underline{B}^T\underline{f}\ (t+1)$$
$$+ \ \underline{L}\ \underline{\xi}(t) \qquad (2.32)$$

Rewriting (2.30) we obtain:

$$\underline{X}(t+1) = \underline{A}_u(t)\ \underline{x}(t)+\underline{B}_u(t)\underline{u}_d(t) + \underline{v}_u(t)$$
$$+ \underline{L}\ \underline{\xi}(t) \qquad (2.33)$$

where:

$$A_u(t) = \underline{A}-\underline{B}\ \underline{G}(t) \qquad (2.34)$$

$$B_u(t) = \underline{B}\ \underline{M}(t)\ \underline{R}(t) \qquad (2.35)$$

$$v_u(t) = \underline{D}-\underline{B}\ \underline{M}(t)\ \underline{B}^T\underline{P}(t+1)\underline{D}\ \ \underline{v}(t)$$
$$+ \ \underline{B}\ \underline{M}(t)\ \underline{N}^T\underline{Q}(t)\ \ \underline{y}_d(t) - Y_2BM(t)B^Tf(t+1)$$
$$(w.36)$$

and for the steady state solution

$$\underline{X}(t+1) = A_u X(t) + B_u u_d(t) + v_u(t) + L\,\xi(t) \qquad (2.37)$$

with:

$$Au_{s.s} = A-BG_{ss} \qquad (2.38)$$

$$Bu_{s.s} = BM_{s.s}R \qquad (2.39)$$

2.6 Some Important Remark

Let us now comment briefly on some of the characteristics of the "new" model based upon the mathematical relationships of the new structure.

The matrices A_u and B_u, of the "new" model reflect the combined effect of the specific tradeoff parameters Q, R on the objective function, and the old dynamics of the standard. Econometric model indepently of the desired targets $u_d(t)$, and $y_d(t)$. This can be interpreted as if the new structure blends the behavior of firms and households, given by the "old" model, with the behavior of the policy makers, reflected in the objective function, this is done independently of society targets (i.e., desired paths for $y_d(t)$, $u_d(t)$). This last assertion guarantees that the new structure's multipliers (Eigenvalues) are not dependent of the particular desired path, and therefore, to certain extend, it should be expected for the new structure to be less sensitive to errors in choosing the desired paths.

The "new" model contains a new exogenous predetermined disturbance vector $v_u(t)$. This new disturbance vector blends.

- o The purely exogenous vector $D_v(t)$

- o The historical targets $y_d(t)$
- o Objective function, via its dependence on $Q(t)$ and $R(t)$
- o Old dynamics, via its dependence on A, B, C, D, and N.

This new exogenous variable will help to characterize particular solutions depending on the selected desired paths.

The role played by the targets on the instruments $u_d(t)$ is very important, since it is $u_d(t)$ the variable that is going to replace the instrument variables of the original model. Furthermore, we know that the original instrument as possible, since they are obtained by solving an optimal tracking problem. Therefore, in a context were the new structure should be used to obtain optimal policies, this optimal policies should be interpreted as types of trends to be followed by the policy makers so as to optimize an objective function. This idea makes sense, since theoretical optimal policies are never applied in reality, and what is really important is to have an idea of the trends to follow so as to drive the entire economic system to follow certain predetermined goals (i.e., desired paths for selected endogenous variables).

It is with these ideas about the expected properties of the "new" model developed so far, that in the next chapters we shall design some experiments to test them, to carry them out a standard econometric model has to be chosen. This is accomplished in the next chapter. The remaining chapters are devoted to the description of simulation experiments and interpretation of the results.

Chapter III

The Econometric Models

3.1 INTRODUCTION

In this chapter we examine two econometric models that will be used to test the theory developed in Chapters I and II. These models will be discussed from an econometric point of view. Three different estimation procedures are used to estimate the first model and their respective properties will be discussed. Afterwards, two slightly different structures are obtained by eliminating some variables with coefficients near zero. The econometric models to be considered in this chapter are: Klein's Model I, see Klein (1950) {2} , and the Samuelson Hicks' Model, see Hicks (1950) {40} .

Econometric Models are mainly constructed to:

- o Test Economic Theories
- o Forecast the evolution of certain economic variables
- o Study the effect of various economic policies

Our theory developed in previous chapters is more concerned with the forecasting properties of econometric Models and the use of them to obtain optimal policies than the testing of economic theories. In this context, we shall consider a very simple model that allows us to compare its behavior against the "new" Econometric Model to be built according to the proposed structure on Chapter 2.

At the same time such a simple model should have structural properties which reflect some dynamics of its own. This last property is very desirable, since the "new" model is obtained by solving an optimal tracking problem about desired target variables. In other words, in forecasting with the "new" model. The foreseeable future is going to be incorporated into the model by specifying a trend for certain (output) endogeneous variables, therefore, if the dynamics of the "old" model are not good enough, the "new" model may follow these trends very closely.

A model with the properties cited in the previous paragraphs is the one developed by Klein in his book "Economic Fluctuations in the United States" (1950) {2} . This model even though it is simple has reasonable properties, and it has the advantage that it has been widely used by Econometricians and its properties are well known. Therefore, conclusions that we can reach from our experiments can be interpreted more easily than if we used a more complicated model.

3.2 Description of Klein's Model I.

The model to be used to carry out our experiments is the least complicated model of the three described by Klein in his book "Economic Fluctuations in the United States" (1950) {2} .

It is a simple annual macroeconomic six-equation model that describes the economic behavior of the U.S.A. for the period: 1921-1941.

This shall model combines. Demand schedules for consumer goods and human labor power, and supply schedule for the producer goods obtained under the assumption of profit maximization.

The first equation of Klein's Model I is the structural equation that describes the consumption function:

$$C = \alpha_o + x_1 W + \alpha_2 P + \alpha_3 P_{-1} + \mu_1 \qquad (3.1)$$

where:

C: Consumption in billions of constant = dollars

W: Wage bill in billions of constant = dollars

P: Non-wage income (profits) in billions of constant = dollars

This equation is obtained from the basic principle of Keynesian Theory that establishes that consumption is a function of income. By introducing W and P, a difference in consumption. Depending if the income receivers are wage earned or profit recipients, is established.

The second equation of the model is given by the investment function.

$$I = \beta_o + \beta_1 P + \beta_2 P_{-1} + \beta_3 K_{-1} + \mu_2 \qquad (3.2)$$

where:

I: Net investment in billions of constant dollars

P: Profits in billions of constant dollars.

K_{-1}: Stock of capital at the beginning of the year.

This equation is obtained under the Heuristic Principle, that profits are the mainspring of economic action in a capitalist society, i.e., firms expand when profits are anticipated to be high and contract when profits are anticipated to be low.

Since, not only the absolute size of profits but also their relation to the existing stock of capital is important, the variable K_{-1} is introduced.

The third equation expresses the demand for labor:

$$W = \gamma_o + \gamma_1 Y + \gamma_2 Y_{-1} + \gamma_3 t + \mu_3 \qquad (3.3)$$

where:

W: Wage bill in billions of constant dollars

Y: National output in constant dollars

t: time

This particular equation that deserves the marginal productivity is obtained by setting the derivative of the profits equation with respect to labor input equal to zero, assuming a production function of constant elasticity.

The trend variable (t) is included to reflect the growing bargaining strength of the organized labor movement.

The last three equations of Klein's Model I are not subject to random errors and they do not have unknown parameters. Two of them are definitional equations and the last establishes the equilibrium condition on which the model is based.

$$P + W = Y \qquad (3.4)$$

$$(K - K_{-1}) = I \qquad (3.5)$$

$$C + I + G = Y \qquad (3.6)$$

Equation (3.4) states that the total output (income) is the sum of profits and wages. Equation (3.5) defines investment as the rate of change of the capital stock.

The last equation states that in equilibrium the total input (Y) is the sum of goods demanded by consumers (C) plus goods demanded by business firms (I) plus goods demanded by the government and foreigners (G).

3.3 Estimation Procedures: OLS, 2SLS, FIML:

Before we turn to the statistical analysis of the coefficients of Klein's Model I obtained under different estimation procedures, we should make some comments on the modifications made on the original structure of Klein's Model described in the previous section.

The first modification is due to the necessity of taking into account the productive efforts of the government as a contribution to the total output. This is done by including in equation (3.5). The government wage bill, therefore the equation for total output (3.5) becomes.

$$Y = W1 + W2 + P \tag{3.7}$$

where:

W 1: Private wage bill

W 2: Government wage bill

W 3: Profits

The National Income of equation (3.6) is measured at market prices, i.e., we are measuring the net national product. On the other hand, in equation (3.7) we measure the national income (Y) at factor cost, i.e., net national income. The difference between these two quantities is roughly business taxes. Therefore, we need to introduce these taxes into equation (3.6). This last equation after including taxes on it, becomes

$$X + T = C + I + G \tag{3.8}$$

where taxes (T) will be treated as an exogenous variable.

After these modification the resulting model is given by the following equations:

(1) $$C = \alpha_0 + \alpha_1 (W1 + W2) + \alpha_2 P + \alpha_3 P_{-1} + \mu_1 \tag{3.9}$$

(2) $$I = \beta_0 + \beta_1 P + \beta_2 P_{-1} + \beta_3 K_{-1} + \mu_2 \tag{3.10}$$

(3) $$W1 = \gamma_0 + \gamma_1 (y + T - W2) + \gamma_2 (y + T - W2)_{-1} + \gamma_3 t + \mu_3 \tag{3.11}$$

(4) $$Y + T = C + I + G \tag{3.12}$$

(5) $$Y = W1 + W2 + P \tag{3.13}$$

(6) $$(k - k_{-1}) = I \tag{3.14}$$

Using this model structure and Klein's data for the years 1921-1941, the coefficients of the model were estimated using three different statistical methods. These procedures were chosen to allow for a wide variety of estimation methods; from the least powerful method OLS (Ordinary Least Squares) up to the most powerful method: FIML (Full Information Maximum Likelihood).

The values of the coefficients and their statistics for each procedure were obtained using the TROLL facilities at NBER (National Bureau of Economic Research) and they are presented on the following pages along with a brief discussion of the properties of each estimation procedure.

3.3.1 Ordinary Least Squares (OLS)

This method of estimation is the less powerful of the econometric methods when used to estimate simultaneous equation models. See for example Dhrymes (1974) {41}. The OLS estimation gives in general a biased and inconsistent estimates. Therefore, simulation results with this model are not expected to be very good.

When using this method to obtain the estimates for the coefficients; each equation is considered independently of the others, then, even though, the statistical results can be satisfactory, considering each equation in particular, the results can be completely different when simulating the model as a whole. Therefore, statistical results for each equation in this method should not be interpreted rigorously. The importance of this procedure is that is a very simple method to compute and it serves as a reference point to compare the results obtained from other methods.

3.3.2 Two - Stage - Least - Squares (2SLS)

The main problem with the OLS is that in obtaining the estimates, it is assumed that the dependent variables are uncorrelated with the residuals, which is not the usual case. This wrong assumption produces the unconsistency and biasedness of the estimators. To correct for this problem the 2 SLS estimation procedure, introduce a first stage to take care of the problem cited above. (see Theil (1971) {42}). The first stage of 2SLS involves the creation of an instrument, generally obtained by regressing. The selected instrument on all the predetermined variables in the equation system. This instrument has the property of being urged of any correlation with the error term. The second stage is reduced to the use of the OLS to estimate each equation with the selected: Variables previously replaced by the instruments obtained in the first stage, by this replacement the correlation of the dependent variables with the residuals is overcome. The main problem with this method is that depending on how the instrument is obtained or selected in the first stage, the results can be quite different. A good property for 2 SLS is that this procedure is not too much affected by small samples or misspecification errors. (See Summer (1965)).

3.3.3 Full-Information-Maximum-Likelihood (FIML)

One of the difficulties with 2 SLS is the arbitrary nature of the normalization involved in obtaining the instrument variable in the first stage of 2 SLS. This difficulty can be eliminated by an estimation procedure which is a generalization of the least-variance ratio. This procedure called Full-Information-Maximum-Likelihood (FIML) arises as the solution to the application of the maximum-likelihood concept to the entire simultaneous equation system. (See Theil (1971) {42}). This is the most powerful method known in econometrics, since it combines all the "A Priori" information about the set of simultaneous equations and it gives unbiased and consistent estimators.

The problem with the FIML method is that only its large-sample properties are known (i.e., Assymptotic properties) and Montecarlo Studies as the one done by Summers (1965) have shown, at least numerically, that FIML is more sensitive that any other econometric method to the sample size and to specification errors. This could be explained by the fact that full information methods, utilize the structure of every equation explicitly in estimating every other equation, therefore a misspecification, no matter where commited, will propagate and thus affect the estimation of every parameter in the system.

3.4 Some comments about the statistical results.

The Statistical results for the three previous estimation procedures are shown in tables 3.1, 3.2, and 3.3.

A close examination of these tables reveals us that OLS has the best statistics of all three procedures, but as we pointed out before, we should not interpret these results rigorously, since OLS results are concerned only with each equation in particular. Therefore, this statistics do not reveal the true characteristics of the model as a whole.

For the consumption equation (c) we observe that 2 SLS gives a non-significant different from zero coefficient for the variable profits (p), meanwhile OLS does the same but for the coefficient related to the lagged value of profits (P_{-1}). We observe that as expected the FIML procedure obtains the higher "t" statistics for the different coefficient of the model. However, we should keep in mind that the sample size for our model is only 20 periods, therefore the expected performance for FIML is not too good.

TABLE 3.1

OLS, 2SLS, AND FIML ESTIMATES OF THE PARAMETERS OF KLEIN'S MODEL I

Consumption (c)

$$C = \alpha_o + \alpha_1 P + \alpha_2 P_{-1} + \alpha_3 (W1 + W2) + \mu_1$$

Variable	OLS	2SLS	FIML
1	16.23660	16.0456	15.8445
	(2.3027)	(1.42944)	(1.25867)
	{12.4639}	{11.225}	{12.5886}
P	0.19293	0.061158	0.301604
	(0.09121)	(0.149436)	(0.098963)
	{2.11528}	{0.409259}*	{3.04765}
P_{-1}	0.08988	0.165065	0.042391
	(0.09065)	(0.129684)	(0.076608)
	{0.99157}*	{1.27283}	{0.553343}*
W1 + W2	0.79622	0.824833	0.780173
	(0.03994)	(0.043465)	(0.040939)
	{19.9334}	{18.9769}	{19.0568}
R^2	0.98101	0.978628	0.979245
$\bar{R}^2$	0.97766	0.974857	0.975582
SSR	17.879	20.12	19.5397
F(3/17)	292.715	259.48	N.A.
DW	1.37	1.47374	1.25698

( ) : Standard Error

{ } : t - Statistic

* : t - Statistics not significant at 1% level

TABLE 3.2

OLS, 2SLS, AND FIML ESTIMATES OF THE PARAMETERS OF KLEIN'S MODEL I

Investment (I)

$$I = \beta_o + \beta_1 P + \beta_2 P_{-1} + \beta_3 K_{-1} + \mu_2$$

Variable	OLS	2SLS	FIML
1	10.12580	22.8062	15.828
	(5.46554)	(11.6781)	(4.97285)
	{1.85265}	{1.9529}	{3.18283}
P	0.47964	0.06783	0.38068
	(0.09711)	(0.313606)	(0.09114)
	{4.93888}	{0.216289}*	{4.17694}
P_{-1}	0.33304	0.68668	0.410922
	(0.10086)	(0.281342)	(0.088097)
	{3.30200}	{2.44073}	{4.66444}
K_{-1}	-0.11179	-0.169232	-0.138261
	(0.02673)	(0.054837)	(0.024112)
	{4.18274}	{-3.08611}	{-5.73405}
R^2	0.93135	0.858734	0.925755
$\bar{R}^2$	0.91923	0.833804	0.912653
SSR	17.323	35.6452	18.7339
F(3/17)	76.875	34.4467	N.A.
D.W	1.81	2.07109	1.89192

( ) : Standard Error

{ } : t - Statistic

* : t - Statistics not significant at 1% level

TABLE 3.3

OLS, 2SLS AND FIML ESTIMATES OF THE PARAMETERS OF KLEIN MODEL I

Private Labor (W1)

$$W1 = \gamma_o + \gamma_1 \ (y + t - W2) + \gamma_2 \ (y + t - W2)_{-1} + \gamma_3 t + \mu_3$$

Variable	OLS	2SLS	FIML
1	4.49706	1.68654	2.07033
	(1.27002)	(1.32406)	(1.35763)
	{1.17876}	{1.27376}	{1.52496}
(y+t - W2)	0.43948	0.403511	0.370503
	(0.03241)	(0.044358)	(0.043454)
	{13.56100}	{9.09667}	{8.52632}
$(y+t - W2)_{-1}$	0.14609	0.18008	0.207641
	(0.03742)	(0.047466)	(0.041458)
	{3.90377}	{3.79387}	{5.00842}
t	0.13025	0.139003	0.184539
	(0.03191)	(0.033792)	(0.040203)
	{4.08162}	{4.11345}	{4.59021}
R^2	0.98741	.986502	0.982841
$\bar{R}^2$	0.98519	.98412	0.979813
SSR	10.005	10.7297	13.6396
F(3/17)	444.583	414.148	N.A.
D.W	1.96	2.16533	2.0225

( ) : Standard Error

{ } : T - Statistic

3.5 Two Different Model Structures

A common practice among economists is to eliminate from the model, coefficient variables with "t" statistics non-significantly different from zero, to improve the statistic accuracy of the model. Even though, forecasters, that are not as concerned with statistical accuracy but, rather, with simulation accuracy prefer not to eliminate them.

Since we are concerned with the effect that this elimination of variables could have in the performance of the "new" model, two structures were obtained by eliminating some variables of the original structure.

The first structure was obtained by eliminating the coefficient "γ_2" corresponding to the lagged value for profits (P_{-1}) in the OLS procedure. Once, this variable was eliminated, the entire model was restimated and the new statistics are shown in tables 3.4, 3.5, and 3.6. For notational convenience the name assigned to this model was "OLS 2" standing for ordinay least squares structure two.

The second structure was obtained by eliminating the coefficient "γ_1" corresponding to the variable profits (P) in the 2SLS procedure. As in the previous paragraph, once this variable was dropped, the entire model was restimated using the 2SLS procedure and their new statistics are shown in tables 3.4, 3.5, and 3.6. For notational convenience the name assigned to this second structure was "2SLS 2" from two-stage-least squares structure 2.

TABLE 3.4

OLS2 AND 2SL2 ESTIMATES OF THE PARAMETERS OF KLEIN'S MODEL I

Consumption (c) $C = \alpha_o + \alpha_1 P + \alpha_2 P_{-1} + \alpha_3 (W1 + W2) + \mu_1$

Variable	OLS2	2SL2
1	16.4303 (1.28737) {12.76270}	16.1395 (1.45296) {11.108}
P	0.25059 (0.07024) {3.56738}	0
P_{-1}	0	0.208209 (0.077476) {2.6874}
W1 + W2	0.80356 (0.03923) {20.48140}	0.8302395 (0.042514) {19.5321}
R^2	0.97991	0.97599
$\bar{R}^2$	0.97768	0.97333
SSR	18.914	22.595
F(2/18)	438.99	365.988
D.W	1.28	1.4925

( ) : Standard Error

{ } : "t" - Statistic

TABLE 3.5

OLS2 AND 2SLS2 ESTIMATES OF THE PARAMETERS OF KLEIN'S MODEL I

Investment (I) $I = \beta_o + \beta_1 P + \beta_2 P_{-1} + \beta_3 K_{-1} + \mu_2$

Variable	OLS2	2SL2
1	10.1258	22.8062
	(5.46554)	(11.6781)
	{1.85265}	{3.18283}
P	0.47964	0.06783
	(0.09711)	(0.313606)
	{4.9388}	{0.216289}
P_{-1}	0.33304	0.68668
	(0.10086)	(0.281342)
	{3.30200}	{2.44073}
K_{-1}	-0.11179	-0.169232
	(0.02673)	(0.054837)
	{-4.18274}	{-3.08611}
R^2	0.93135	0.858734
$\bar{R}^2$	0.91923	0.838734
SSR	17.323	35.6452
F	76.875	34.4467
D.W	1.81	2.07109

( ) : Standard Error

{ } : "t" Statistics

TABLE 3.6

OLS2 AND 2SLS2 ESTIMATES OF THE PARAMETERS OF KLEIN'S MODEL I

Private Labor (W1) $W1 = \gamma_o + \gamma_1 (y + t - W2) + \gamma_2 (y + t - W2)_{-1} + \gamma_3 t + \mu_3$

Variable	OLS2	2SL2
1	1.49706	1.68627
	(1.27002)	(1.32408)
	{1.17876}	{1.27353}
Y+T - W2	0.43948	0.403507
	(0.03241)	(0.044358)
	{13.5610}	{9.09651}
$(Y+T - W2)_{-1}$	0.14609	0.18009
	(0.03742)	(0.047467)
	{3.90377}	{3.79403}
t	0.13025	0.139003
	(0.03191)	(0.033793)
	{4.08162}	{4.1134}
R^2	0.98741	0.986502
$\bar{R}^2$	0.98519	0.98412
SSR	10.005	10.7297
F	444.883	414.148
D.W	1.96	2.16533

( ) : Standard Error

{ } : "t" - Statistic

As expected, in tables 3.4, 3.3, and 3.6 we observe a substantial improvement on the statistics of the new structures, specially for the equations where the changes were made.

3.6 Model Stability

If we examine the homogenous equation of Klein's Mode I, (i.e., the terms related only to the endogenous variables.) we conclude that Klein's Model corresions to a "Third Order" system. A closer look at the coefficients gives us three roots for the homogeneous equation (the determinant of (δI-A) where A is the matrix that describes the homogenous set of equations of the Model). The values of this roots' for the different estimation procedures and for the different structures are shown in table 3.7, the last table reveals that the value of the roots are not only highly dependent on the structure of the model, but also on the estimation procedure use to obtain the coefficients of the model.

As we know from any standard text on Discrete-Time Linear Systems Theory, see for example Freeman (1965) {31} the position of the roots on the "Z" plane determines the behavior of the mathematical model. This indicates that the different versions of the model are going to behave differently because the variation on the position of their roots. But, the fact that we want to point out at this stage, is that the dynamics of Klein's Model (in this case given mainly by the position of the complex loots) are going to introduce periodicities into the model and thus give a representation of the business cycle. If the models are "good" models then the historical periodicities should coincide with the

TABLE 3.7

VALUES OF THE ROOTS FOR THE DIFFERENT VERSIONS OF KLIEN'S MODEL I

	ROOT 1	ROOT 2	ROOT 3
OLS	0.24015	0.2507 + j 0.9253	0.2507 - j 0.9253
2SLS	0.3426	0.7752 + j 0.3666	0.7752 - j 0.3666
FIML	0.4446	0.6928 + j 0.5125	0.6928 - j 0.5125
OLS2	0.35756	0.6175 + j 0.3492	0.6175 - j 0.3492
2SLS2	0.3483	0.7434 + j 0.3959	0.7434 - j 0.3959

periodicities of the mathematical model. It turns out that these econometric models do not exhibit periodicities that are close to the historical periodicities, therefore, the need for a "new" model that, by means of using feedback, changes the positions of the roots on the plane "Z" as to conform for the historical periodicities is to a certain extent quite clear. This property along with other features will be hopefully study in detail.

3.7 Description of Samuelson-Hicks Model

The second model, to be used to test the theory described is the model constructed by Hicks as an application of the theory of the multiplier and accelarator effect described by Samuelson (1938) . This model was presented and discussed in detail by Hicks (1950) {40}.

The model is basically a single equation model that describes the variation of national income (Y) as a result of different government policies. It consists of the following parameters, variables, and functional relationships:

Endogenous Variables:

C_t : Consumption in period t

I_t : Investment in period t

Y_t : National income in period t

G_t : Governmental expenditure in period t

Structural equations:

$$C_t = \gamma_1 Y_{t-1} + \gamma_2 Y_{t-2} + \mu_2 \qquad (3.15)$$

$$I_t = \beta_1 \ (Y_{t-1} - Y_{t-2}) + \mu_2 \qquad (3.16)$$

$$G_t = g \ Y_{t-1} + \mu_3 \qquad (3.17)$$

Identify

$$Y_t = C_t + I_t + G_t \qquad (3.18)$$

where:

α_1: Marginal propensity to consume in period t-1

α_2: Marginal propensity to consume in period t-2

β_1: Accelerator coefficient

g: Governmental parameter

by substituting the values of C_t, I_t, and G_t, given by (3.15), (3.16), and (3.17), respectively, into (3.18) we obtain the single equation model:

$$Y_t = -\alpha_1 Y_{t-1} - \alpha_2 Y_{t-2} + \mu_4 \qquad (3.19)$$

Some slight modifications were made in Samuelson - Hicks Model so as to include taxes (TX) into the oriental formulation.

First, the identity (3.18) was modified as to include taxes in, so the new identity became:

$$Y_t = C_t + I_t + G_t - TX_t \qquad (3.20)$$

Second, government expenditure was converted to exogenous variable, and a constant parameter were added in each structural equation. The final version of the modified Samuelson - Hicks is given by the following equations:

Endogenous variables

C_t: Consumption in period t

I_t: Investment in period t

Y_t: National income in period t

Exogenous Variables

G_t: Governmental expenditure in period t

TX_t: Taxes

Structural equations

$$C_t = \alpha_o + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \mu_1 \qquad (3.21)$$

$$I_t = \beta_o + \beta_1 (Y_{t-1} - Y_{t-2}) + \mu_2 \qquad (3.22)$$

Identity

$$Y_t = C_t + I_t + G_t - TX_t \qquad (3.23)$$

From (3.21), (3.22), and (3.23) the system becomes:

$$Y_t = \alpha_o + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + G_t - TX_t \qquad (3.24)$$

This model was estimated using OLS using the NBER Troll facilities and using the same data used for estimating Klein's Model I.

The results are shown on Table (3.8). For convenience the model was estimated using equations (3.22) and (3.23) instead of the single equation model of (3.24). This was done to facilitate the input data for the computer program to be used to solve the optimal control problem.

The results of Table (3.8) show very low D.W. statistics for both equations. This effect was expected, since the two lags on national income introduce a big autocorrelation in the residuals,

TABLE 3.8

OLS ESTIMATES FOR THE COEFFICIENTS OF SAMUELSON-HICKS MODEL

Consumption (C) $C = \alpha_o + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \mu_1$

	α_o	α_1	α_2
Coefficient	30.9045	0.75476	-0.16836
Standard Error	4.94319	0.1378	0.14555
"t" Statistic	4.22894	5.4772	-1.15672

$R^2 = 0.78415$

$\bar{R}^2 = 0.75876$

SSR = 170.055

F(2/17) = 30.880

DW = 1.26

Investment (I) $I = \beta_o + \beta_1 (Y_{t-1} - Y_{t-2}) + \mu_2$

	β_o	β_1
Coefficient	0.69867	0.42193
Standard Error	0.67470	0.12307
"t" Statistic	1.03553	3.42845

$R^2 = 0.39505$ SSR = 151.280

$\bar{R}^2 = 0.36144$ F(2/17) = 11.754

DW = 0.96

therefore since no correction for this problem was made a low D.W. is justified. On the other hand the acceptable "t" statistics are in accord with one would expected for a single equation model.

3.8 Summary

In the chapter, we have introduced two econometric models along with some estimation procedures. We have found in all of them basic differences in their results, specially if we interpret the position of the roots in "Z" plane, as an indication of the behavior of the models. In the next chapters, we shall use these econometric models to try to answer, by means of some numeral experiments, the causes of this different behaviors of the same structure estimated under different procedures.

Chapter 4

SENSITIVITY OF THE "NEW" MODEL TO DIFFERENT ESTIMATION AND MODEL STRUCTURES:

4.1 INTRODUCTION.-

This chapter discusses the computational results of several numerical experiments related to the sensitivity of the "new" model.

Three different estimation procedures and two different model structures, described in the previous chapter, were used to test the sensitivity of the new structure to variations on the coefficient values of the original structure. The objective of these experiments is to gain insight into the main properties of feedback control in an econometric context, namely:

- o capacity of handling modelling errors
- o capability of handling uncertainties.

Using the theory developed in Chapter 3, a computer program was written to implement the new structure and to have the capability to simulate the "old" and "new" model at the same time, so as to compare the behavior of both models against the historical values.

The program was written in fortran IV and its code is presented in Appendix B. It was run on an IBM 370/ of the M.F.T. Information Processing Center.

In the following sections, a description of the experiments is given firstly. Next, results for the different estimation procedures and model structures runs are given along with some interpretations. In the last section a comparative study of the results is given, and some important remarks are included as well.

4.2 Setting Up The Experiments

All of the experiments described in this chapter were run for twenty-one periods, beginning with the year 1920 and ending with the year 1940. The data used was the same yearly data used to estimate the different versions of Klein's Model I.

The three estimation procedures and the two different structures described in the previous chapter, OLS, 2SLS, FIML, OLS2, and 2SLS2, were used to obtain "new" models according to the proposed structure in Chapter 2.

For convenience, nine variables were defined, from the original Klein's Model structure, instead of the six needed, this was done to facilitate the definition of output variables so as to obtain more information about the model.

The nine variables are as follows:

$X_1(t) = C_t$: Consumption in period t

$X_2(t) = I_t$: Net investment in period t

$X_3(t) = W1_t$: Private wage bill in period t

$X_4(t) = Y_t$: Net national income in period t

$X_5(t) = P_t$: Non-wage income (profits) in period t

$X_6(t) = K_t$: Capital stock end of period t

$X_7(t) = W2_t$: Governmental wage bill in period t

$X_8(t) = G_t$: Governmental demand in period t

$X_9(t) = TX_t$: Business taxes in period t

Two purely exogenous variables and three investments were defined, corresponding to the constant term, time trend variable, government wage bill, government expenditure and taxes respectively.

$v_1(t) = 1$: Constant term in each estimated equation

$v_2(t) = t$: Time trend in private wage bill (W2)

$\mu_1(t) = W2_t$: Governmental wage bill in period t

$\mu_2(t) = G_t$: Governmental demand in period t

$\mu_3(t) = TX_t$: Business taxes in period t

For each estimation procedure the "old" model was entered into the program by inputting the matrices A_o, A_1, B_1, D_1, C, N of the following structure:

$$A_o x(t+1) = A_1 x(t) + B_1 u(t) + D_1 v(t) \quad (4.1)$$

$$Y(t) = Cx(t) + Nu(t) \quad (4.2)$$

This was done by first specifying the dimension of the matrices, and then entering the non-zero element of each matrix. It should be noted that for the sensitivity experiments the output variables (Y(t)) were chosen to be equal to the state variables, i.e.; the matrix "C" of equation (4.2) was set to be equal to the identity matrix, and the matrix "N" was set to be equal zero.

After entrering the model structure the cost matrices, Q and R, were entered in a similar fashion. For simplicity, only direct weights on the output and control variables were considered, i.e., both Q and R were chosen to be diagonal matrices.

Each diagonal element of the above matrices, was chosen as to normalize the cost of deviation from the historical values of the corresponding output or control variable. The normalized weights were obtained by using the following relationship: (values are shown in Table 4.1)

$$q_{ii} = \frac{100}{(Y_{ni_{max}} - Y_{ni_{min}})^2} \qquad (i = 1,.....6)^* \qquad (4.3)$$

$$r_{ii} = \frac{100}{(\mu_{ni_{max}} - \mu_{ni_{min}})^2} \qquad (i = 1,2,3) \qquad (4.4)$$

Next, information concerning the name of the output variables to be used to obtain the titles for each diagram to be printed and information concerning the number of periods of time, starting year and quarter, was entered into the program.

Values of the weights used for "sensitivity" experiment

$q_{1,1} = 15.75$

$q_{2,2} = 71.82$

$q_{3,3} = 26.30$

---

* Formula (4.3) was used only to obtain the weights for the first six variables, the last three were chosen to be very low numbers, since these variables (control variables) were already being weighted by relationship (4.4).

$q_{4,4} = 8.91$

$q_{5,5} = 46.28$

$q_{6,6} = 9,127$

$q_{7,7} = 1.0$

$q_{8,8} = 1.0$

$q_{9,9} = 1.0$

$r_{1,1} = 297.3$

$r_{2,2} = 85.73$

$r_{3,3} = 260.1$

TABLE 4.1

Next, the historical data for each output variable was entered followed by the historical control variables and the exogenous variables. Immediately afterwards the desired values for the output and control variables were inputed. It should be pointed out that the desired values were chosen to be equal to the historical values for the series of experiments. The last bit of imformation to be entered was that corresponding to the initial values for the state variables for the year 1920.

4.3 Sensitivity of "New" Model to Different Estimation Procedures

In the following experiments described in this section, numerical solutions are obtained for three different estimation procedures, OLS, 2SLS and FIML, whose characteristic were discussed in Chapter three. In each case, the results (historical, OLS, and new path) are presented in numerical and graphical form; this is done so as to make it possible to easily observe and compare the behavior of both, old and new models, against the historical values.

When interpreting the results it is important to keep in mind the fact that the last three variables (government wage bill, government expenditure, and taxes) to be shown in the last three diagrams of each procedure are the values corresponding to the optimal values obtained by solving the optimal tracking problem. (i.e., obtained from the relationship $\mu^*(t) = G(t) + h(t)$). They should not be interpreted as the control variables of the "new" model but as an internal by-product of the "new" structure. The control variables used to simulate the "new" model were the same variables used to simulate the "old" model (i.e., the historical values).

The reason of including these optimal control variables is the hope that they will help us to interpret the behavior of the "new" model.

4.3.1 Ordinary Least Squares Structure 1 (OLS)

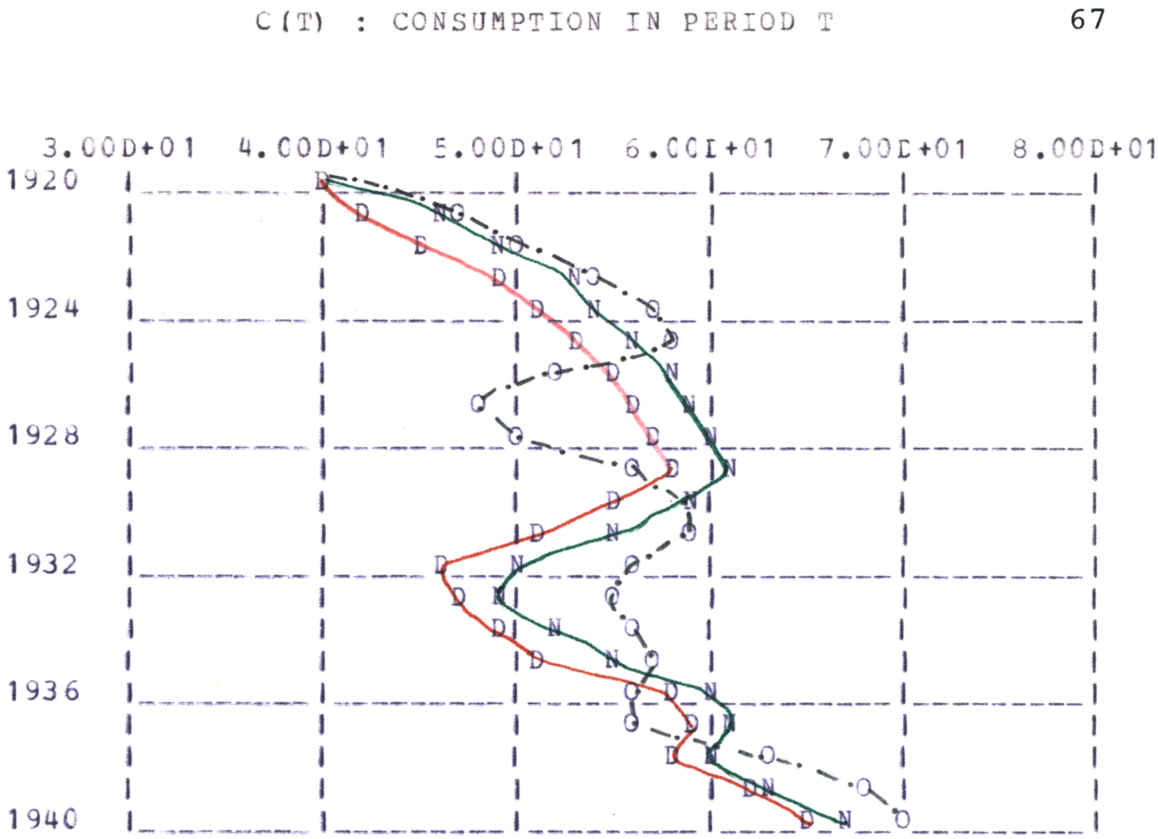
In this first run, the standard econometric model ("old" model) was obtained by applying the ordinary least squares estimation procedure to Klein's original structure. As it was discussed in Chapter three, OLS does not have good properties for simultaneous equations. So, one would not expect to obtain the best results with the "new" model.

The results are shown numerically and graphically on Tables 4.2 to 4.19 and Figures 4.1 to 4.18. Note that time runs along the vertical axis, and that the historical path is denoted by letter "D", the "old" model simulated path by "O" and the "new" model path by "N".

First, we observe the striking change on the dynamics of the "new" model with respect to the dynamics of the "old" model. This is due, as it will discuss later, to the change of position of the complex roots in the "new" model because the presence of a feedback closed loop.

Consumption, private wage bill, and national income all run significantly higher than the historical values, while the capital stock drops from its historical values. A possible explanation could be motivated by the fact that the "old" model fits badly the historical values for capital stock (K). Because K(t) is a definition variable and it is not obtained from an estimated equation. The "new" model, in order to close this gap, has to sacrifice performance on other variables as consumption, national income and private wage bill. This last sentence makes sense since we know that an increase on the capital stock produces an increase on C(t), Y(t) and Wl(t).

The optimal policy variables follow closely the historical values with the exemption of government expenditure for the years 1926-1928 and 1934-1937. If we observe the diagrams more closely, we realize that the differences from the historical values in government expenditure are present to correct the big departure from the historical values on mostly every variable for the corresponding years (i.e., 1926-1928 and 1934-1937).



<u>Figure 4.1</u>

C(T) : Consumption in Period T

<u>Sensitivity Experiment for OLS Structure</u>

C(T) : CONSUMPTION IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
39.8000D+00	39.8000D+00	39.8000D+00	39.8000D+00	0.0	0.0
41.9000D+00	46.8649D+00	46.0255D+00	41.9000D+00	-49.6492D-01	-41.2553D-01
45.0000D+00	50.3231D+00	49.2825D+00	45.0000D+00	-53.2314D-01	-42.8249D-01
49.2000D+00	53.5089D+00	52.6022D+00	49.2000D+00	-43.0890D-01	-34.0219D-01
50.6000D+00	57.2819D+00	54.2591D+00	50.6000D+00	-66.8190D-01	-36.5913D-01
52.6000D+00	57.5059D+00	56.3829D+00	52.6000D+00	-49.0592D-01	-37.8291D-01
55.1000D+00	52.2898D+00	58.0942D+00	55.1000D+00	28.1020D-01	-29.9417D-01
56.2000D+00	47.7399D+00	58.7900D+00	56.2000D+00	84.6008D-01	-25.8998D-01
57.3000D+00	49.6560D+00	59.6217D+00	57.3000D+00	76.4403D-01	-23.2168D-01
57.8000D+00	56.2135D+00	61.2557D+00	57.8000D+00	15.8652D-01	-34.5568D-01
55.0000D+00	59.0718D+00	58.7492D+00	55.0000D+00	-40.7179D-01	-37.4918D-01
50.9000D+00	59.1084D+00	54.5965D+00	50.9000D+00	-82.0839D-01	-36.9651D-01
45.6000D+00	56.1557D+00	49.8175D+00	45.6000D+00	-10.5557D+00	-42.1753D-01
46.5000D+00	54.6381D+00	49.3115D+00	46.5000D+00	-81.3810D-01	-28.1147D-01
48.7000D+00	55.8385D+00	51.6508D+00	48.7000D+00	-71.3848D-01	-29.5080D-01
51.3000D+00	57.0179D+00	54.7168D+00	51.3000D+00	-57.1790D-01	-34.1682D-01
57.7000D+00	56.3447D+00	59.6899D+00	57.7000D+00	13.5528D-01	-19.8987D-01
58.7000D+00	56.4633D+00	60.5668D+00	58.7000D+00	22.3670D-01	-18.6676D-01
57.5000D+00	62.5495D+00	60.2660D+00	57.5000D+00	-50.4949D-01	-27.6601D-01
61.6000D+00	67.8219D+00	63.0958D+00	61.6000D+00	-62.2193D-01	-14.9582D-01
65.0000D+00	70.4239D+00	67.3121D+00	65.0000D+00	-54.2389D-01	-23.1206D-01

QUADRATIC ERROR OLD MODEL: 7264.1637D-01

QUADRATIC ERROR NEW MODEL: 2041.1183D-01

Table 4.2

C(T) : Consumption in period T

Sensitivity Experiment for OLS Structure

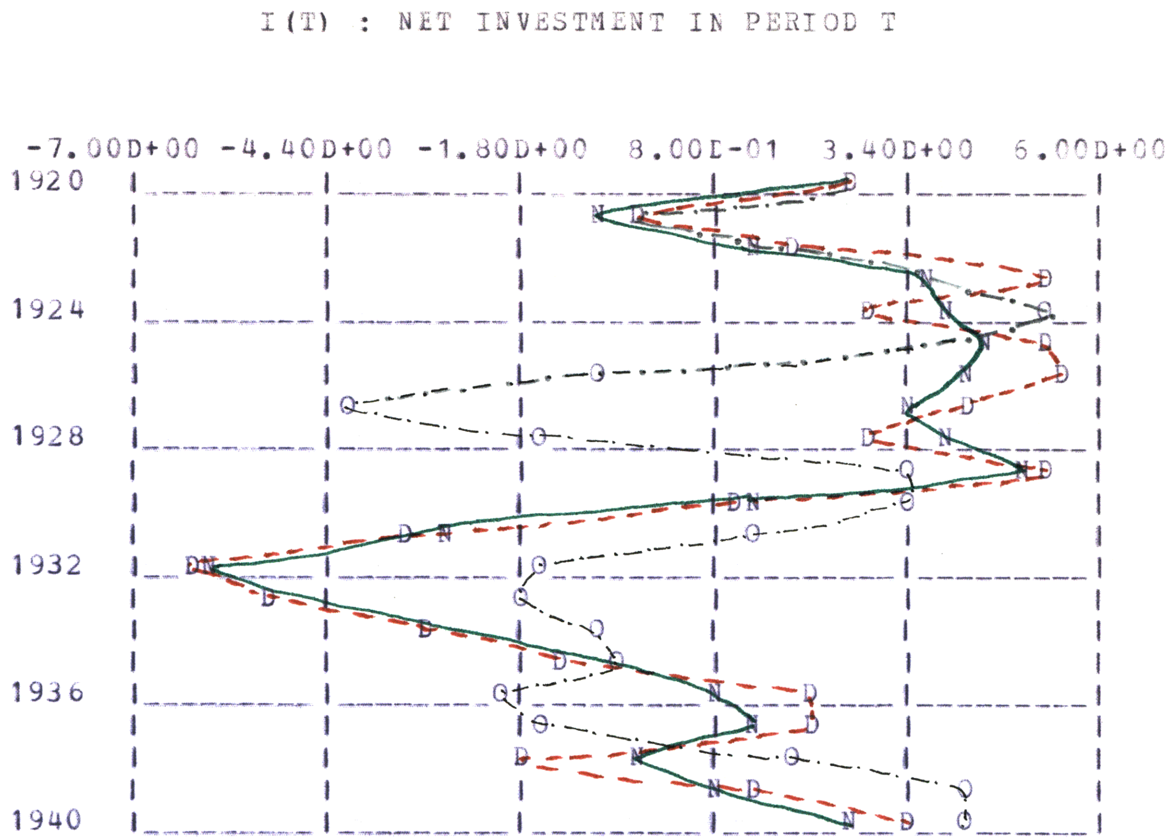


Figure 4.2

I(T) : Net Investment in Period T

Sensitivity Experiment for OLS Structure

I(T) : NET INVESTMENT IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
27.0000D-01	27.0000D-01	27.0000D-01	27.0000D-01	0.0	0.0
-20.0000D-02	-68.3347D-02	-82.4472D-02	-20.0000D-02	48.3347D-02	62.4472D-02
19.0000D-01	13.9981D-01	12.6876D-01	19.0000D-01	50.0192D-02	63.1237D-02
52.0000D-01	36.9924D-01	36.3230D-01	52.0000D-01	15.0076D-01	15.6770D-01
30.0000D-01	53.4894D-01	39.6938D-01	30.0000D-01	-23.4894D-01	-96.9384D-02
51.0000D-01	43.2855D-01	44.0898D-01	51.0000D-01	77.1452D-02	69.1021D-02
56.0000D-01	-72.0529D-02	42.1750D-01	56.0000D-01	63.2053D-01	13.8250D-01
42.0000D-01	-42.2865D-01	34.8068D-01	42.0000D-01	84.2865D-01	71.9322D-02
30.0000D-01	-16.6337D-01	40.1447D-01	30.0000D-01	46.6337D-01	-10.1447D-01
51.0000D-01	33.2678D-01	49.0676D-01	51.0000D-01	17.7322D-01	19.3237D-02
10.0000D-01	33.0776D-01	14.2685D-01	10.0000D-01	-23.0776D-01	-42.6848D-02
-34.0000D-01	12.4112D-01	-28.8329D-01	-34.0000D-01	-46.4112D-01	-51.6714D-02
-62.0000D-01	-14.5471D-01	-60.5966D-01	-62.0000D-01	-47.4529D-01	-14.0338D-02
-51.0000D-01	-18.1058D-01	-51.5123D-01	-51.0000D-01	-32.8942D-01	51.2335D-03
-30.0000D-01	-77.2482D-02	-29.8798D-01	-30.0000D-01	-22.2752D-01	-12.0239D-03
-13.0000D-01	-50.9104D-02	-13.4331D-01	-13.0000D-01	-79.0896D-02	43.3097D-03
21.0000D-01	-21.5375D-01	70.7808D-02	21.0000D-01	42.5375D-01	13.9219D-01
20.0000D-01	-15.9393D-01	12.7027D-01	20.0000D-01	35.9393D-01	72.9729D-02
-19.0000D-01	19.6571D-01	-15.0227D-02	-19.0000D-01	-38.6571D-01	-17.4977D-01
13.0000D-01	41.9446D-01	68.5218D-02	13.0000D-01	-28.9446D-01	61.4782D-02
33.0000D-01	42.1300D-01	26.6736D-01	33.0000D-01	-91.2996D-02	63.2640D-02

CUADRATIC ERROR OLD MODEL: 2656.8836D-01

CUADRATIC ERROR NEW MODEL: 1494.2679D-02

Table 4.3

I(T) : Net Investment in Period T

Sensitivity Experiment for OLS Structure

W1(T) : PRIVATE WAGE BIII IN PERICD T

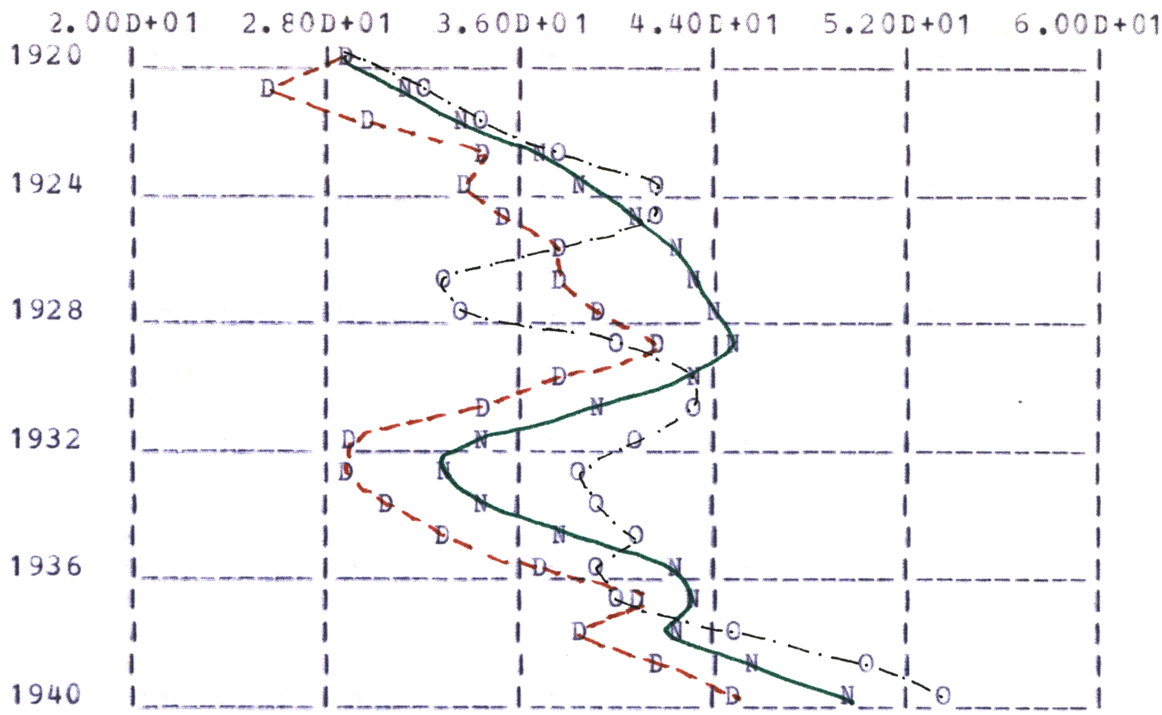


Figure 4.3

Wl(T) : Private Wage Bill in Period T

Sensitivity Experiment for OLS Structure

W1(T) : PRIVATE WAGE BILL IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
28.8000D+00	28.8000D+00	28.8000D+00	28.8000D+00	0.0	0.0
25.5000D+00	31.7598D+00	30.9875D+00	25.5000D+00	-62.5981D-01	-54.8751D-01
29.3000D+00	34.7743D+00	33.7624D+00	29.3000D+00	-54.7426D-01	-44.6242D-01
34.1000D+00	37.8462D+00	36.8960D+00	34.1000D+00	-37.4619D-01	-27.9603D-01
33.9000D+00	41.4097D+00	38.4537D+00	33.9000D+00	-75.0968D-01	-45.5367D-01
35.4000D+00	41.9960D+00	40.7751D+00	35.4000D+00	-65.9596D-01	-53.7511D-01
37.4000D+00	37.4694D+00	42.7913D+00	37.4000D+00	-69.3900D-03	-53.9133D-01
37.9000D+00	32.8672D+00	43.4328D+00	37.9000D+00	50.3277D-01	-55.3281D-01
39.2000D+00	33.9806D+00	43.8233D+00	39.2000D+00	52.1944D-01	-46.2325D-01
41.3000D+00	39.8253D+00	45.0512D+00	41.3000D+00	14.7470D-01	-37.5120D-01
37.9000D+00	43.3581D+00	43.2743D+00	37.9000D+00	-54.5815D-01	-53.7430D-01
34.5000D+00	43.4790D+00	39.1442D+00	34.5000D+00	-89.7901D-01	-46.4420D-01
29.0000D+00	40.4932D+00	34.2372D+00	29.0000D+00	-11.4932D+00	-52.3723D-01
28.5000D+00	38.3020D+00	32.8495D+00	28.5000D+00	-98.0202D-01	-43.4952D-01
30.6000D+00	39.0992D+00	34.7485D+00	30.6000D+00	-84.9915D-01	-41.4848D-01
33.2000D+00	40.4099D+00	37.9529D+00	33.2000D+00	-72.0990D-01	-47.5293D-01
36.8000D+00	39.1313D+00	42.0821D+00	36.8000D+00	-23.3133D-01	-52.8206D-01
41.0000D+00	39.6176D+00	43.4823D+00	41.0000D+00	13.8241D-01	-24.8227D-01
38.2000D+00	44.7299D+00	42.7323D+00	38.2000D+00	-65.2992D-01	-45.3225D-01
41.6000D+00	50.2824D+00	45.6873D+00	41.6000D+00	-86.8241D-01	-40.8727D-01
45.0000D+00	53.2009D+00	49.9886D+00	45.0000D+00	-82.0087D-01	-49.8861D-01

QUADRATIC ERROR OLD MODEL: 8932.6930D-01

QUADRATIC ERROR NEW MODEL: 4353.8978D-01

Table 4.4

W1(T); Private wage Bill in Period T

Sensitivity Experiment for OLS Structure

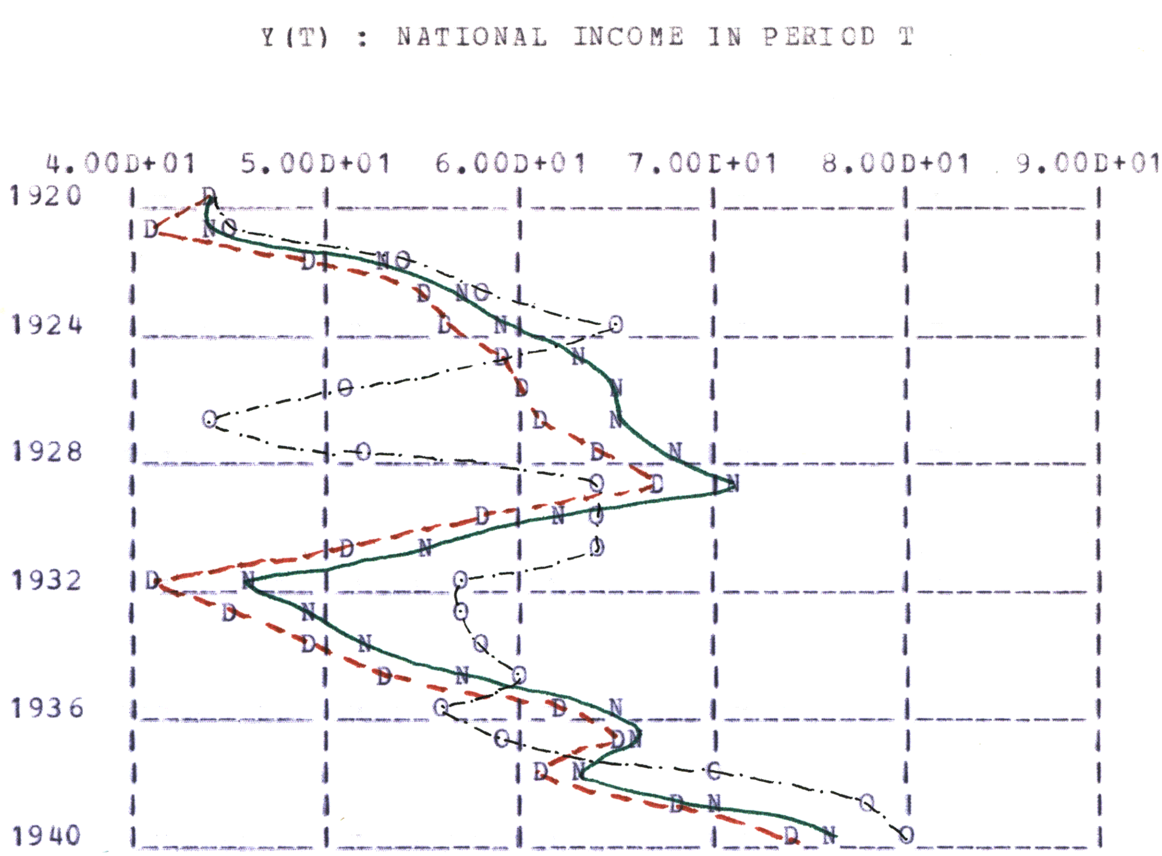


Figure 4.4

Y(T) : National Income in Period T

Sensitivity Experiment for OLS Structure

Y(T) : NATIONAL INCOME IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
43.7000D+00	43.7000D+00	43.7000D+00	43.7000D+00	0.0	0.0
40.6000D+00	45.0816D+00	43.8044D+00	40.6000D+00	-44.8158D-01	-32.0441D-01
49.1000D+00	53.9229D+00	52.5720D+00	49.1000D+00	-48.2295D-01	-34.7204D-01
55.4000D+00	58.2081D+00	56.9806D+00	55.4000D+00	-28.0814D-01	-15.8062D-01
56.4000D+00	65.4308D+00	59.4798D+00	56.4000D+00	-90.3084D-01	-30.7979D-01
58.7000D+00	62.8345D+00	63.0773D+00	58.7000D+00	-41.3446D-01	-43.7728D-01
60.3000D+00	51.1693D+00	64.8489D+00	60.3000D+00	91.3073D-01	-45.4888D-01
61.3000D+00	44.4113D+00	65.4949D+00	61.3000D+00	16.8887D+00	-41.9488D-01
64.0000D+00	51.6926D+00	68.2180D+00	64.0000D+00	12.3074D+00	-42.1804D-01
67.0000D+00	63.6403D+00	71.0060D+00	67.0000D+00	33.5974D-01	-40.0599D-01
57.7000D+00	64.0795D+00	62.4007D+00	57.7000D+00	-63.7955D-01	-47.0075D-01
50.7000D+00	63.5495D+00	55.1076D+00	50.7000D+00	-12.8495D+00	-44.0765D-01
41.3000D+00	56.6010D+00	45.9981D+00	41.3000D+00	-15.3010D+00	-46.9809D-01
45.3000D+00	56.7275D+00	48.7085D+00	45.3000D+00	-11.4275D+00	-34.0855D-01
48.9000D+00	58.2660D+00	51.7765D+00	48.9000D+00	-93.6600D-01	-28.7653D-01
53.3000D+00	59.8088D+00	57.2339D+00	53.3000D+00	-65.0880D-01	-39.3387D-01
61.8000D+00	56.1910D+00	65.0586D+00	61.8000D+00	56.0904D-01	-32.5861D-01
65.0000D+00	59.1694D+00	65.6297D+00	65.0000D+00	58.3063D-01	-62.9738D-02
61.2000D+00	70.1152D+00	63.4495D+00	61.2000D+00	-89.1520D-01	-22.4950D-01
68.4000D+00	77.5164D+00	69.8493D+00	68.4000D+00	-91.1639D-01	-14.4926D-01
74.1000D+00	80.4369D+00	76.2282D+00	74.1000D+00	-63.3688D-01	-21.2821D-01

QUADRATIC ERROR OLD MODEL: 1650.0472D+00

QUADRATIC ERROR NEW MODEL: 2472.6583D-01

Table 4.5

Y(T) : National Income in Period T

Sensitivity Experiment for OLS Structure

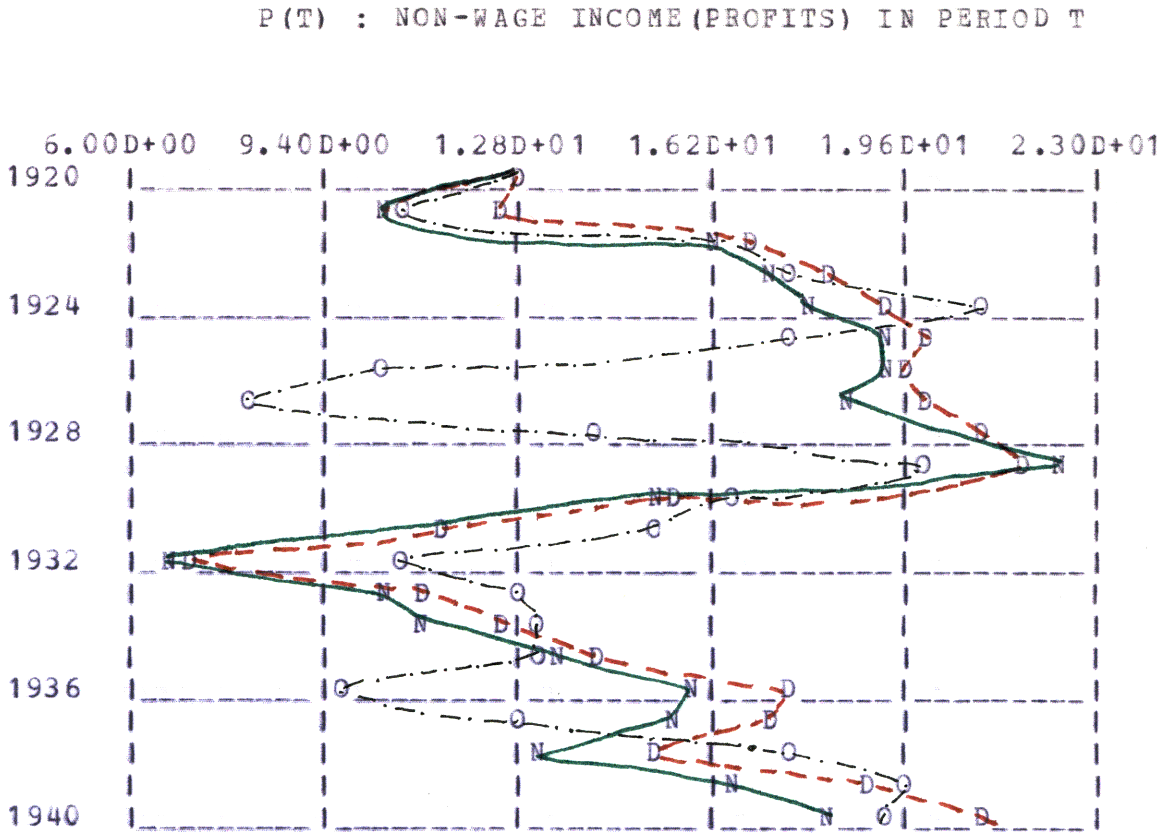


Figure 4.5

P(T) : Non-Wage Income(Profits) in Period T

Sensitivity Experiment for OLS Structure

P(T) : NON-WAGE INCOME(PROFITS) IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
12.7000D+00	12.7000D+00	12.7000D+00	12.7000D+00	0.0	0.0
12.4000D+00	10.6218D+00	10.3275D+00	12.4000D+00	17.7823D-01	20.7247D-01
16.9000D+00	16.2487D+00	16.1469D+00	16.9000D+00	65.1308D-02	75.3114D-02
18.4000D+00	17.4620D+00	17.3296D+00	18.4000D+00	93.8049D-02	10.7036D-01
19.4000D+00	20.9212D+00	18.0578D+00	19.4000D+00	-15.2116D-01	13.4224D-01
20.1000D+00	17.6385D+00	19.3938D+00	20.1000D+00	24.6149D-01	70.6159D-02
19.6000D+00	10.3999D+00	19.0945D+00	19.6000D+00	92.0012D-01	50.5489D-02
19.8000D+00	79.4404D-01	18.7491D+00	19.8000D+00	11.8560D+00	10.5087D-01
21.1000D+00	14.0120D+00	20.9131D+00	21.1000D+00	70.8796D-01	18.6910D-02
21.7000D+00	19.8150D+00	22.2065D+00	21.7000D+00	18.8504D-01	-50.6534D-02
15.6000D+00	16.5214D+00	15.1968D+00	15.6000D+00	-92.1401D-02	40.3215D-02
11.4000D+00	15.2705D+00	11.4104D+00	11.4000D+00	-38.7050D-01	-10.4029D-03
70.0000D-01	10.8078D+00	67.4507D-01	70.0000D-01	-38.0782D-01	25.4932D-02
11.2000D+00	12.8255D+00	10.4661D+00	11.2000D+00	-16.2550D-01	73.3887D-02
12.3000D+00	13.1668D+00	11.1920D+00	12.3000D+00	-86.6848D-02	11.0804D-01
14.0000D+00	13.2989D+00	13.4205D+00	14.0000D+00	70.1096D-02	57.9485D-02
17.6000D+00	96.5963D-01	15.8364D+00	17.6000D+00	79.4037D-01	17.6361D-01
17.3000D+00	12.8518D+00	15.4966D+00	17.3000D+00	44.4823D-01	18.0344D-01
15.3000D+00	17.6853D+00	13.0670D+00	15.3000D+00	-23.8528D-01	22.3301D-01
19.0000D+00	19.4340D+00	16.4608D+00	19.0000D+00	-43.3978D-02	25.3922D-01
21.1000D+00	19.2360D+00	18.3966D+00	21.1000D+00	18.6399D-01	27.0344D-01

CUADRATIC ERROR OLD MODEL: 4182.4048D-01

CUADRATIC ERROR NEW MODEL: 3739.4692D-02

Table 4.6

P(T) : Non-Wage Income (Profits) in Period T

Sensitivity Experiment for OLS Structure

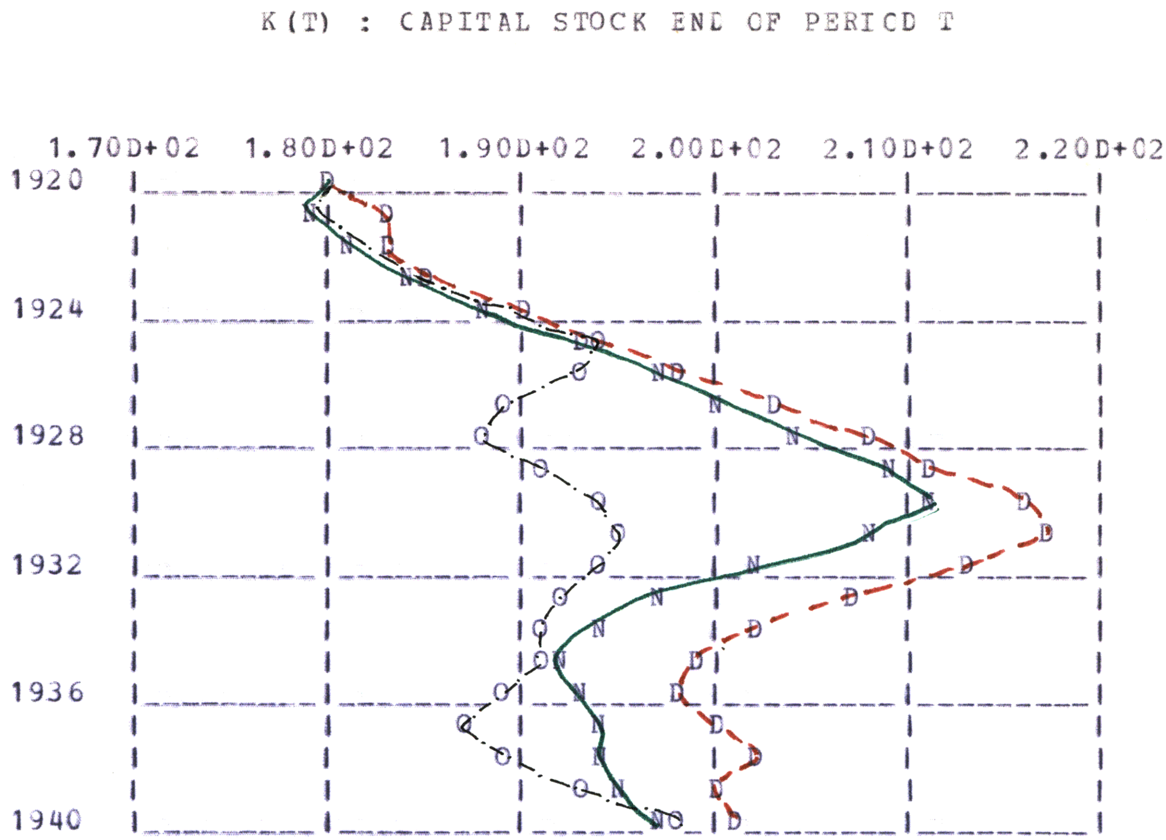


Figure 4.6

K(T) : Capital Stock End of Period T

Sensitivity Experiment for OLS Structure

K(T) : CAPITAL STOCK END OF PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
18.0100D+01	18.0100D+01	18.0100D+01	18.0100D+01	0.0	0.0
18.2800D+01	17.9417D+01	17.9276D+01	18.2800D+01	33.8335D-01	35.2447D-01
18.2600D+01	18.0816D+01	18.0544D+01	18.2600D+01	17.8354D-01	20.5571D-01
18.4500D+01	18.4516D+01	18.4177D+01	18.4500D+01	-15.7024D-03	32.3409D-02
18.9700D+01	18.9865D+01	18.8146D+01	18.9700D+01	-16.4645D-02	15.5403D-01
19.2700D+01	19.4193D+01	19.2555D+01	19.2700D+01	-14.9319D-01	14.5047D-02
19.7800D+01	19.3473D+01	19.6772D+01	19.7800D+01	43.2734D-01	10.2755D-01
20.3400D+01	18.9244D+01	20.0253D+01	20.3400D+01	14.1560D+00	31.4687D-01
20.7600D+01	18.7581D+01	20.4268D+01	20.7600D+01	20.0194D+00	33.3240D-01
21.0600D+01	19.0907D+01	20.9174D+01	21.0600D+01	19.6926D+00	14.2564D-01
21.5700D+01	19.4215D+01	21.0601D+01	21.5700D+01	21.4848D+00	50.9879D-01
21.6700D+01	19.5456D+01	20.7718D+01	21.6700D+01	21.2437D+00	89.8208D-01
21.3300D+01	19.4002D+01	20.1658D+01	21.3300D+01	19.2984D+00	11.6417D+00
20.7100D+01	19.2191D+01	19.6507D+01	20.7100D+01	14.9090D+00	10.5930D+00
20.2000D+01	19.1419D+01	19.3519D+01	20.2000D+01	10.5815D+00	84.8095D-01
19.9000D+01	19.0909D+01	19.2176D+01	19.9000D+01	80.9058D-01	68.2426D-01
19.7700D+01	18.8756D+01	19.2884D+01	19.7700D+01	89.4433D-01	48.1645D-01
19.9800D+01	18.7162D+01	19.4154D+01	19.9800D+01	12.6383D+00	56.4618D-01
20.1800D+01	18.9127D+01	19.4004D+01	20.1800D+01	12.6725D+00	77.9640D-01
19.9900D+01	19.3322D+01	19.4689D+01	19.9900D+01	65.7809D-01	52.1119D-01
20.1200D+01	19.7535D+01	19.7356D+01	20.1200D+01	36.6509D-01	38.4383D-01

QUADRATIC ERROR OLD MODEL: 3166.6240D+00

QUADRATIC ERROR NEW MODEL: 6739.9083D-01

Table 4.7

K(T) : Capital Stock End of Period T

Sensitivity Experiment for OLS Structure

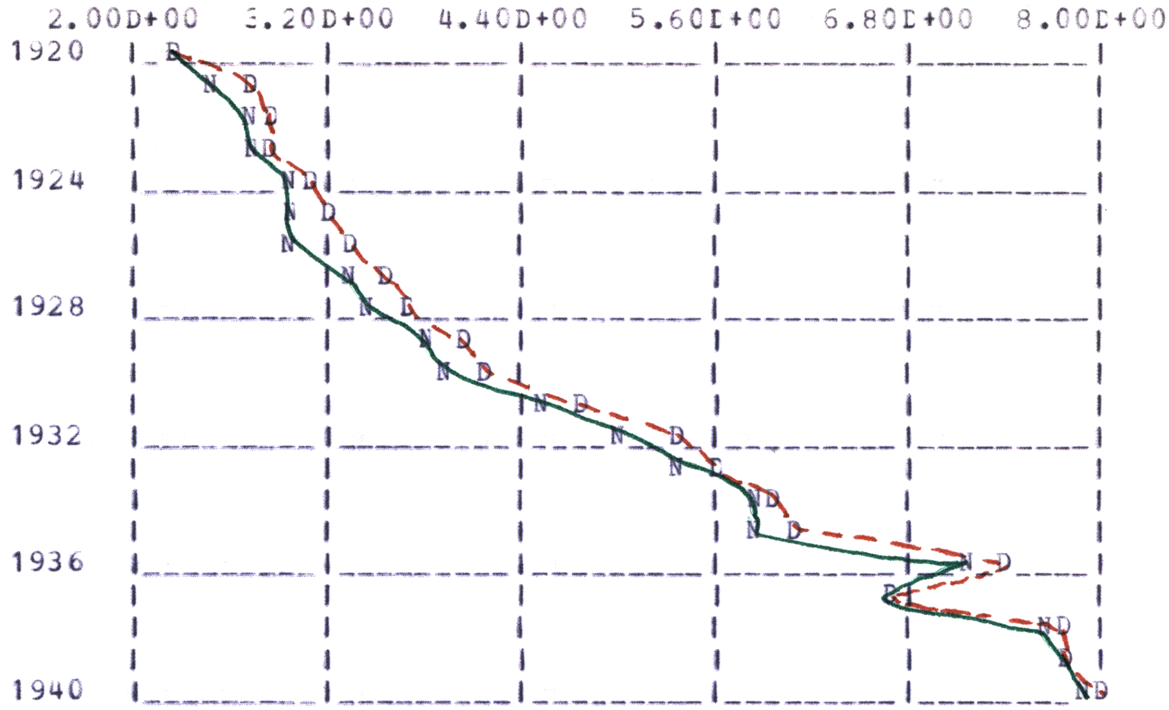


Figure 4.7

W2(T) : Governmental Wage Bill in Period T

Sensitivity Experiment for OLS Structure

W2(T) : GOVERNMENTAL WAGE BILL IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
22.0000D-01	22.0000D-01	22.0000D-01	22.0000D-01	0.0	0.0
27.0000D-01	27.0000D-01	24.8936D-01	27.0000D-01	0.0	21.0636D-02
29.0000D-01	29.0000D-01	26.6272D-01	29.0000D-01	0.0	23.7275D-02
29.0000D-01	29.0000D-01	27.5495D-01	29.0000D-01	0.0	14.5051D-02
31.0000D-01	31.0000D-01	29.6836D-01	31.0000D-01	0.0	13.1636D-02
32.0000D-01	32.0000D-01	29.0833D-01	32.0000D-01	0.0	29.1670D-02
33.0000D-01	33.0000D-01	29.6304D-01	33.0000D-01	0.0	33.6960D-02
36.0000D-01	36.0000D-01	33.1294D-01	36.0000D-01	0.0	28.7065D-02
37.0000D-01	37.0000D-01	34.8170D-01	37.0000D-01	0.0	21.8296D-02
40.0000D-01	40.0000D-01	37.4825D-01	40.0000D-01	0.0	25.1746D-02
42.0000D-01	42.0000D-01	39.2966D-01	42.0000D-01	0.0	27.0339D-02
48.0000D-01	48.0000D-01	45.5304D-01	48.0000D-01	0.0	24.6956D-02
53.0000D-01	53.0000D-01	50.1579D-01	53.0000D-01	0.0	28.4205D-02
56.0000D-01	56.0000D-01	53.9292D-01	56.0000D-01	0.0	20.7085D-02
60.0000D-01	60.0000D-01	58.3609D-01	60.0000D-01	0.0	16.3910D-02
61.0000D-01	61.0000D-01	58.6042D-01	61.0000D-01	0.0	23.9582D-02
74.0000D-01	74.0000D-01	71.4017D-01	74.0000D-01	0.0	25.9832D-02
67.0000D-01	67.0000D-01	66.5091D-01	67.0000D-01	0.0	49.0915D-03
77.0000D-01	77.0000D-01	76.5026D-01	77.0000D-01	0.0	49.7436D-03
78.0000D-01	78.0000D-01	77.0121D-01	78.0000D-01	0.0	98.7908D-03
80.0000D-01	80.0000D-01	78.4304D-01	80.0000D-01	0.0	15.6957D-02

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 9798.6986D-04

Table 4.8

W2(T) : Governmental Wage Bill in Period T

Sensitivity Experiment for OLS Structure

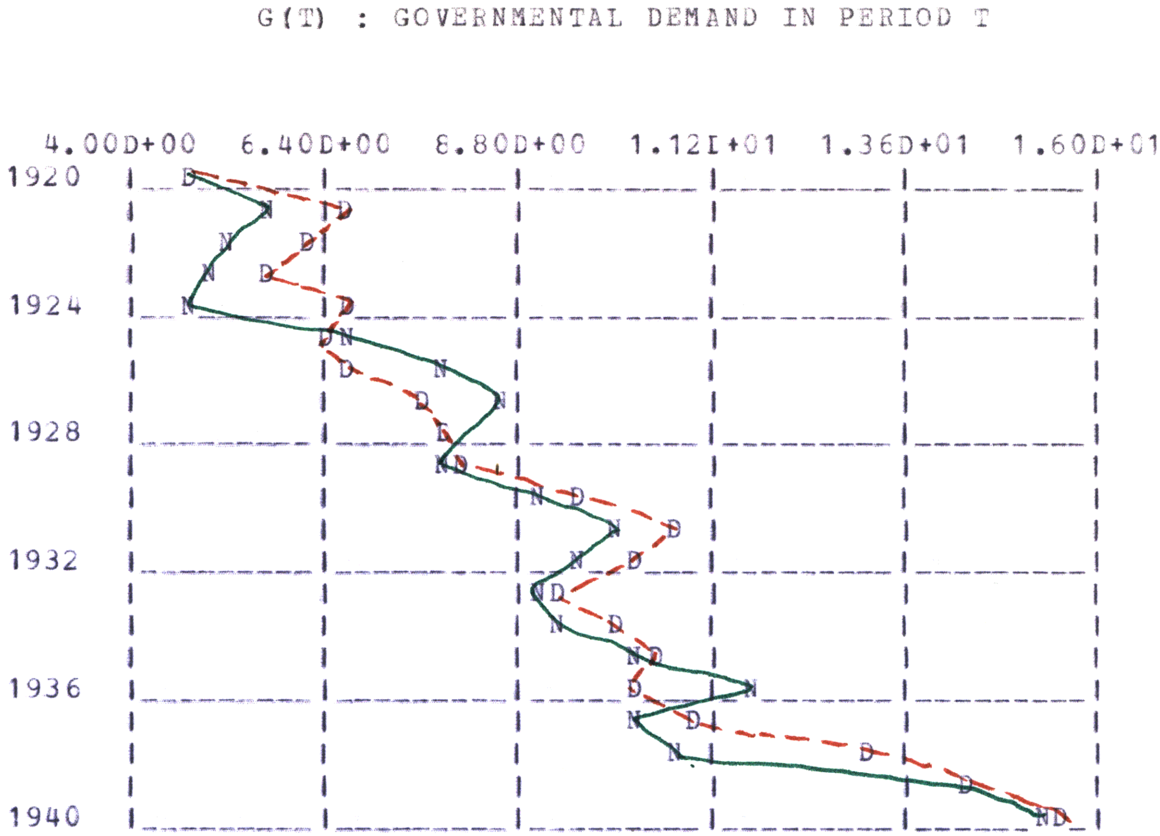


Figure 4.8

G(T) : Governmental Demand in Period T

Sensitivity Experiment for OLS Structure

G(T) : GOVERNMENTAL DEMAND IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
46.0000D-01	46.0000D-01	46.0000D-01	46.0000D-01	0.0	0.0
66.0000D-01	66.0000D-01	56.1259D-01	66.0000D-01	0.0	98.7414D-02
61.0000D-01	61.0000D-01	53.1587D-01	61.0000D-01	0.0	78.4127D-02
57.0000D-01	57.0000D-01	49.3752D-01	57.0000D-01	0.0	76.2484D-02
66.0000D-01	66.0000D-01	46.7312D-01	66.0000D-01	0.0	19.2688D-01
65.0000D-01	65.0000D-01	65.3186D-01	65.0000D-01	0.0	-31.8600D-03
66.0000D-01	66.0000D-01	78.6915D-01	66.0000D-01	0.0	-12.6915D-01
76.0000D-01	76.0000D-01	84.9233D-01	76.0000D-01	0.0	-89.2334D-02
79.0000D-01	79.0000D-01	78.1049D-01	79.0000D-01	0.0	89.5101D-03
81.0000D-01	81.0000D-01	78.7743D-01	81.0000D-01	0.0	22.2566D-02
94.0000D-01	94.0000D-01	89.3274D-01	94.0000D-01	0.0	46.7255D-02
10.7000D+00	10.7000D+00	10.0233D+00	10.7000D+00	0.0	67.6721D-02
10.2000D+00	10.2000D+00	96.3585D-01	10.2000D+00	0.0	56.4153D-02
93.0000D-01	93.0000D-01	90.8192D-01	93.0000D-01	0.0	21.8077D-02
10.0000D+00	10.0000D+00	92.2268D-01	10.0000D+00	0.0	77.7316D-02
10.5000D+00	10.5000D+00	10.1361D+00	10.5000D+00	0.0	36.3921D-02
10.3000D+00	10.3000D+00	11.6305D+00	10.3000D+00	0.0	-13.3046D-01
11.0000D+00	11.0000D+00	10.1867D+00	11.0000D+00	0.0	81.3272D-02
13.0000D+00	13.0000D+00	10.7433D+00	13.0000D+00	0.0	22.5672D-01
14.4000D+00	14.4000D+00	14.2754D+00	14.4000D+00	0.0	12.4572D-02
15.4000D+00	15.4000D+00	15.3357D+00	15.4000D+00	0.0	64.2970D-03

CUADRATIC ERROR OLD MODEL: 0.0

CUADRATIC ERROR NEW MODEL: 1767.2395D-02

Table 4.9

G(T) : Governmental Demand in Period T

Sensitivity Experiment for OLS Structure

TX(T) : BUSINESS TAXES IN PERIOD T

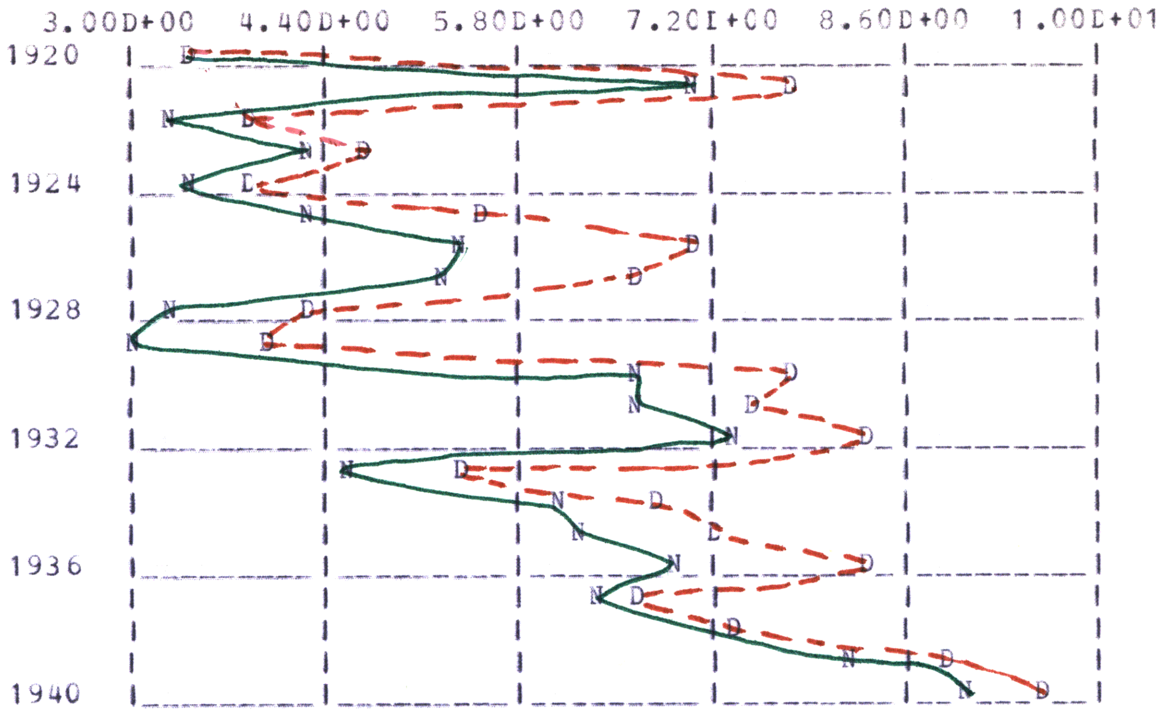


Figure 4.9

TX(T) : Business Taxes in Period T

Sensitivity Experiment for OLS Structure

TX(T) : BUSINESS TAXES IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
34.0000D-01	34.0000D-01	34.0000D-01	34.0000D-01	0.0	0.0
77.0000D-01	77.0000D-01	70.0923D-01	77.0000D-01	0.0	69.0771D-02
39.0000D-01	39.0000D-01	32.9509D-01	39.0000D-01	0.0	60.4909D-02
47.0000D-01	47.0000D-01	41.9139D-01	47.0000D-01	0.0	50.8609D-02
38.0000D-01	38.0000D-01	34.2184D-01	38.0000D-01	0.0	37.8163D-02
55.0000D-01	55.0000D-01	42.4647D-01	55.0000D-01	0.0	12.5353D-01
70.0000D-01	70.0000D-01	53.3194D-01	70.0000D-01	0.0	16.6806D-01
67.0000D-01	67.0000D-01	52.6812D-01	67.0000D-01	0.0	14.3188D-01
42.0000D-01	42.0000D-01	32.2860D-01	42.0000D-01	0.0	97.1400D-02
40.0000D-01	40.0000D-01	30.3388D-01	40.0000D-01	0.0	96.6116D-02
77.0000D-01	77.0000D-01	67.0802D-01	77.0000D-01	0.0	99.1976D-02
75.0000D-01	75.0000D-01	66.2886D-01	75.0000D-01	0.0	87.1138D-02
83.0000D-01	83.0000D-01	73.9563D-01	83.0000D-01	0.0	90.4370D-02
54.0000D-01	54.0000D-01	45.3361D-01	54.0000D-01	0.0	86.6393D-02
68.0000D-01	68.0000D-01	61.0899D-01	68.0000D-01	0.0	69.1014D-02
72.0000D-01	72.0000D-01	62.7572D-01	72.0000D-01	0.0	92.4277D-02
83.0000D-01	83.0000D-01	69.6953D-01	83.0000D-01	0.0	13.3047D-01
67.0000D-01	67.0000D-01	63.9402D-01	67.0000D-01	0.0	30.5976D-02
74.0000D-01	74.0000D-01	74.0956D-01	74.0000D-01	0.0	-95.5838D-04
89.0000D-01	89.0000D-01	82.0720D-01	89.0000D-01	0.0	69.2798D-02
96.0000D-01	96.0000D-01	90.8692D-01	96.0000D-01	0.0	51.3084D-02

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 1677.6128D-02

Table 4.10

TX(T) : Business Taxes in Period T

Sensitivity Experiment for OLS Structure

4.3.2. Two Stages Least Squares Structure 1 (2SLS)

For this run, the standard econometric model ("old" model) was obtained by applying the two stage least squares estimation procedure to Klein's original structure. As it was discussed in Chapter three, the 2SLS procedure is the one that, for this particular data, exhibits the best performance, eventhough some problem with multi-colinearity seems to appear for the profits (P) variable, therefore a slightly low performance is expected for this variable.

The results are shown numerically and graphically on Tables 4.20 to 4.37 and on Figures 4.18 to 4.36. The symbols are the same as used for the first run (i.e., for OLS).

Once more, as it was the case for OLS, we observe a change on the dynamics of the "new" model. In this case, as expected, the results are closer to the historical paths than the run for OLS. This is due to the fact that 2SLS is a simultaneous equation estimation procedures, and all the biases present in the OLS are not present any longer, therefore the performance of the new model is improved.

There are no significant biases in this run. Consumption, investment and capital stocks run closer to the historical values than profits, wages and national income, but the differences are not significant. This small differences can be attributed to the multi-linearity present in the original model through the profits variable.

With respect to the optimal instrument variable, eventhough, the behavior of these variables is similar to the one obtained in the first run (OLS), i.e., only government expenditure departs significantly from the historical values, in this run the difference is greater specially for the period 1927-1932, (the big depression). This departure can be motivated so as to correct the big gap existing between the simulated values by the old model and the historical values for this period, specially for profits and national income.

C(T) : CONSUMPTION IN PERIOD T

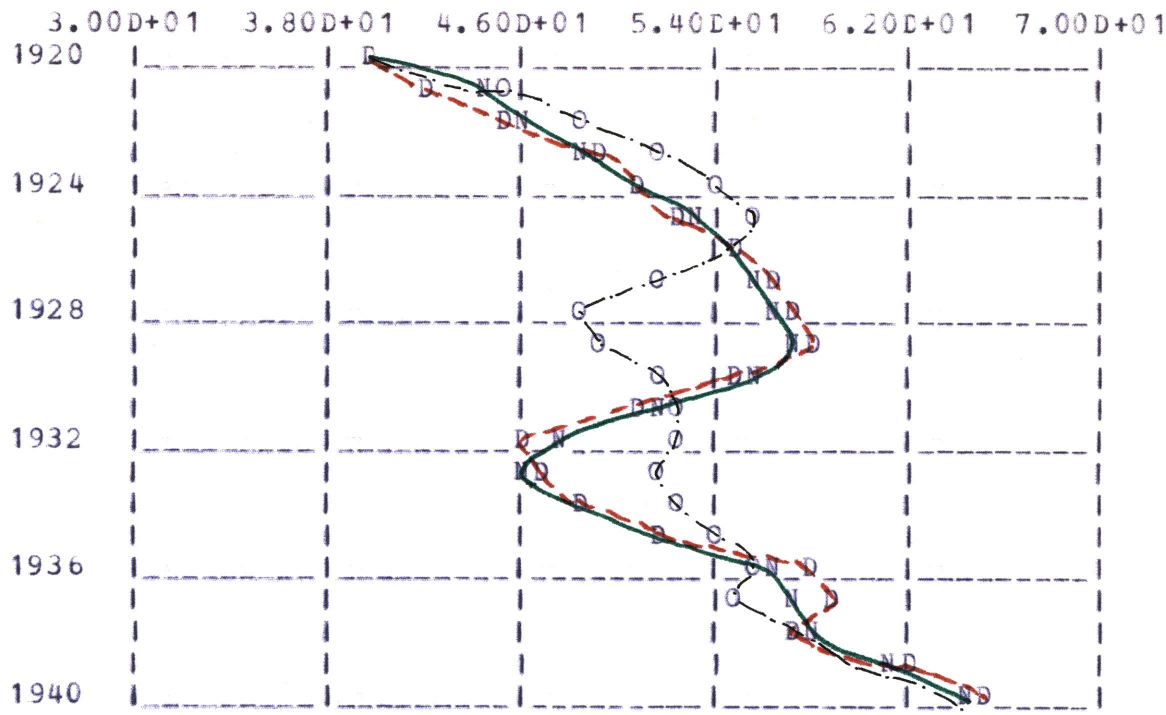


Figure 4.10

C(T) : Consumption in Period T

Sensitivity Experiment for 2SLS Structure

C(T) : CONSUMPTION IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
39.8000D+00	39.8000D+00	39.8000D+00	39.8000D+00	0.0	0.0
41.9000D+00	45.1683D+00	44.0165D+00	41.9000D+00	-32.6830D-01	-21.1649D-01
45.0000D+00	48.0097D+00	45.6912D+00	45.0000D+00	-30.0974D-01	-69.1200D-02
49.2000D+00	51.3217D+00	48.4554D+00	49.2000D+00	-21.2171D-01	74.4555D-02
50.6000D+00	54.1722D+00	50.4918D+00	50.6000D+00	-35.7217D-01	10.8158D-02
52.6000D+00	55.7724D+00	52.8607D+00	52.6000D+00	-31.7240D-01	-26.0656D-02
55.1000D+00	54.4600D+00	54.6501D+00	55.1000D+00	63.9984D-02	44.9912D-02
56.2000D+00	51.3467D+00	55.4976D+00	56.2000D+00	48.5334D-01	70.2448D-02
57.3000D+00	48.7785D+00	56.0471D+00	57.3000D+00	85.2147D-01	12.5292D-01
57.8000D+00	49.1829D+00	56.8601D+00	57.8000D+00	86.1709D-01	93.9913D-02
55.0000D+00	51.2587D+00	55.5518D+00	55.0000D+00	37.4125D-01	-55.1829D-02
50.9000D+00	52.5129D+00	51.7712D+00	50.9000D+00	-16.1286D-01	-87.1228D-02
45.6000D+00	52.6986D+00	47.9510D+00	45.6000D+00	-70.9863D-01	-23.5100D-01
46.5000D+00	51.6414D+00	46.2101D+00	46.5000D+00	-51.4144D-01	28.9904D-02
48.7000D+00	52.5481D+00	48.3603D+00	48.7000D+00	-38.4810D-01	33.9731D-02
51.3000D+00	53.8586D+00	51.7891D+00	51.3000D+00	-25.5857D-01	-48.9117D-02
57.7000D+00	55.3827D+00	56.4295D+00	57.7000D+00	23.1729D-01	12.7049D-01
58.7000D+00	54.7221D+00	57.0398D+00	58.7000D+00	39.7791D-01	16.6015D-01
57.5000D+00	57.7525D+00	58.1961D+00	57.5000D+00	-25.2485D-02	-69.6080D-02
61.6000D+00	61.4081D+00	60.9104D+00	61.6000D+00	19.1886D-02	68.9588D-02
65.0000D+00	64.4303D+00	64.6013D+00	65.0000D+00	56.9656D-02	39.8722D-02

QUADRATIC ERROR OLD MODEL: 3542.9673D-01

QUADRATIC ERROR NEW MODEL: 2125.9086D-02

<u>Table 4.11</u>

C(T) : Consumption in Period T

<u>Sensitivity Experiment for 2SLS Structure</u>

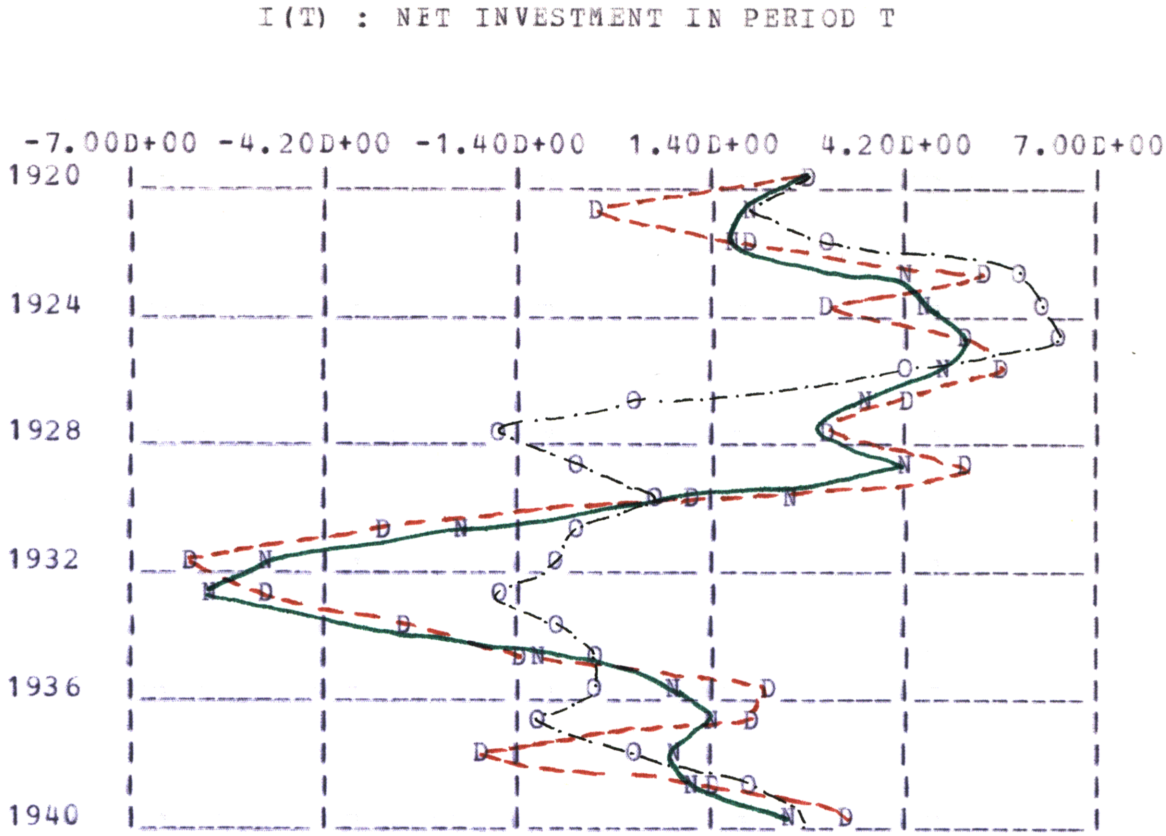


Figure 4.11

I(T) : Net Investment in Period T

Sensitivity Experiment for 2SLS Structure

I (T) : NET INVESTMENT IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
27.0000D-01	27.0000D-01	27.0000D-01	27.0000D-01	0.0	0.0
-20.0000D-02	20.2472D-01	18.7942D-01	-20.0000D-02	-22.2472D-01	-20.7942D-01
19.0000D-01	31.5039D-01	15.4893D-01	19.0000D-01	-12.5039D-01	35.1075D-02
52.0000D-01	58.2604D-01	43.3698D-01	52.0000D-01	-62.6044D-02	86.3024D-02
30.0000D-01	62.2305D-01	43.7952D-01	30.0000D-01	-32.2305D-01	-13.7952D-01
51.0000D-01	65.1385D-01	50.8267D-01	51.0000D-01	-14.1385D-01	17.3251D-03
56.0000D-01	40.6937D-01	47.9714D-01	56.0000D-01	15.3063D-01	80.2861D-02
42.0000D-01	31.4569D-02	35.9025D-01	42.0000D-01	38.3543D-01	60.9753D-02
30.0000D-01	-16.2897D-01	31.9569D-01	30.0000D-01	46.2897D-01	-19.5686D-02
51.0000D-01	-62.5638D-02	40.9120D-01	51.0000D-01	57.2564D-01	10.0880D-01
10.0000D-01	48.8109D-02	25.4410D-01	10.0000D-01	51.1891D-02	-15.4410D-01
-34.0000D-01	-65.0636D-02	-22.5953D-01	-34.0000D-01	-27.4936D-01	-11.4047D-01
-62.0000D-01	-80.8075D-02	-49.0670D-01	-62.0000D-01	-53.9193D-01	-12.9330D-01
-51.0000D-01	-17.4502D-01	-59.1702D-01	-51.0000D-01	-33.5498D-01	81.7020D-02
-30.0000D-01	-71.6899D-02	-31.4156D-01	-30.0000D-01	-22.8310D-01	14.1557D-02
-13.0000D-01	-32.0662D-02	-12.1811D-01	-13.0000D-01	-97.9338D-02	-81.8933D-03
21.0000D-01	-15.1933D-02	90.3565D-02	21.0000D-01	22.5193D-01	11.9644D-01
20.0000D-01	-10.6898D-01	12.9783D-01	20.0000D-01	30.6898D-01	70.2166D-02
-19.0000D-01	17.7299D-02	74.0613D-02	-19.0000D-01	-20.7730D-01	-26.4061D-01
13.0000D-01	18.4687D-01	10.7571D-01	13.0000D-01	-54.6874D-02	22.4286D-02
33.0000D-01	25.1381D-01	26.0425D-01	33.0000D-01	78.6186D-02	69.5749D-02

CUADRATIC ERROR OLD MODEL: 1649.8506D-01

CUADRATIC ERROR NEW MODEL: 2465.1292D-02

Table 4.12

I(T) : Net Investment in Period T

Sensitivity Experiment for 2SLS Structure

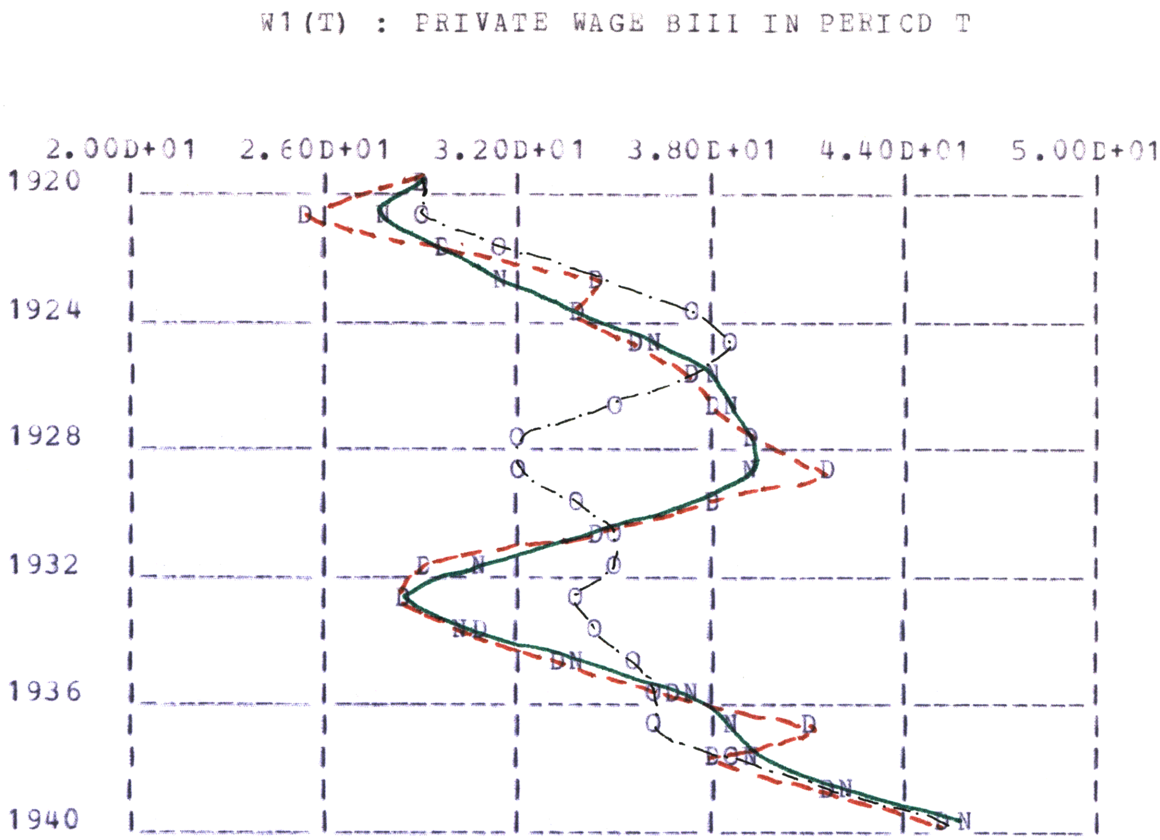


Figure 4.12

Wl(T) : Private Wage Bill in Period T

Sensitivity Experiment for 2SLS Structure

W1(T) : PRIVATE WAGE BILL IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
28.8000D+00	28.8000D+00	28.8000D+00	28.8000D+00	0.0	0.0
25.5000D+00	28.9987D+00	27.8315D+00	25.5000D+00	-34.9870D-01	-23.3155D-01
29.3000D+00	31.5713D+00	29.3684D+00	29.3000D+00	-22.7125D-01	-68.3574D-03
34.1000D+00	34.5533D+00	31.5944D+00	34.1000D+00	-45.3268D-02	25.0557D-01
33.9000D+00	37.2913D+00	33.6456D+00	33.9000D+00	-33.9133D-01	25.4383D-02
35.4000D+00	38.8235D+00	36.0651D+00	35.4000D+00	-34.2355D-01	-66.5131D-02
37.4000D+00	37.7511D+00	38.0148D+00	37.4000D+00	-35.1133D-02	-61.4840D-02
37.9000D+00	34.7247D+00	38.8622D+00	37.9000D+00	31.7532D-01	-96.2223D-02
39.2000D+00	32.0131D+00	39.2202D+00	39.2000D+00	71.8688D-01	-20.2217D-03
41.3000D+00	31.9034D+00	39.3664D+00	41.3000D+00	93.9665D-01	19.3365D-01
37.9000D+00	34.0087D+00	38.2135D+00	37.9000D+00	38.9126D-01	-31.3504D-02
34.5000D+00	35.2492D+00	34.5269D+00	34.5000D+00	-74.9222D-02	-26.9185D-03
29.0000D+00	35.1430D+00	30.6326D+00	29.0000D+00	-61.4298D-01	-16.3256D-01
28.5000D+00	33.8181D+00	28.4786D+00	28.5000D+00	-53.1813D-01	21.3876D-03
30.6000D+00	34.2837D+00	30.0557D+00	30.6000D+00	-36.8369D-01	54.4340D-02
33.2000D+00	35.6752D+00	33.6846D+00	33.2000D+00	-24.7522D-01	-48.4532D-02
36.8000D+00	36.2714D+00	37.2777D+00	36.8000D+00	52.8580D-02	-47.7742D-02
41.0000D+00	36.3735D+00	38.3562D+00	41.0000D+00	46.2653D-01	26.4384D-01
38.2000D+00	38.6097D+00	39.0908D+00	38.2000D+00	-40.9671D-02	-89.0847D-02
41.6000D+00	42.3722D+00	41.9990D+00	41.6000D+00	-77.2240D-02	-39.9049D-02
45.0000D+00	45.5157D+00	45.6949D+00	45.0000D+00	-51.5739D-02	-69.4918D-02

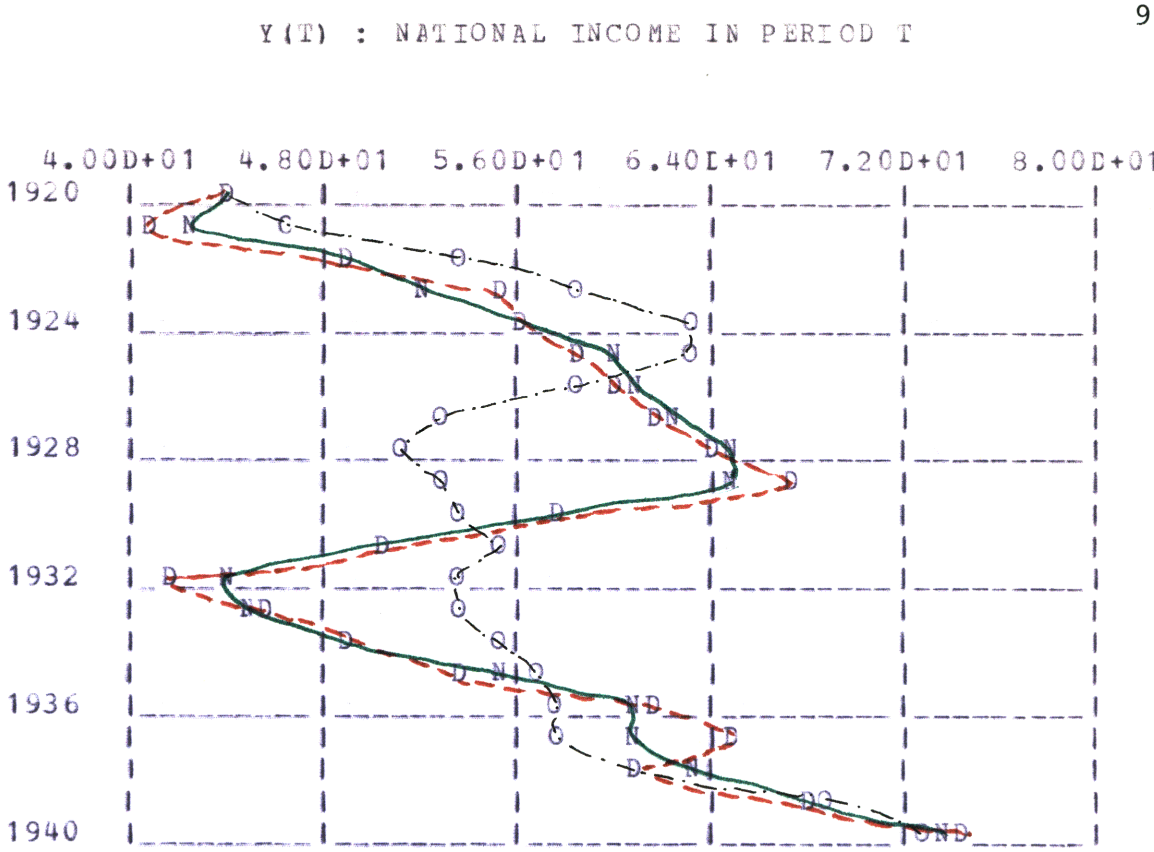
QUADRATIC ERROR OLD MODEL: 3151.1359D-01

QUADRATIC ERROR NEW MODEL: 2921.8805D-02

Table 4.13

W1(T) : Private Wage Bill in Period T

Sensitivity Experiment for 2SLS Structure



<u>Figure 4.13</u>

Y(T) : National Income in Period T

<u>Sensitivity Experiment for 2SLS Structure</u>

Y(T) : NATIONAL INCOME IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
43.7000D+00	43.7000D+00	43.7000D+00	43.7000D+00	0.0	0.0
40.6000D+00	46.0930D+00	42.7133D+00	40.6000D+00	-54.9302D-01	-21.1331D-01
49.1000D+00	53.3601D+00	48.8607D+00	49.1000D+00	-42.6013D-01	23.9348D-02
55.4000D+00	58.1478D+00	52.2041D+00	55.4000D+00	-27.4776D-01	31.9587D-01
56.4000D+00	63.1952D+00	56.3521D+00	56.4000D+00	-67.9522D-01	47.9185D-03
58.7000D+00	63.2862D+00	59.6490D+00	58.7000D+00	-45.8625D-01	-94.8982D-02
60.3000D+00	58.1294D+00	61.0979D+00	60.3000D+00	21.7062D-01	-79.7858D-02
61.3000D+00	52.5612D+00	62.3324D+00	61.3000D+00	87.3877D-01	-10.3235D-01
64.0000D+00	50.8496D+00	64.9757D+00	64.0000D+00	13.1504D+00	-97.5723D-02
67.0000D+00	52.6573D+00	64.9226D+00	67.0000D+00	14.3427D+00	20.7744D-01
57.7000D+00	53.4469D+00	57.9486D+00	57.7000D+00	42.5315D-01	-24.8595D-02
50.7000D+00	55.0622D+00	50.7402D+00	50.7000D+00	-43.6222D-01	-40.2029D-03
41.3000D+00	53.7906D+00	44.2317D+00	41.3000D+00	-12.4906D+00	-29.3168D-01
45.3000D+00	53.7964D+00	44.9362D+00	45.3000D+00	-84.9642D-01	36.3752D-02
48.9000D+00	55.0312D+00	48.6899D+00	48.9000D+00	-61.3120D-01	21.0070D-02
53.3000D+00	56.8379D+00	54.9998D+00	53.3000D+00	-35.3791D-01	-16.9984D-01
61.8000D+00	57.2308D+00	60.8710D+00	61.8000D+00	45.6923D-01	92.9018D-02
65.0000D+00	57.9531D+00	60.9454D+00	65.0000D+00	70.4689D-01	40.5458D-01
61.2000D+00	63.5298D+00	62.8622D+00	61.2000D+00	-23.2978D-01	-16.6223D-01
68.4000D+00	68.7550D+00	68.2199D+00	68.4000D+00	-35.4988D-02	18.0147D-02
74.1000D+00	72.7442D+00	73.7611D+00	74.1000D+00	13.5584D-01	33.8852D-02

QUADRATIC ERROR OLD MODEL: 9761.6474D-01

QUADRATIC ERROR NEW MODEL: 5454.6992D-02

<u>Table 4.14</u>

Y(T) : National Income in Period T

<u>Sensitivity Experiment for 2SLS Structure</u>

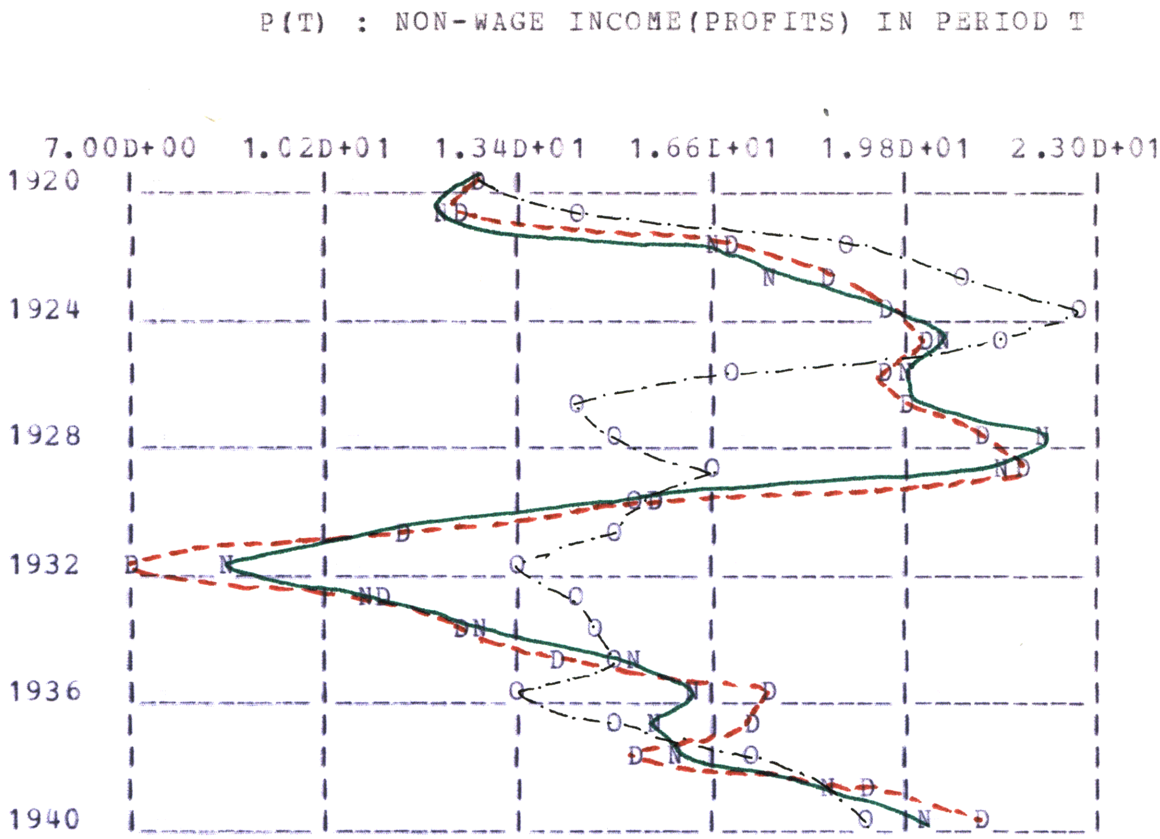


Figure 4.14

P(T) : Non-Wage Income(Profits) in Period T

Sensitivity Experiment for 2SLS Structure

P(T) : NON-WAGE INCOME(PROFITS) IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
12.7000D+00	12.7000D+00	12.7000D+00	12.7000D+00	0.0	0.0
12.4000D+00	14.3943D+00	12.2522D+00	12.4000D+00	-19.9432D-01	14.7791D-02
16.9000D+00	18.8889D+00	16.6021D+00	16.9000D+00	-19.8888D-01	29.7910D-02
18.4000D+00	20.6945D+00	17.5339D+00	18.4000D+00	-22.9449D-01	86.6142D-02
19.4000D+00	22.8039D+00	19.5488D+00	19.4000D+00	-34.0388D-01	-14.8813D-02
20.1000D+00	21.2627D+00	20.4434D+00	20.1000D+00	-11.6270D-01	-34.3394D-02
19.6000D+00	17.0783D+00	19.8585D+00	19.6000D+00	25.2175D-01	-25.8470D-02
19.8000D+00	14.2365D+00	19.9557D+00	19.8000D+00	55.6345D-01	-15.5675D-02
21.1000D+00	15.1364D+00	22.1122D+00	21.1000D+00	59.6355D-01	-10.1216D-01
21.7000D+00	16.7539D+00	21.4563D+00	21.7000D+00	49.4608D-01	24.3745D-02
15.6000D+00	15.2381D+00	15.4951D+00	15.6000D+00	36.1886D-02	10.4866D-02
11.4000D+00	15.0130D+00	11.3715D+00	11.4000D+00	-36.1300D-01	28.4519D-03
70.0000D-01	13.3476D+00	84.5294D-01	70.0000D-01	-63.4758D-01	-14.5294D-01
11.2000D+00	14.3783D+00	10.8627D+00	11.2000D+00	-31.7828D-01	33.7259D-02
12.3000D+00	14.7475D+00	12.6223D+00	12.3000D+00	-24.4750D-01	-32.2333D-02
14.0000D+00	15.0627D+00	15.3280D+00	14.0000D+00	-10.6269D-01	-13.2795D-01
17.6000D+00	13.5594D+00	16.1777D+00	17.6000D+00	40.4065D-01	14.2234D-01
17.3000D+00	14.8796D+00	15.6425D+00	17.3000D+00	24.2035D-01	16.5748D-01
15.3000D+00	17.2201D+00	16.0831D+00	15.3000D+00	-19.2011D-01	-78.3124D-02
19.0000D+00	18.5827D+00	18.4107D+00	19.0000D+00	41.7252D-02	58.9277D-02
21.1000D+00	19.2284D+00	20.0658D+00	21.1000D+00	18.7158D-01	10.3416D-01

QUADRATIC ERROR OLD MODEL: 2237.2111D-01

QUADRATIC ERROR NEW MODEL: 1308.0037D-02

Table 4.15

P(T) : Non-Wage Income(Profits) in Period T

Sensitivity Experiment for 2SLS Structure

K(T) : CAPITAL STOCK END OF PERIOD T

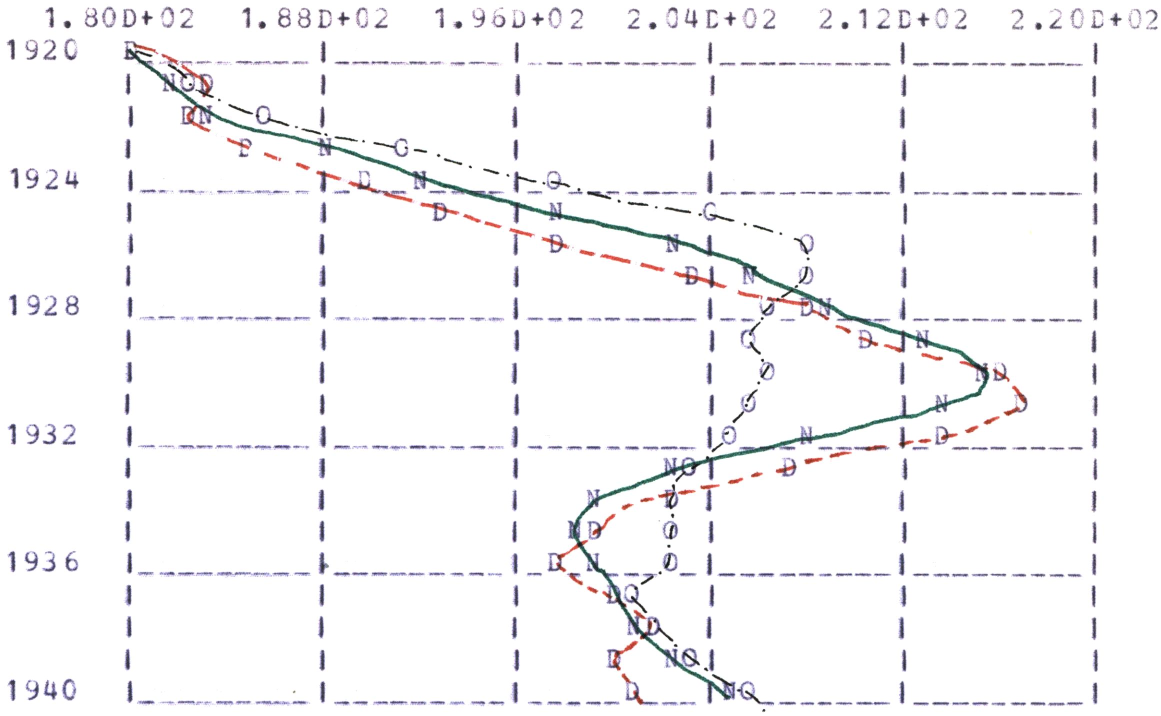


Figure 4.15

K(T) : Capital Stock End of Period T

Sensitivity Experiment for 2SLS Structure

K(T) : CAPITAL STOCK END OF PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
18.0100D+01	18.0100D+01	18.0100D+01	18.0100D+01	0.0	0.0
18.2800D+01	18.2125D+01	18.1979D+01	18.2800D+01	67.5280D-02	82.0580D-02
18.2600D+01	18.5275D+01	18.3528D+01	18.2600D+01	-26.7511D-01	-92.8345D-02
18.4500D+01	19.1101D+01	18.7865D+01	18.4500D+01	-66.0116D-01	-33.6532D-01
18.9700D+01	19.7324D+01	19.2245D+01	18.9700D+01	-76.2421D-01	-25.4484D-01
19.2700D+01	20.3838D+01	19.7328D+01	19.2700D+01	-11.1381D+00	-46.2752D-01
19.7800D+01	20.7907D+01	20.2125D+01	19.7800D+01	-10.1074D+00	-43.2466D-01
20.3400D+01	20.8222D+01	20.5715D+01	20.3400D+01	-48.2199D-01	-23.1490D-01
20.7600D+01	20.6593D+01	20.8911D+01	20.7600D+01	10.0697D-01	-13.1059D-01
21.0600D+01	20.5967D+01	21.3002D+01	21.0600D+01	46.3261D-01	-24.0179D-01
21.5700D+01	20.6455D+01	21.5546D+01	21.5700D+01	92.4450D-01	15.4112D-02
21.6700D+01	20.5805D+01	21.3286D+01	21.6700D+01	10.8951D+00	34.1364D-01
21.3300D+01	20.4997D+01	20.8380D+01	21.3300D+01	83.0321D-01	49.2034D-01
20.7100D+01	20.3252D+01	20.2463D+01	20.7100D+01	38.4824D-01	46.3736D-01
20.2000D+01	20.2535D+01	19.9321D+01	20.2000D+01	-53.4864D-02	26.7892D-01
19.9000D+01	20.2214D+01	19.8103D+01	19.9000D+01	-32.1420D-01	89.7026D-02
19.7700D+01	20.2062D+01	19.9007D+01	19.7700D+01	-43.6227D-01	-13.0654D-01
19.9800D+01	20.0993D+01	20.0304D+01	19.9800D+01	-11.9329D-01	-50.4373D-02
20.1800D+01	20.1171D+01	20.1045D+01	20.1800D+01	62.9412D-02	75.5013D-02
19.9900D+01	20.3017D+01	20.2121D+01	19.9900D+01	-31.1746D-01	-22.2070D-01
20.1200D+01	20.5531D+01	20.4725D+01	20.1200D+01	-43.3128D-01	-35.2495D-01

QUADRATIC ERROR OLD MODEL: 7291.2144D-01

QUADRATIC ERROR NEW MODEL: 1575.5952D-01

Table 4.16

K(T) : Capital Stock End of Period T

Sensitivity Experiment for 2SLS Structure

W2(T) : GOVERNMENTAL WAGE BILL IN PERIOD T

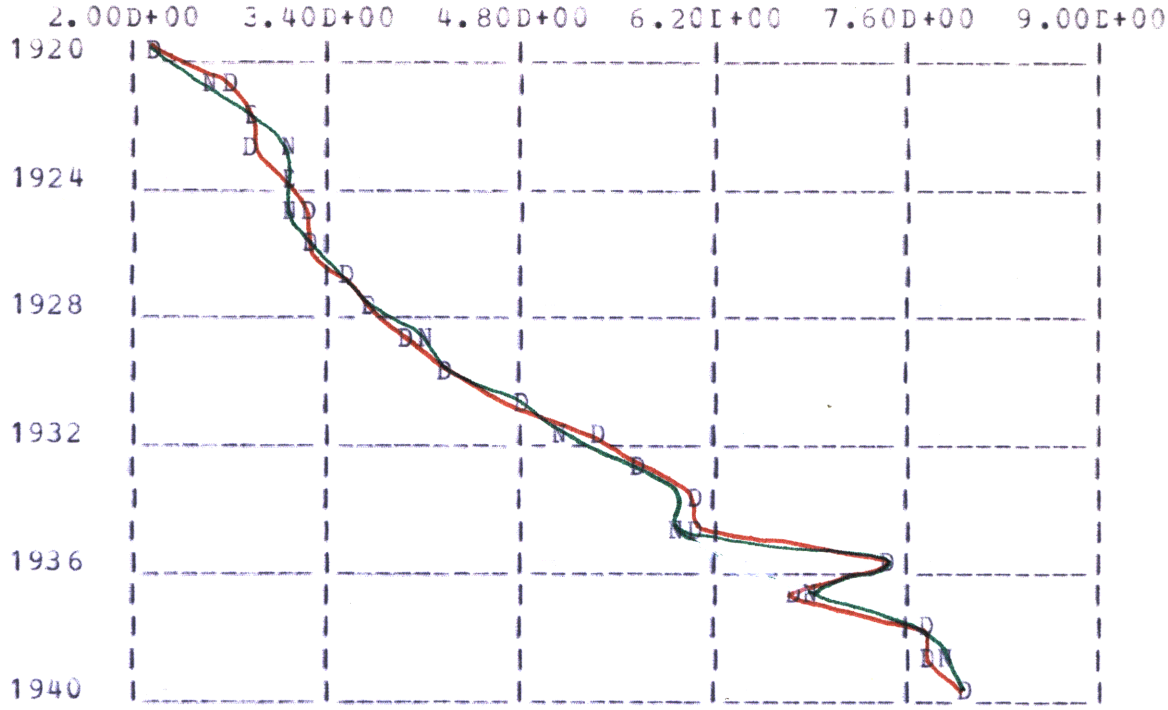


Figure 4.16

W2(T) : Governmental Wage Bill in Period T

Sensitivity Experiment for 2SLS Structure

W2(T) : GOVERNMENTAL WAGE BILL IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
22.0000D-01	22.0000D-01	22.0000D-01	22.0000D-01	0.0	0.0
27.0000D-01	27.0000D-01	26.2955D-01	27.0000D-01	0.0	70.4451D-03
29.0000D-01	29.0000D-01	28.9020D-01	29.0000D-01	0.0	97.9533D-04
29.0000D-01	29.0000D-01	30.7584D-01	29.0000D-01	0.0	-17.5838D-02
31.0000D-01	31.0000D-01	31.5765D-01	31.0000D-01	0.0	-57.6514D-03
32.0000D-01	32.0000D-01	31.4046D-01	32.0000D-01	0.0	59.5433D-03
33.0000D-01	33.0000D-01	32.2455D-01	33.0000D-01	0.0	75.4514D-03
36.0000D-01	36.0000D-01	35.1445D-01	36.0000D-01	0.0	85.5472D-03
37.0000D-01	37.0000D-01	36.4334D-01	37.0000D-01	0.0	56.6605D-03
40.0000D-01	40.0000D-01	40.9995D-01	40.0000D-01	0.0	-99.9466D-03
42.0000D-01	42.0000D-01	42.3996D-01	42.0000D-01	0.0	-39.9560D-03
48.0000D-01	48.0000D-01	48.4174D-01	48.0000D-01	0.0	-41.7363D-03
53.0000D-01	53.0000D-01	51.4617D-01	53.0000D-01	0.0	15.3828D-02
56.0000D-01	56.0000D-01	55.9489D-01	56.0000D-01	0.0	51.0584D-04
60.0000D-01	60.0000D-01	60.1194D-01	60.0000D-01	0.0	-11.9371D-03
61.0000D-01	61.0000D-01	59.8731D-01	61.0000D-01	0.0	11.2690D-02
74.0000D-01	74.0000D-01	74.1558D-01	74.0000D-01	0.0	-15.5779D-03
67.0000D-01	67.0000D-01	69.4674D-01	67.0000D-01	0.0	-24.6742D-02
77.0000D-01	77.0000D-01	76.8826D-01	77.0000D-01	0.0	11.7371D-03
78.0000D-01	78.0000D-01	78.1008D-01	78.0000D-01	0.0	-10.0812D-03
80.0000D-01	80.0000D-01	80.0039D-01	80.0000D-01	0.0	-39.1132D-05

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 1702.9047D-04

Table 4.17

W2(T) : Governmental Wage Bill in Period T

Sensitivity Experiment for 2SLS Structure

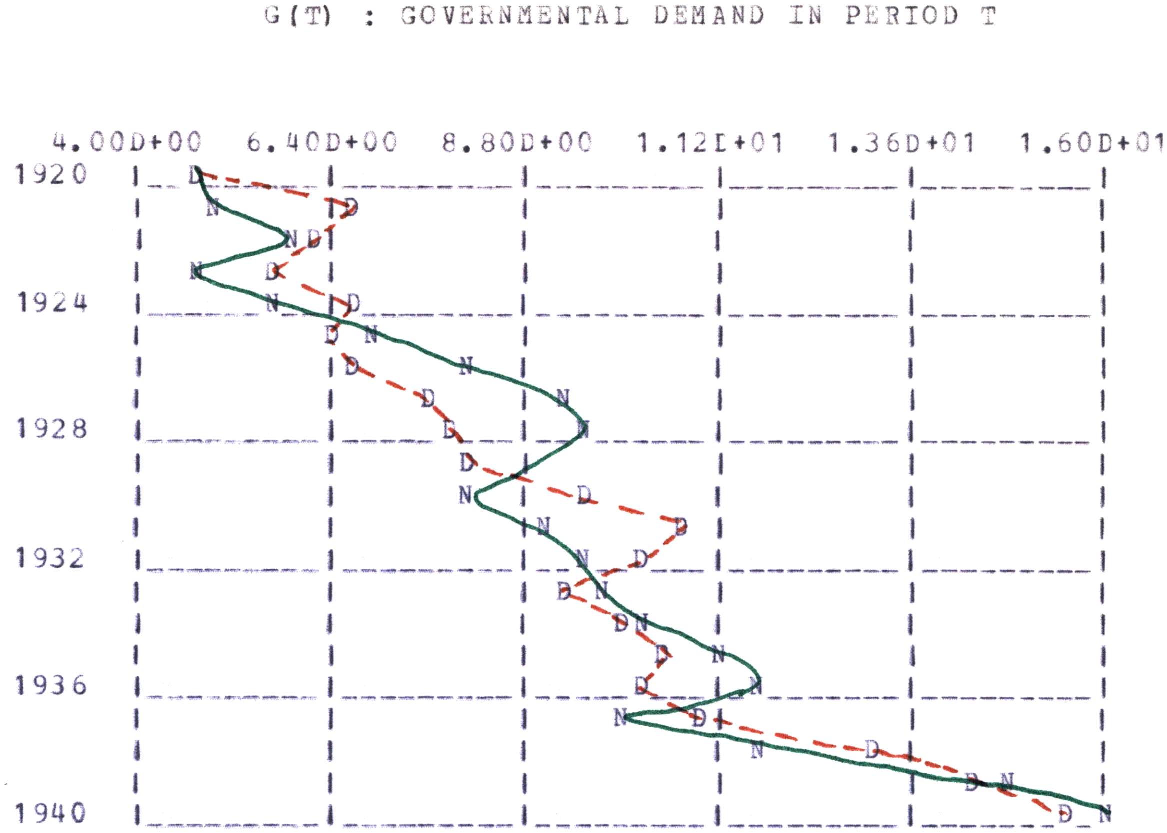


Figure 4.17

G(T) : Governmental Demand in Period T

Sensitivity Experiment for 2SLS Structure

G(T) : GOVERNMENTAL DEMAND IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
46.0000D-01	46.0000D-01	46.0000D-01	46.0000D-01	0.0	0.0
66.0000D-01	66.0000D-01	49.3419D-01	66.0000D-01	0.0	16.6581D-01
61.0000D-01	61.0000D-01	58.4175D-01	61.0000D-01	0.0	25.8249D-02
57.0000D-01	57.0000D-01	47.5875D-01	57.0000D-01	0.0	94.1249D-02
66.0000D-01	66.0000D-01	55.8877D-01	66.0000D-01	0.0	10.1123D-01
65.0000D-01	65.0000D-01	68.8957D-01	65.0000D-01	0.0	-38.9568D-02
66.0000D-01	66.0000D-01	79.9798D-01	66.0000D-01	0.0	-13.9798D-01
76.0000D-01	76.0000D-01	92.7455D-01	76.0000D-01	0.0	-16.7455D-01
79.0000D-01	79.0000D-01	95.1127D-01	79.0000D-01	0.0	-16.1127D-01
81.0000D-01	81.0000D-01	81.5974D-01	81.0000D-01	0.0	-59.7410D-03
94.0000D-01	94.0000D-01	79.9804D-01	94.0000D-01	0.0	14.0196D-01
10.7000D+00	10.7000D+00	91.1224D-01	10.7000D+00	0.0	15.8776D-01
10.2000D+00	10.2000D+00	94.9072D-01	10.2000D+00	0.0	70.9283D-02
93.0000D-01	93.0000D-01	98.6141D-01	93.0000D-01	0.0	-56.1405D-02
10.0000D+00	10.0000D+00	10.1793D+00	10.0000D+00	0.0	-17.9290D-02
10.5000D+00	10.5000D+00	11.2973D+00	10.5000D+00	0.0	-79.7274D-02
10.3000D+00	10.3000D+00	11.6252D+00	10.3000D+00	0.0	-13.2516D-01
11.0000D+00	11.0000D+00	99.5312D-01	11.0000D+00	0.0	10.4688D-01
13.0000D+00	13.0000D+00	11.6605D+00	13.0000D+00	0.0	13.3950D-01
14.4000D+00	14.4000D+00	14.8973D+00	14.4000D+00	0.0	-49.7275D-02
15.4000D+00	15.4000D+00	15.9319D+00	15.4000D+00	0.0	-53.1916D-02

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 2340.9152D-02

Table 4.18

G(T) : Governmental Demand in Period T

Sensitivity Experiment for 2SLS Structure

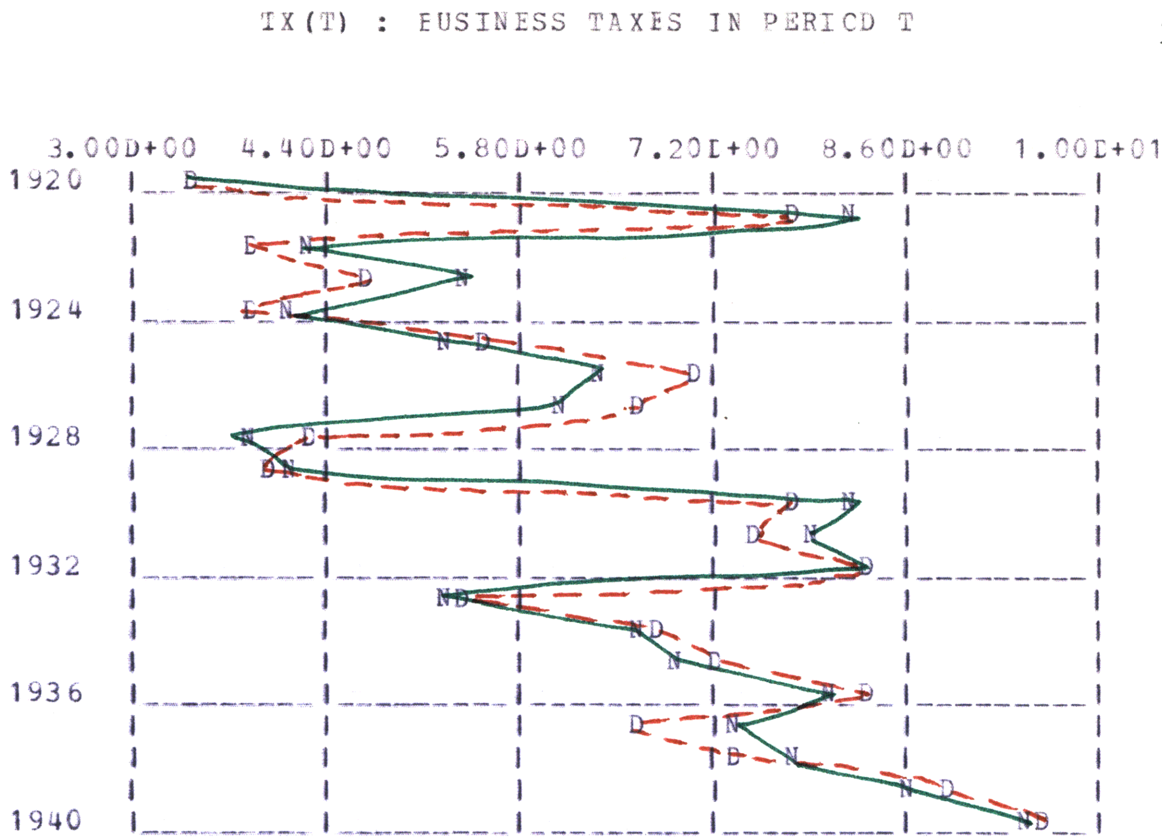


Figure 4.18

TX(T) : Business Taxes in Period T

Sensitivity Experiment for 2SLS Structure

TX(T) : BUSINESS TAXES IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
34.0000D-01	34.0000D-01	34.0000D-01	34.0000D-01	0.0	0.0
77.0000D-01	77.0000D-01	81.1678D-01	77.0000D-01	0.0	-41.6780D-02
39.0000D-01	39.0000D-01	42.2122D-01	39.0000D-01	0.0	-32.1224D-02
47.0000D-01	47.0000D-01	53.4705D-01	47.0000D-01	0.0	-64.7047D-02
38.0000D-01	38.0000D-01	41.0805D-01	38.0000D-01	0.0	-30.8048D-02
55.0000D-01	55.0000D-01	51.8392D-01	55.0000D-01	0.0	31.6083D-02
70.0000D-01	70.0000D-01	63.4734D-01	70.0000D-01	0.0	65.2656D-02
67.0000D-01	67.0000D-01	60.3000D-01	67.0000D-01	0.0	67.0000D-02
42.0000D-01	42.0000D-01	37.7831D-01	42.0000D-01	0.0	42.1690D-02
40.0000D-01	40.0000D-01	41.8847D-01	40.0000D-01	0.0	-18.8472D-02
77.0000D-01	77.0000D-01	81.4537D-01	77.0000D-01	0.0	-44.5367D-02
75.0000D-01	75.0000D-01	78.8373D-01	75.0000D-01	0.0	-38.3733D-02
83.0000D-01	83.0000D-01	83.0334D-01	83.0000D-01	0.0	-33.3960D-04
54.0000D-01	54.0000D-01	52.1823D-01	54.0000D-01	0.0	18.1767D-02
68.0000D-01	68.0000D-01	67.0807D-01	68.0000D-01	0.0	91.9279D-03
72.0000D-01	72.0000D-01	68.6844D-01	72.0000D-01	0.0	33.1558D-02
83.0000D-01	83.0000D-01	80.8726D-01	83.0000D-01	0.0	21.2741D-02
67.0000D-01	67.0000D-01	73.4538D-01	67.0000D-01	0.0	-64.5377D-02
74.0000D-01	74.0000D-01	77.3496D-01	74.0000D-01	0.0	-33.4965D-02
89.0000D-01	89.0000D-01	86.6355D-01	89.0000D-01	0.0	23.6453D-02
96.0000D-01	96.0000D-01	93.7630D-01	96.0000D-01	0.0	22.3703D-02

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 3155.5258D-03

Table 4.19

TX(T) : Business Taxes in Period T

Sensitivity Experiment for 2SLS Structure

4.3.3 Full Information Maximum Likelihood (FIML)

For this run, the "old" model was obtained by applying the full-information-maximum-likelihood estimation procedure to Klein's original structure. The properties of this method were already discussed in Chapter 3. Among these properties, we discussed the property of FIML to perform badly when sample size is small or alieu there is a misspecification error. This run seems to be the case in which FIML performs badly, even worst than OLS. We observe that the oscilations of most of the variables are bigger than of the other estimation procedures and this explains the big quadratic errors obtained for this method.

The results for this run are shown numerically and graphically on Tables 4.38 to 4.55 and on Figures 4.37 to 4.54. The symbols used to plot the different variables are the same as with other runs.

Eventhough, the "old" model exhibits the worst performance for all the estimation procedures, the new structure performs very well and in most of the variables better than any other procedure or structure. This could be due to the fact that FIML for small samples performs badly in reproducing the historical values. But the statistical accuracy of this method is better than other procedures, and hence the new structure, that utilizes the statistical information containaed in the original model, is going to improve it's performance referred to other structures. The last affirmation could be corrroborated by looking at the "t" statistics of the different coefficients for FIML. (see Table 3, in Chapter 3). We observe that the "t" statistics for FIML are higher than for any other estimation procedures.

Observing the diagrams corresponding to the optimal "policy" variables we note that the difference with the historical values is not that big as for other procedures, this means that a smaller correction, than for other models, is needed and therefore the new model behaves better than the other structures.

C(T) : CONSUMPTION IN PERIOD T

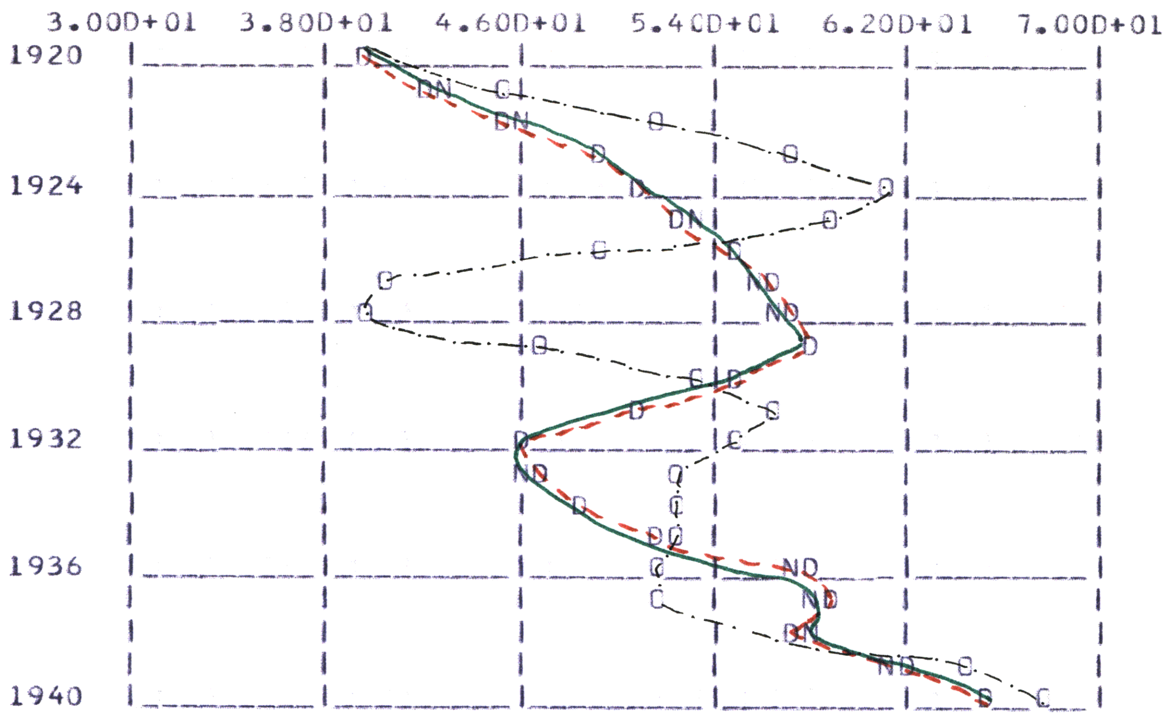


Figure 4.19

C(T) : Consumption in Period T

Sensitivity Experiment for FIML Structure

C(T) : CONSUMPTION IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
39.8000D+00	39.8000D+00	39.8000D+00	39.8000D+00	0.0	0.0
41.9000D+00	44.9269D+00	42.6304D+00	41.9000D+00	-30.2687D-01	-73.0445D-02
45.0000D+00	51.6939D+00	46.1446D+00	45.0000D+00	-66.9391D-01	-11.4462D-01
49.2000D+00	57.0552D+00	48.8782D+00	49.2000D+00	-78.5516D-01	32.1784D-02
50.6000D+00	61.0707D+00	50.6995D+00	50.6000D+00	-10.4707D+00	-99.5192D-03
52.6000D+00	58.7950D+00	52.8382D+00	52.6000D+00	-61.9495D-01	-23.8187D-02
55.1000D+00	49.4228D+00	54.4985D+00	55.1000D+00	56.7718D-01	60.1460D-02
56.2000D+00	40.3758D+00	55.2950D+00	56.2000D+00	15.8242D+00	90.4951D-02
57.3000D+00	39.7592D+00	56.5039D+00	57.3000D+00	17.5408D+00	79.6118D-02
57.8000D+00	46.9893D+00	57.9494D+00	57.8000D+00	10.8107D+00	-14.9435D-02
55.0000D+00	52.8552D+00	55.0350D+00	55.0000D+00	21.4484D-01	-34.9982D-03
50.9000D+00	56.2664D+00	51.0825D+00	50.9000D+00	-53.6640D-01	-18.2497D-02
45.6000D+00	54.5418D+00	46.3728D+00	45.6000D+00	-89.4184D-01	-77.2760D-02
46.5000D+00	52.7835D+00	46.2604D+00	46.5000D+00	-62.8347D-01	23.9645D-02
48.7000D+00	52.4614D+00	48.3122D+00	48.7000D+00	-37.6140D-01	38.7798D-02
51.3000D+00	52.7900D+00	51.7209D+00	51.3000D+00	-14.8999D-01	-42.0919D-02
57.7000D+00	51.5738D+00	56.8209D+00	57.7000D+00	61.2619D-01	87.9082D-02
58.7000D+00	51.6603D+00	57.7290D+00	58.7000D+00	70.3971D-01	97.1041D-02
57.5000D+00	57.9482D+00	57.7699D+00	57.5000D+00	-44.8222D-02	-26.9864D-02
61.6000D+00	64.2895D+00	60.8915D+00	61.6000D+00	-26.8947D-01	70.8474D-02
65.0000D+00	67.9329D+00	64.9682D+00	65.0000D+00	-29.3287D-01	31.7784D-03

QUADRATIC ERROR OLD MODEL: 1243.2019D+00

QUADRATIC ERROR NEW MODEL: 7158.8727D-03

Table 4.20

C(T) : Consumption in Period T

Sensitivity Experiment for FIML Structure

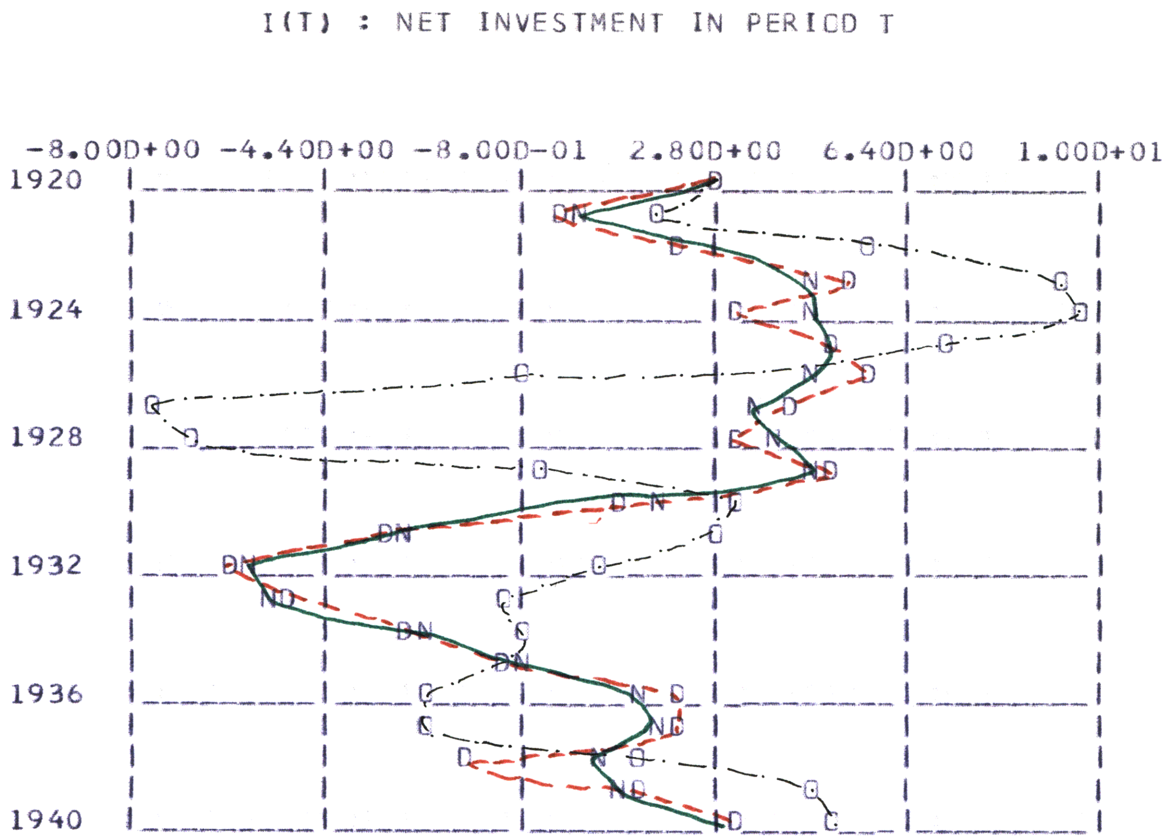


Figure 4.20

I(T) : Net Investment in Period T

Sensitivity Experiment for FIML Structure

I(T) : NET INVESTMENT IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
27.0000D-01	27.0000D-01	27.0000D-01	27.0000D-01	0.0	0.0
-20.0000D-02	16.8433D-01	41.4230D-02	-20.0000D-02	-18.8433D-01	-61.4230D-02
19.0000D-01	55.1603D-01	20.3588D-01	19.0000D-01	-36.1603D-01	-13.5877D-02
52.0000D-01	92.4644D-01	44.9621D-01	52.0000D-01	-40.4644D-01	70.3794D-02
30.0000D-01	98.1996D-01	45.2516D-01	30.0000D-01	-68.1996D-01	-15.2516D-01
51.0000D-01	69.7135D-01	48.3533D-01	51.0000D-01	-18.7135D-01	26.4674D-02
56.0000D-01	-96.3264D-02	46.1362D-01	56.0000D-01	65.6326D-01	98.6381D-02
42.0000D-01	-77.6247D-01	36.5782D-01	42.0000D-01	11.9625D+00	54.2178D-02
30.0000D-01	-68.9667D-01	38.7704D-01	30.0000D-01	98.9667D-01	-87.7036D-02
51.0000D-01	-33.0584D-02	46.9908D-01	51.0000D-01	54.3058D-01	40.0925D-02
10.0000D-01	31.7362D-01	17.4522D-01	10.0000D-01	-21.7362D-01	-74.5217D-02
-34.0000D-01	27.3721D-01	-29.3624D-01	-34.0000D-01	-61.3721D-01	-46.3764D-02
-62.0000D-01	58.9480D-02	-58.5237D-01	-62.0000D-01	-67.8948D-01	-34.7630D-02
-51.0000D-01	-11.8604D-01	-53.8712D-01	-51.0000D-01	-39.1396D-01	28.7125D-02
-30.0000D-01	-87.4728D-02	-26.8119D-01	-30.0000D-01	-21.2527D-01	-31.8807D-02
-13.0000D-01	-10.3549D-01	-92.9274D-02	-13.0000D-01	-26.4511D-02	-37.0726D-02
21.0000D-01	-25.6058D-01	12.1525D-01	21.0000D-01	46.6058D-01	88.4751D-02
20.0000D-01	-26.7771D-01	17.4417D-01	20.0000D-01	46.7771D-01	25.5827D-02
-19.0000D-01	12.2764D-01	50.6799D-02	-19.0000D-01	-31.2764D-01	-24.0680D-01
13.0000D-01	45.8190D-01	11.4852D-01	13.0000D-01	-32.8190D-01	15.1478D-02
33.0000D-01	51.3746D-01	31.9888D-01	33.0000D-01	-18.3746D-01	10.1121D-02

QUADRATIC ERROR OLD MODEL: 5725.5044D-01

QUADRATIC ERROR NEW MODEL: 1337.0944D-02

Table 4.21

I(T) : Net Investment in Period T

Sensitivity Experiment for FIML Structure

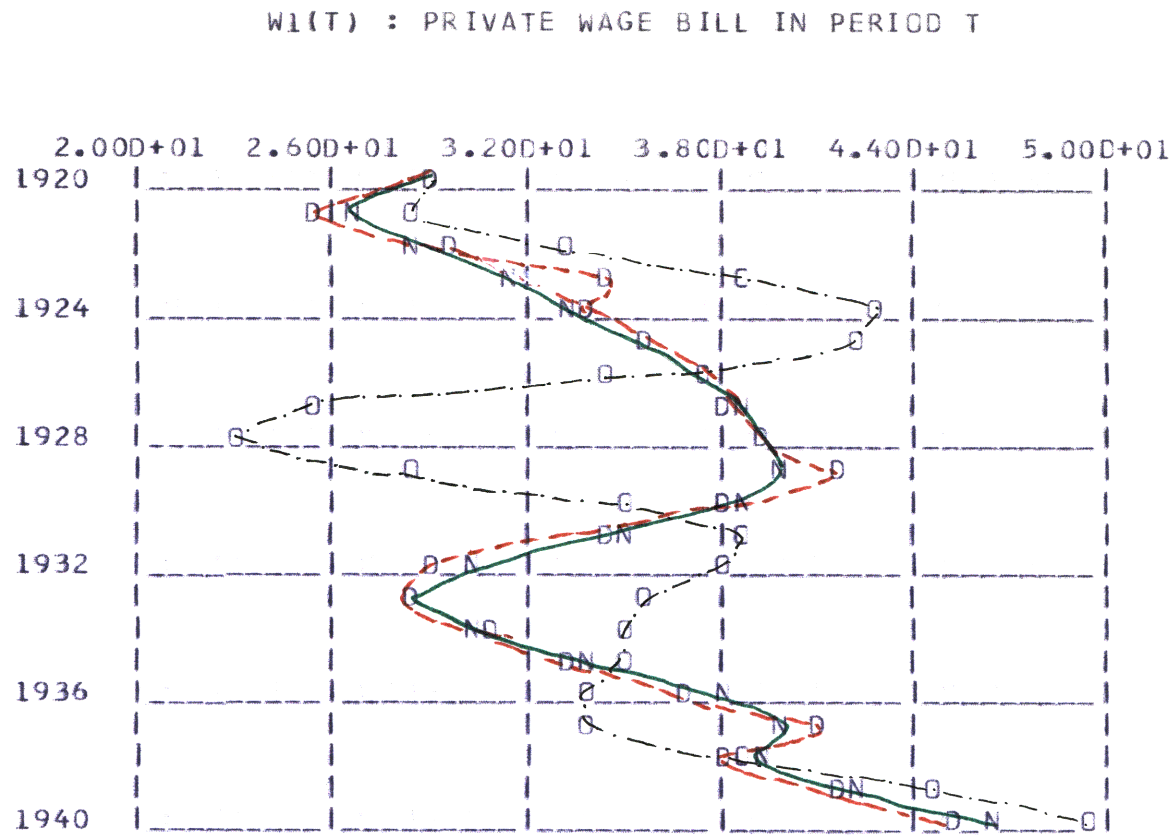


Figure 4.21

Wl(T) : Private Wage Bill in Period T

Sensitivity Experiment for FIML Structure

W1(T) : PRIVATE WAGE BILL IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
28.8000D+00	28.8000D+00	28.8000D+00	28.8000D+00	0.0	0.0
25.5000D+00	28.2626D+00	26.5757D+00	25.5000D+00	-27.6258D-01	-10.7567D-01
29.3000D+00	33.2797D+00	28.6490D+00	29.3000D+00	-39.7975D-01	65.1020D-02
34.1000D+00	38.7400D+00	31.3956D+00	34.1000D+00	-46.3995D-01	27.0437D-01
33.9000D+00	42.6889D+00	33.1488D+00	33.9000D+00	-87.8886D-01	75.1225D-02
35.4000D+00	41.9989D+00	35.3570D+00	35.4000D+00	-65.9893D-01	43.0043D-03
37.4000D+00	34.6657D+00	37.5095D+00	37.4000D+00	27.3429D-01	-10.9462D-02
37.9000D+00	25.6449D+00	38.3823D+00	37.9000D+00	12.2551D+00	-48.2277D-02
39.2000D+00	22.8509D+00	38.9011D+00	39.2000D+00	16.3491D+00	29.8905D-02
41.3000D+00	28.2032D+00	39.9333D+00	41.3000D+00	13.0968D+00	13.6668D-01
37.9000D+00	35.1108D+00	38.7321D+00	37.9000D+00	27.8916D-01	-83.2149D-02
34.5000D+00	38.8309D+00	34.9831D+00	34.5000D+00	-43.3092D-01	-48.3086D-02
29.0000D+00	37.9733D+00	30.4550D+00	29.0000D+00	-89.7331D-01	-14.5499D-01
28.5000D+00	35.3922D+00	28.6674D+00	28.5000D+00	-68.9224D-01	-16.7377D-02
30.6000D+00	34.7010D+00	30.2510D+00	30.6000D+00	-41.0099D-01	34.9034D-02
33.2000D+00	35.1560D+00	33.5590D+00	33.2000D+00	-19.5597D-01	-35.8997D-02
36.8000D+00	33.8870D+00	37.7336D+00	36.8000D+00	29.1298D-01	-93.3638D-02
41.0000D+00	33.6982D+00	39.5483D+00	41.0000D+00	73.0176D-01	14.5171D-01
38.2000D+00	38.3143D+00	39.3898D+00	38.2000D+00	-11.4259D-02	-11.8977D-01
41.6000D+00	44.8969D+00	42.0047D+00	41.6000D+00	-32.9685D-01	-40.4663D-02
45.0000D+00	49.2166D+00	46.1702D+00	45.0000D+00	-42.1664D-01	-11.7019D-01

QUADRATIC ERROR OLD MODEL: 1027.9370D+00

QUADRATIC ERROR NEW MODEL: 2091.1807D-02

Table 4.22

W1(T) : Private Wage Bill in Period T

Sensitivity Experiment for FIML Structure

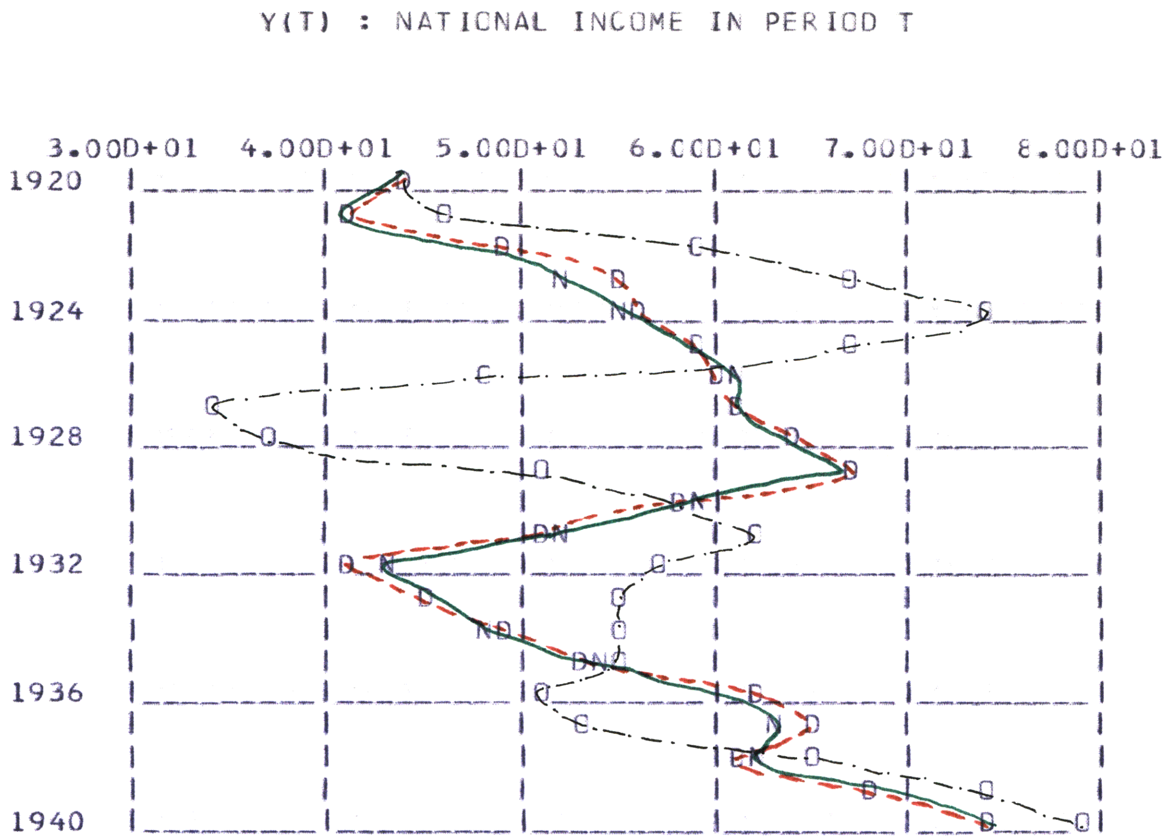


Figure 4.22

Y(T) : National Income in Period T

Sensitivity Experiment for FIML Structure

Y(T) : NATIONAL INCOME IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
43.7000D+00	43.7000D+00	43.7000D+00	43.7000D+00	0.0	0.0
40.6000D+00	45.5112D+00	40.5211D+00	40.6000D+00	-49.1121D-01	78.8620D-03
49.1000D+00	59.4099D+00	48.7967D+00	49.1000D+00	-10.3099D+00	30.3250D-02
55.4000D+00	67.3016D+00	52.4082D+00	55.4000D+00	-11.9016D+00	29.9183D-01
56.4000D+00	73.6907D+00	55.2835D+00	56.4000D+00	-17.2907D+00	11.1645D-01
58.7000D+00	66.7663D+00	58.8560D+00	58.7000D+00	-80.6630D-01	-15.6045D-02
60.3000D+00	48.0596D+00	60.6734D+00	60.3000D+00	12.2404D+00	-37.3428D-02
61.3000D+00	33.5133D+00	61.4538D+00	61.3000D+00	27.7867D+00	-15.3823D-02
64.0000D+00	36.5626D+00	64.4764D+00	64.0000D+00	27.4374D+00	-47.6440D-02
67.0000D+00	50.7587D+00	66.8240D+00	67.0000D+00	16.2413D+00	17.6013D-02
57.7000D+00	57.7288D+00	58.6477D+00	57.7000D+00	-28.7771D-03	-94.7740D-02
50.7000D+00	62.2036D+00	51.5491D+00	50.7000D+00	-11.5036D+00	-84.9116D-02
41.3000D+00	57.0313D+00	42.9869D+00	41.3000D+00	-15.7313D+00	-16.8687D-01
45.3000D+00	55.4974D+00	45.4888D+00	45.3000D+00	-10.1974D+00	-18.8837D-02
48.9000D+00	54.7867D+00	48.4717D+00	48.9000D+00	-58.8667D-01	42.8298D-02
53.3000D+00	55.0545D+00	54.4057D+00	53.3000D+00	-17.5450D-01	-11.0570D-01
61.8000D+00	51.0132D+00	62.3050D+00	61.8000D+00	10.7868D+00	-50.5027D-02
65.0000D+00	53.2826D+00	62.8337D+00	65.0000D+00	11.7174D+00	21.6630D-01
61.2000D+00	64.7759D+00	61.8671D+00	61.2000D+00	-35.7586D-01	-66.7083D-02
68.4000D+00	74.3714D+00	68.2575D+00	68.4000D+00	-59.7137D-01	14.2540D-02
74.1000D+00	78.8703D+00	74.3621D+00	74.1000D+00	-47.7033D-01	-26.2071D-02

QUADRATIC ERROR OLD MODEL: 3420.9959D+00

QUADRATIC ERROR NEW MODEL: 2212.9485D-02

Table 4.23

Y(T) : National Income in Period T

Sensitivity Experiment for FIML Structure

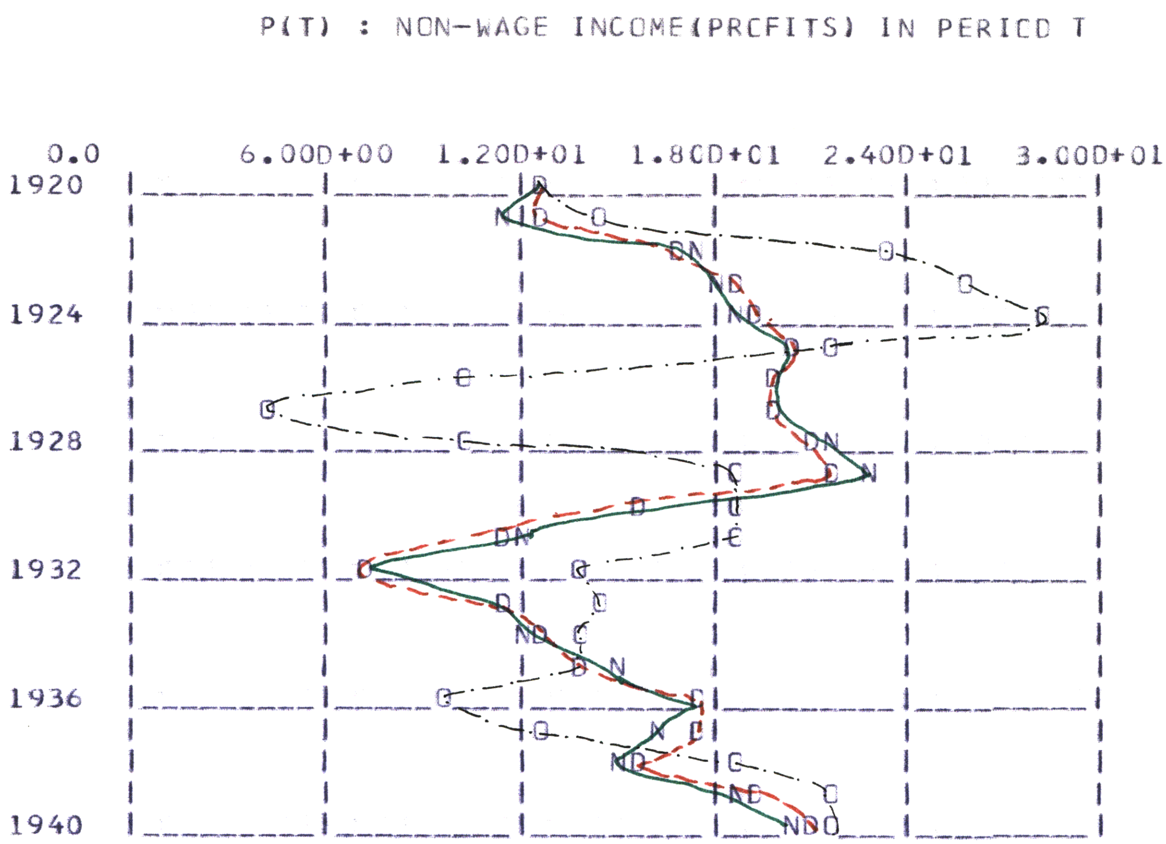


Figure 4.23

P(T) : Non-Wage Income(Profits) in Period T

Sensitivity Experiment for FIML Structure

P(T) : NON-WAGE INCOME(PROFITS) IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
12.7000D+00	12.7000D+00	12.7000D+00	12.7000D+00	0.0	0.0
12.4000D+00	14.5486D+00	11.2123D+00	12.4000D+00	-21.4863D-01	11.8774D-01
16.9000D+00	23.2302D+00	17.2284D+00	16.9000D+00	-63.3020D-01	-32.8441D-02
18.4000D+00	25.6616D+00	17.9367D+00	18.4000D+00	-72.6165D-01	46.3285D-02
19.4000D+00	27.9018D+00	18.8812D+00	19.4000D+00	-85.0183D-01	51.8777D-02
20.1000D+00	21.5674D+00	20.3199D+00	20.1000D+00	-14.6738D-01	-21.9950D-02
19.6000D+00	10.0939D+00	19.9407D+00	19.6000D+00	95.0615D-01	-34.0700D-02
19.8000D+00	42.6838D-01	19.5150D+00	19.8000D+00	15.5316D+00	28.5038D-02
21.1000D+00	10.0116D+00	21.8788D+00	21.1000D+00	11.0884D+00	-77.8848D-02
21.7000D+00	18.5555D+00	22.8947D+00	21.7000D+00	31.4449D-01	-11.9468D-01
15.6000D+00	18.4179D+00	15.7455D+00	15.6000D+00	-28.1794D-01	-14.5477D-02
11.4000D+00	18.5727D+00	11.7989D+00	11.4000D+00	-71.7269D-01	-39.8912D-02
70.0000D-01	13.7580D+00	73.3229D-01	70.0000D-01	-67.5801D-01	-33.2292D-02
11.2000D+00	14.5052D+00	11.2503D+00	11.2000D+00	-33.0519D-01	-50.2997D-03
12.3000D+00	14.0857D+00	12.1726D+00	12.3000D+00	-17.8568D-01	12.7395D-02
14.0000D+00	13.7985D+00	14.8053D+00	14.0000D+00	20.1475D-02	-80.5285D-02
17.6000D+00	97.2622D-01	17.2593D+00	17.6000D+00	78.7378D-01	34.0672D-02
17.3000D+00	12.8843D+00	16.4411D+00	17.3000D+00	44.1566D-01	85.8870D-02
15.3000D+00	18.7616D+00	14.7074D+00	15.3000D+00	-34.6160D-01	59.2610D-02
19.0000D+00	21.6745D+00	18.4486D+00	19.0000D+00	-26.7452D-01	55.1382D-02
21.1000D+00	21.6537D+00	20.2133D+00	21.1000D+00	-55.3691D-02	88.6666D-02

QUADRATIC ERROR OLD MODEL: 8564.4096D-01

QUADRATIC ERROR NEW MODEL: 7534.9774D-03

Table 4.24

P(T) : Non-Wage Income(Profits) in Period T

Sensitivity Experiment for FIML Structure

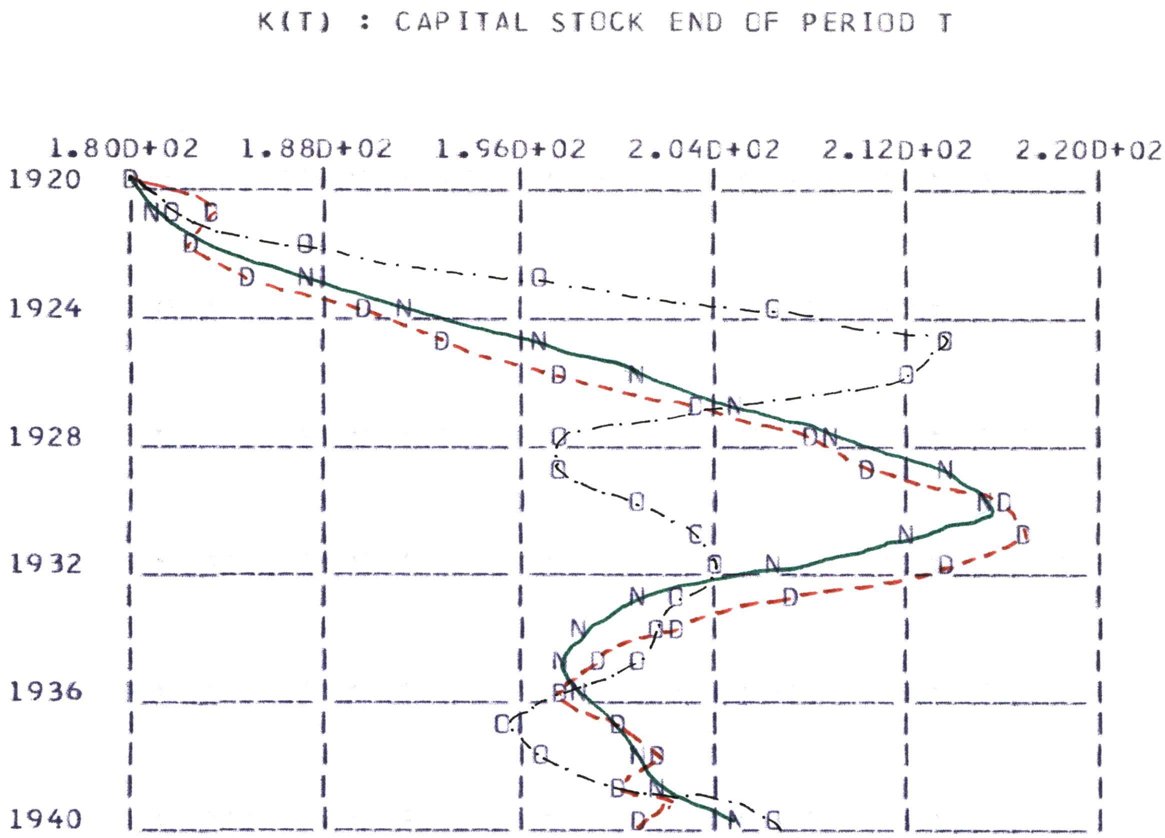


Figure 4.24

K(T) : Capital Stock End of Period T

Sensitivity Experiment for FIML Structure

K(T) : CAPITAL STOCK END OF PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
18.0100D+01	18.0100D+01	18.0100D+01	18.0100D+01	0.0	0.0
18.2800D+01	18.1784D+01	18.0514D+01	18.2800D+01	10.1567D-01	22.8577D-01
18.2600D+01	18.7300D+01	18.2550D+01	18.2600D+01	-47.0037D-01	49.8924D-03
18.4500D+01	19.6547D+01	18.7046D+01	18.4500D+01	-12.0468D+00	-25.4631D-01
18.9700D+01	20.6367D+01	19.1571D+01	18.9700D+01	-16.6668D+00	-18.7147D-01
19.2700D+01	21.3338D+01	19.6407D+01	19.2700D+01	-20.6381D+00	-37.0680D-01
19.7800D+01	21.2375D+01	20.1020D+01	19.7800D+01	-14.5749D+00	-32.2042D-01
20.3400D+01	20.4612D+01	20.4678D+01	20.3400D+01	-12.1239D-01	-12.7824D-01
20.7600D+01	19.7716D+01	20.8555D+01	20.7600D+01	98.8429D-01	-95.5278D-02
21.0600D+01	19.7385D+01	21.3254D+01	21.0600D+01	13.2149D+00	-26.5435D-01
21.5700D+01	20.0559D+01	21.5000D+01	21.5700D+01	15.1413D+00	70.0430D-02
21.6700D+01	20.3296D+01	21.2063D+01	21.6700D+01	13.4040D+00	46.3667D-01
21.3300D+01	20.3885D+01	20.6211D+01	21.3300D+01	94.1456D-01	70.8904D-01
20.7100D+01	20.2699D+01	20.0824D+01	20.7100D+01	44.0060D-01	62.7616D-01
20.2000D+01	20.1825D+01	19.8143D+01	20.2000D+01	17.5332D-02	38.5735D-01
19.9000D+01	20.0789D+01	19.7213D+01	19.9000D+01	-17.8918D-01	17.8663D-01
19.7700D+01	19.8229D+01	19.8429D+01	19.7700D+01	-52.8599D-02	-72.8622D-02
19.9800D+01	19.5551D+01	20.0173D+01	19.9800D+01	42.4911D-01	-37.2795D-02
20.1800D+01	19.6779D+01	20.0680D+01	20.1800D+01	50.2147D-01	11.2041D-01
19.9900D+01	20.1360D+01	20.1828D+01	19.9900D+01	-14.6043D-01	-19.2812D-01
20.1200D+01	20.6498D+01	20.5027D+01	20.1200D+01	-52.9789D-01	-38.2700D-01

QUADRATIC ERROR OLD MODEL: 1952.0993D+00

QUADRATIC ERROR NEW MODEL: 1989.1067D-01

<u>Table 4.25</u>

K(T) : Capital Stock End of Period T

<u>Sensitivity Experiment for FIML Structure</u>

W2(T) : GOVERNMENTAL WAGE BILL IN PERIOD T

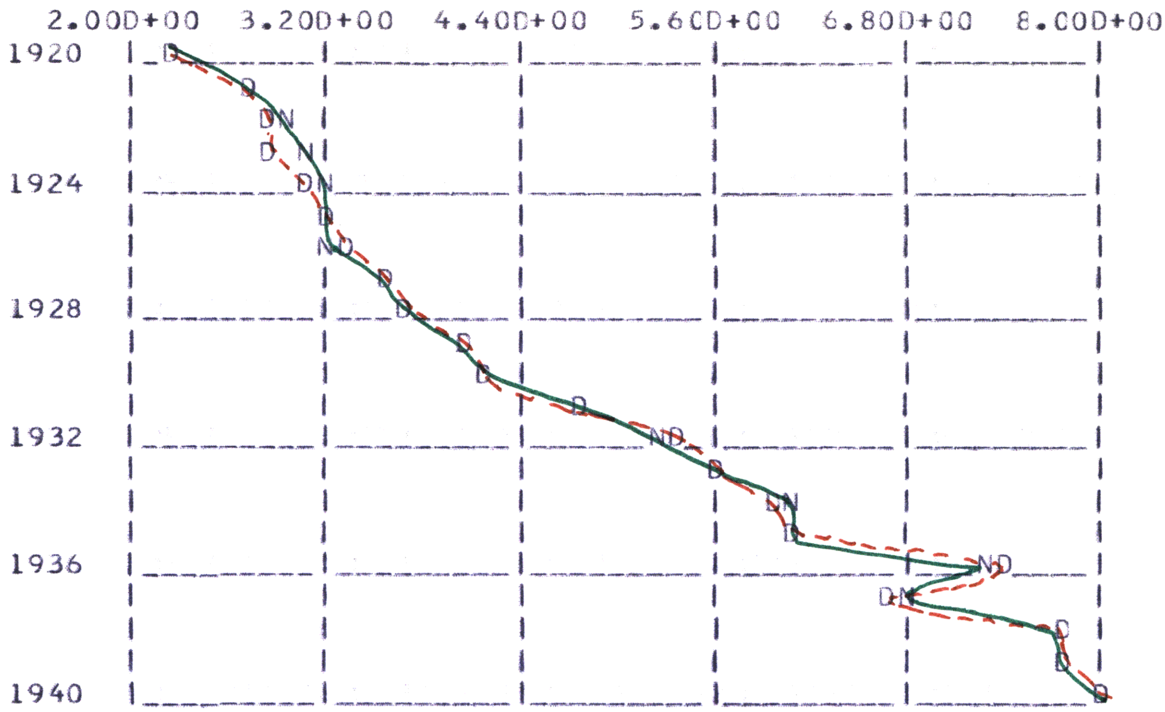


Figure 4.25

W2(T) : Governmental Wage Bill in Period T

Sensitivity Experiment for FIML Structure

W2(T) : GOVERNMENTAL WAGE BILL IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
22.0000D-01	22.0000D-01	22.0000D-01	22.0000D-01	0.0	0.0
27.0000D-01	27.0000D-01	27.3321D-01	27.0000D-01	0.0	-33.2071D-03
29.0000D-01	29.0000D-01	29.1933D-01	29.0000D-01	0.0	-19.3287D-03
29.0000D-01	29.0000D-01	30.7582D-01	29.0000D-01	0.0	-17.5823D-02
31.0000D-01	31.0000D-01	32.5355D-01	31.0000D-01	0.0	-15.3549D-02
32.0000D-01	32.0000D-01	31.7910D-01	32.0000D-01	0.0	20.9008D-03
33.0000D-01	33.0000D-01	32.2327D-01	33.0000D-01	0.0	76.7343D-03
36.0000D-01	36.0000D-01	35.5658D-01	36.0000D-01	0.0	43.4160D-03
37.0000D-01	37.0000D-01	36.9650D-01	37.0000D-01	0.0	35.0284D-04
40.0000D-01	40.0000D-01	39.9599D-01	40.0000D-01	0.0	40.0623D-04
42.0000D-01	42.0000D-01	41.7011D-01	42.0000D-01	0.0	29.8860D-03
48.0000D-01	48.0000D-01	47.6712D-01	48.0000D-01	0.0	32.8823D-03
53.0000D-01	53.0000D-01	51.9958D-01	53.0000D-01	0.0	10.0419D-02
56.0000D-01	56.0000D-01	55.7116D-01	56.0000D-01	0.0	28.8390D-03
60.0000D-01	60.0000D-01	60.4813D-01	60.0000D-01	0.0	-48.1300D-03
61.0000D-01	61.0000D-01	60.4142D-01	61.0000D-01	0.0	58.5785D-03
74.0000D-01	74.0000D-01	73.1206D-01	74.0000D-01	0.0	87.9384D-03
67.0000D-01	67.0000D-01	68.4428D-01	67.0000D-01	0.0	-14.4276D-02
77.0000D-01	77.0000D-01	77.6993D-01	77.0000D-01	0.0	-69.9273D-03
78.0000D-01	78.0000D-01	78.0418D-01	78.0000D-01	0.0	-41.7939D-04
80.0000D-01	80.0000D-01	79.7855D-01	80.0000D-01	0.0	21.4529D-03

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 1167.6034D-04

Table 4.26

W2(T) : Governmental Wage Bill in Period T

Sensitivity Experiment for FIML Structure

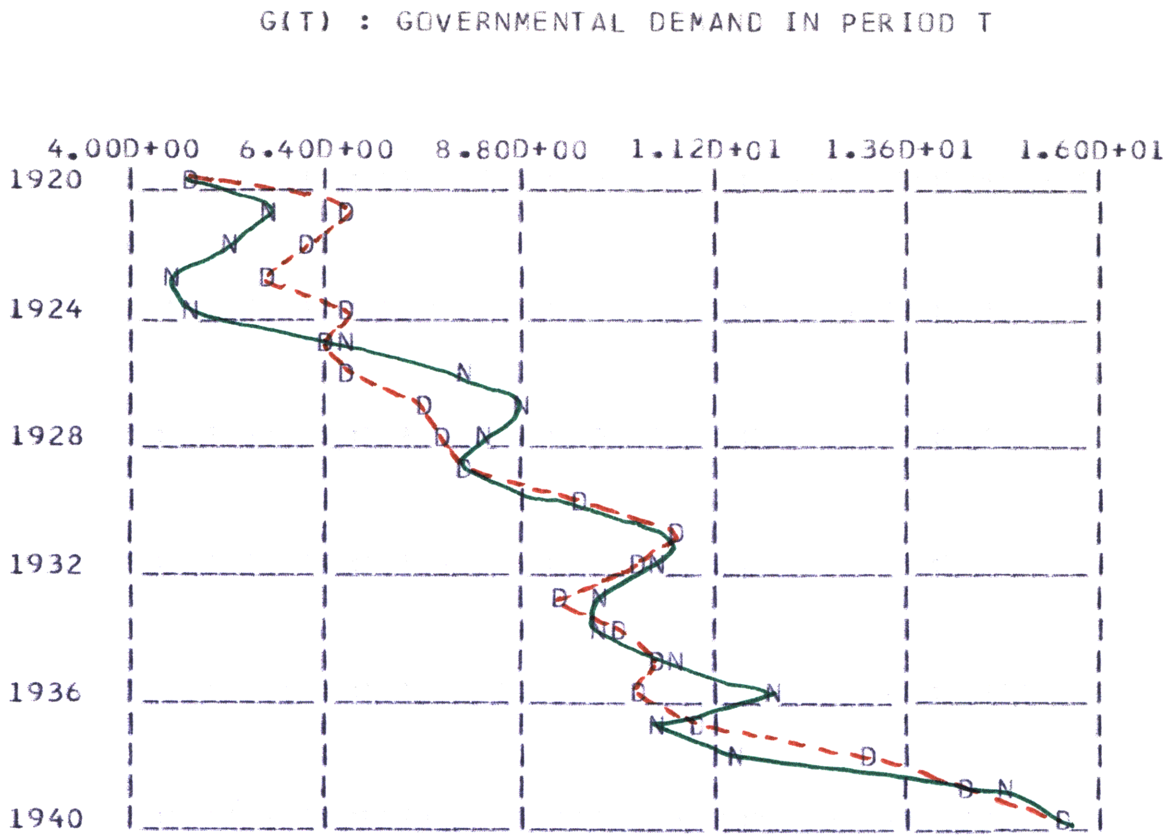


Figure 4.26

G(T) : Governmental Demand in Period T

Sensitivity Experiment for FIML Structure

G(T) : GOVERNMENTAL DEMAND IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
46.0000D-01	46.0000D-01	46.0000D-01	46.0000D-01	0.0	0.0
66.0000D-01	66.0000D-01	56.4673D-01	66.0000D-01	0.0	95.3270D-02
61.0000D-01	61.0000D-01	52.0183D-01	61.0000D-01	0.0	89.8172D-02
57.0000D-01	57.0000D-01	45.5499D-01	57.0000D-01	0.0	11.4501D-01
66.0000D-01	66.0000D-01	46.5557D-01	66.0000D-01	0.0	19.4443D-01
65.0000D-01	65.0000D-01	66.0056D-01	65.0000D-01	0.0	-10.0563D-02
66.0000D-01	66.0000D-01	80.1343D-01	66.0000D-01	0.0	-14.1343D-01
76.0000D-01	76.0000D-01	87.9039D-01	76.0000D-01	0.0	-11.9039D-01
79.0000D-01	79.0000D-01	82.4513D-01	79.0000D-01	0.0	-34.5127D-02
81.0000D-01	81.0000D-01	81.4863D-01	81.0000D-01	0.0	-48.6325D-03
94.0000D-01	94.0000D-01	94.0207D-01	94.0000D-01	0.0	-20.7395D-04
10.7000D+00	10.7000D+00	10.7000D+00	10.7000D+00	0.0	74.8249D-07
10.2000D+00	10.2000D+00	10.4847D+00	10.2000D+00	0.0	-28.4684D-02
93.0000D-01	93.0000D-01	98.1731D-01	93.0000D-01	0.0	-51.7308D-02
10.0000D+00	10.0000D+00	96.9710D-01	10.0000D+00	0.0	30.2897D-02
10.5000D+00	10.5000D+00	10.6284D+00	10.5000D+00	0.0	-12.8439D-02
10.3000D+00	10.3000D+00	12.0061D+00	10.3000D+00	0.0	-17.0609D-01
11.0000D+00	11.0000D+00	10.3810D+00	11.0000D+00	0.0	61.8955D-02
13.0000D+00	13.0000D+00	11.4205D+00	13.0000D+00	0.0	15.7953D-01
14.4000D+00	14.4000D+00	14.8577D+00	14.4000D+00	0.0	-45.7729D-02
15.4000D+00	15.4000D+00	15.6336D+00	15.4000D+00	0.0	-23.3604D-02

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 1686.3453D-02

Table 4.27

G(T) : Governmental Demand in Period T

Sensitivity Experiment for FIML Structure

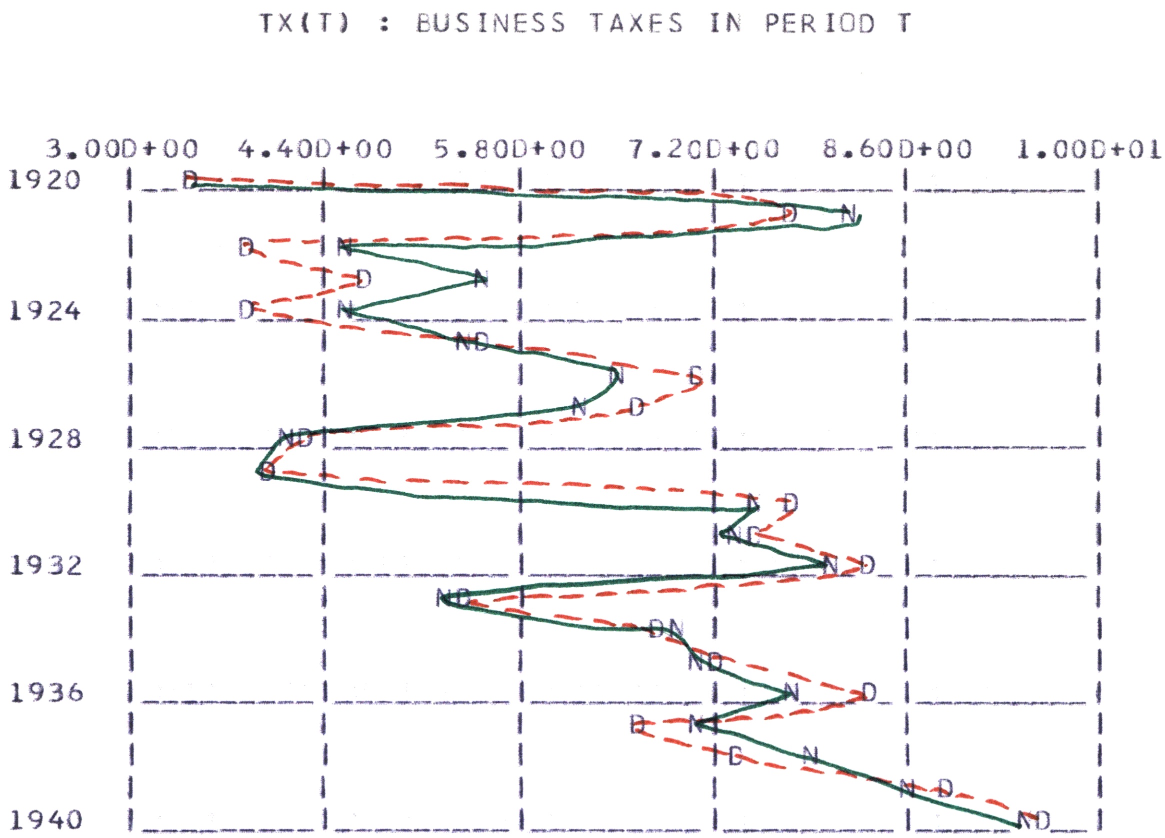


Figure 4.27

TX(T) : Business Taxes in Period T

Sensitivity Experiment for FIML Structure

TX(T) : BUSINESS TAXES IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
34.0000D-01	34.0000D-01	34.0000D-01	34.0000D-01	0.0	0.0
77.0000D-01	77.0000D-01	81.7027D-01	77.0000D-01	0.0	-47.0267D-02
39.0000D-01	39.0000D-01	45.8558D-01	39.0000D-01	0.0	-68.5577D-02
47.0000D-01	47.0000D-01	55.2124D-01	47.0000D-01	0.0	-82.1244D-02
38.0000D-01	38.0000D-01	45.9670D-01	38.0000D-01	0.0	-79.6700D-02
55.0000D-01	55.0000D-01	54.1803D-01	55.0000D-01	0.0	81.9690D-03
70.0000D-01	70.0000D-01	64.5216D-01	70.0000D-01	0.0	54.7841D-02
67.0000D-01	67.0000D-01	62.8944D-01	67.0000D-01	0.0	41.0558D-02
42.0000D-01	42.0000D-01	41.4960D-01	42.0000D-01	0.0	50.3956D-03
40.0000D-01	40.0000D-01	39.7316D-01	40.0000D-01	0.0	26.8445D-03
77.0000D-01	77.0000D-01	75.3455D-01	77.0000D-01	0.0	16.5451D-02
75.0000D-01	75.0000D-01	72.9714D-01	75.0000D-01	0.0	20.2863D-02
83.0000D-01	83.0000D-01	80.1821D-01	83.0000D-01	0.0	28.1791D-02
54.0000D-01	54.0000D-01	52.0170D-01	54.0000D-01	0.0	19.8299D-02
68.0000D-01	68.0000D-01	68.5641D-01	68.0000D-01	0.0	-56.4101D-03
72.0000D-01	72.0000D-01	70.1438D-01	72.0000D-01	0.0	18.5620D-02
83.0000D-01	83.0000D-01	77.3723D-01	83.0000D-01	0.0	56.2770D-02
67.0000D-01	67.0000D-01	70.2048D-01	67.0000D-01	0.0	-32.0482D-02
74.0000D-01	74.0000D-01	78.3005D-01	74.0000D-01	0.0	-43.0053D-02
89.0000D-01	89.0000D-01	86.4032D-01	89.0000D-01	0.0	25.9683D-02
96.0000D-01	96.0000D-01	94.3863D-01	96.0000D-01	0.0	16.1366D-02

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 3401.7379D-03

Table 4.28

TX(T) : Business Taxes in Period T

Sensitivity Experiment for FIML Structure

4.4 Sensitivity of "New" Model To Different Model Structures

In the previous section we have tested the sensitivity of the "new" model for three different estimation procedures and the results show that in general the new model is not affected by the estimation procedure used to obtain the coefficient of the original structure. In particular, small improvements are obtained by improving the statistical accuracy of the original models. In this sense, the FIML estimation procedure, eventhough, it gives the worst results for reproducing the historical values, it is the estimation that originates the new structure with the best performance.

In this section we will present the results for another type of experiment. In this case, related with the sensitivity of the "new" model to changes in the structure of the original model. Two different structures were obtained by dropping the variables corresponding to coefficient with non-significant "t" statistics and restimating the entire model. These structure were obtained for OLS and 2SLS as described in Chapter 3. The results are shown in the next pages along with some comments for each particular run.

It should be pointed out that the objective of these experiments are not only to test the sensitivity of the "new" model to different structures but also to study the effect of dropping variables in the new model from the point of view of performance in simulation.

4.4.1 Ordinary Least Squares Structure Two (OLS2)

For this run, the "old" model was obtained by restimating the model obtained with the OLS procedure once we have dropped the variables with coefficients not significantly different from zero. In this case the lag value for profits (P_{-1}) in the consumption equation (equation 3.4) was eliminated.

The results for this run are shown numerically and graphically on the following pages. As usual, the symbols used to plot the variables are the same as other runs.

The results show, a slightly degradation in performance in the "old" model with respect to the OLS model, this was expected due to the well known rule of thumb of forecasters. The more variables you drop from your model the lower the performance of your model is going to be. However, this rule of thumb seems not to work for the "new" structure, since it improves its performance over the new structure obtained with the OLS model. This again, could be explained by the fact that the OLS2 structure has more statistical accuracy than the OLS structure. This is verified by the value of the "t" statistics for both models.

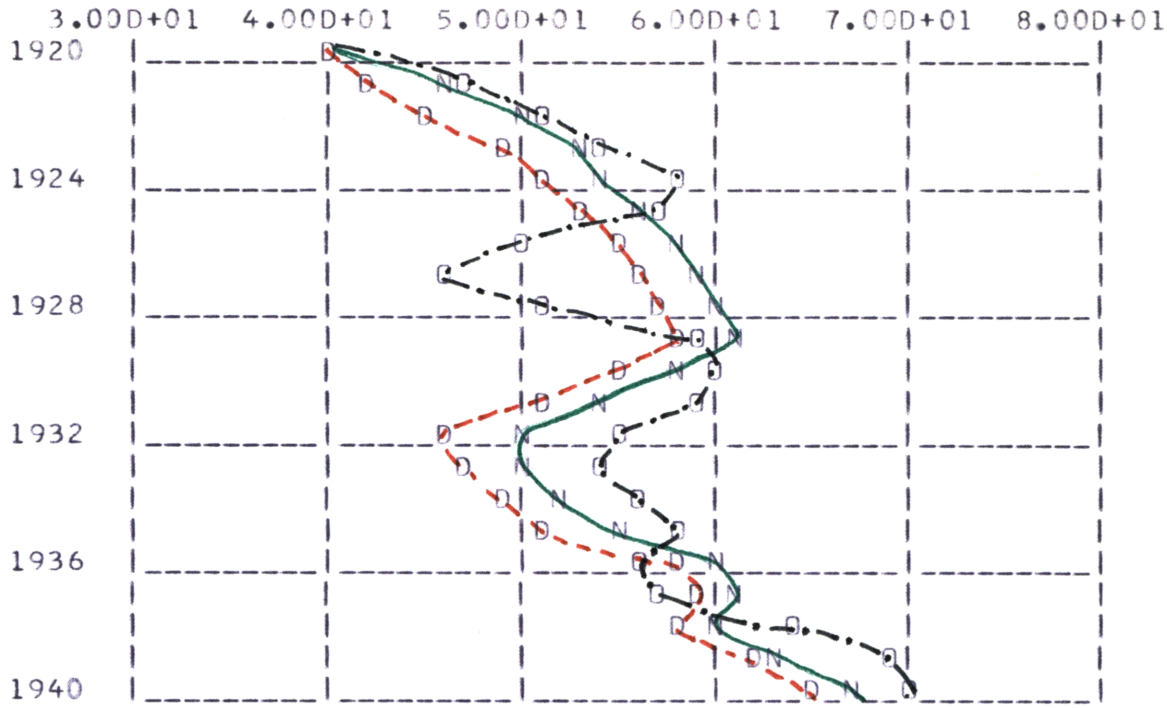


Figure 4.28

C(T) : Consumption in Period T

Sensitivity Experiment for OLS2 Structure

C(T) : CONSUMPTION IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
39.8000D+00	39.8000D+00	39.8000D+00	39.8000D+00	0.0	0.0
41.9000D+00	46.55[illegible]3D+00	45.8416D+00	41.9000D+00	-46.5933D-01	-39.4163D-01
45.0000D+00	51.4659D+00	49.7702D+00	45.0000D+00	-64.6589D-01	-47.7[illegible]17D-01
49.2000D+00	54.29[illegible]8D+00	52.7061D+00	49.2000D+00	-50.9083D-01	-35.0607D-01
50.6000D+00	58.0021D+00	54.1844D+00	50.6000D+00	-74.0210D-01	-35.8438D-01
52.6000D+00	56.5019D+00	56.3110D+00	52.6000D+00	-39.0188D-01	-37.11[illegible]4D-01
55.1000D+00	49.75[illegible]8D+00	57.926[illegible]D+00	55.1000D+00	53.4919D-01	-28.2602D-01
56.2000D+00	46.0397D+00	58.6434D+00	56.2000D+00	10.1603D+00	-24.4335D-01
57.3000D+00	50.7722D+00	59.6428D+00	57.3000D+00	65.2779D-01	-23.4279D-01
57.8000D+00	58.7168D+00	61.2368D+00	57.8000D+00	-91.6753D-02	-34.3681D-01
55.0000D+00	59.8615D+00	58.0919D+00	55.0000D+00	-48.6148D-01	-3[illegible].9191D-01
50.9000D+00	58.9425D+00	54.3579D+00	50.9000D+00	-80.4247D-01	-34.5786D-01
45.6000D+00	54.8[illegible]88D+00	49.5224D+00	45.6000D+00	-92.0882D-01	-39.2238D-01
46.5000D+00	54.3697D+00	49.7893D+00	46.5000D+00	-78.6966D-01	-32.8935D-01
48.7000D+00	56.0751D+00	51.8318D+00	48.7000D+00	-73.7511D-01	-31.3176D-01
51.3000D+00	57.5656D+00	54.8809D+00	51.3000D+00	-62.6562D-01	-35.8[illegible]94D-01
57.7000D+00	56.2241D+00	59.9585D+00	57.7000D+00	14.7591D-01	-22.5852D-01
58.7000D+00	57.3942D+00	60.6789D+00	58.7000D+00	13.0584D-01	-19.7889D-01
57.5000D+00	64.2228D+00	60.0447D+00	57.5000D+00	-67.2279D-01	-25.4471D-01
61.6000D+00	68.9050D+00	63.4394D+00	61.6000D+00	-73.0503D-01	-18.3936D-01
65.0000D+00	70.4110D+00	67.4809D+00	65.0000D+00	-54.1103D-01	-24.8[illegible]94D-01

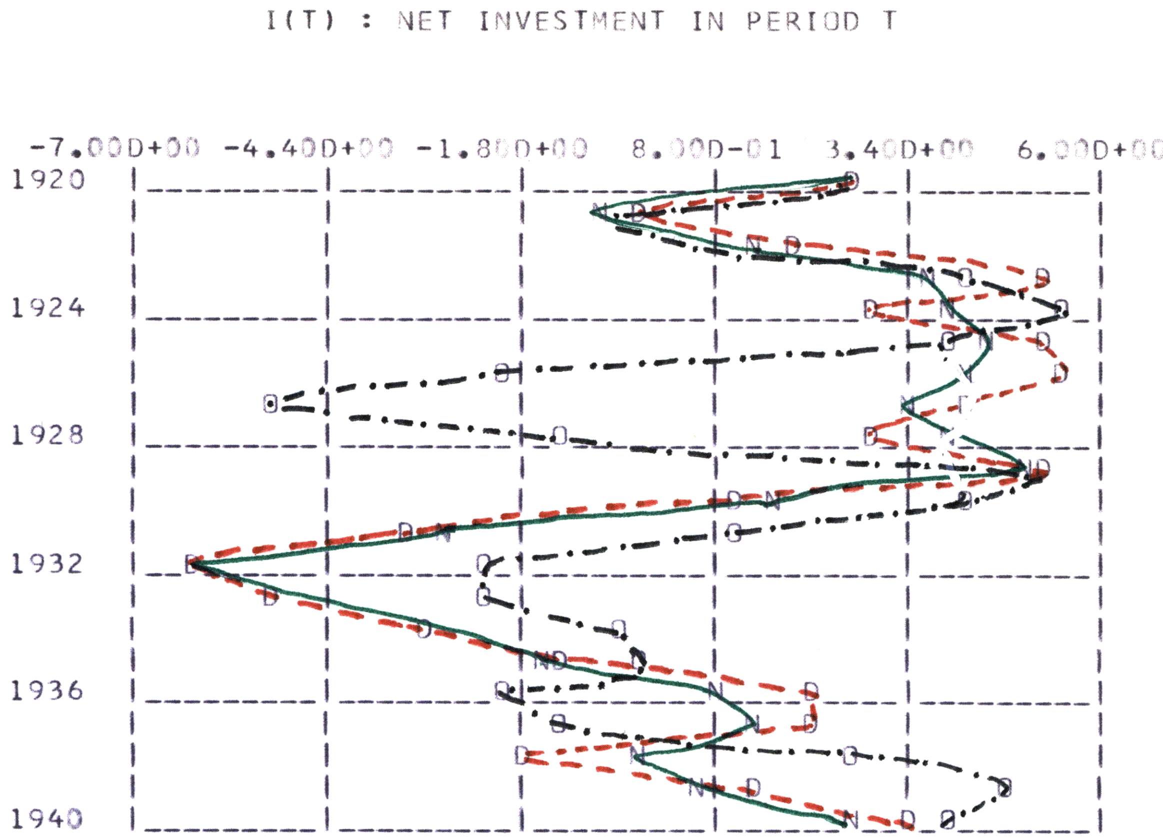
QUADRATIC ERROR OLD MODEL: 7950.8604D-01

QUADRATIC ERROR NEW MODEL: 2038.4343D-01

<u>Table 4.29</u>

C(T) : Consumption in Period T

<u>Sensitivity Experiment for OLS2 Structure</u>



<u>Figure 4.29</u>

I(T) : Net Investment in Period T

<u>Sensitivity Experiment for OLS2 Structure</u>

I(T) : NET INVESTMENT IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
27.0000D-01	27.0000D-01	27.0000D-01	27.0000D-01	0.0	0.0
-20.0000D-02	-79.9025D-02	-85.2051D-02	-20.0000D-02	59.9025D-02	65.2051D-02
19.0000D-01	17.6904D-01	12.6282D-01	19.0000D-01	13.0956D-02	63.7183D-02
52.0000D-01	42.1783D-01	36.8300D-01	52.0000D-01	98.2168D-02	15.1700D-01
30.0000D-01	56.0264D-01	39.5041D-01	30.0000D-01	-26.0264D-01	-95.0412D-02
51.0000D-01	38.7149D-01	43.5212D-01	51.0000D-01	12.2860D-01	74.7880D-02
56.0000D-01	-20.3896D-01	42.0817D-01	56.0000D-01	76.3896D-01	13.9183D-01
42.0000D-01	-52.5745D-01	34.9094D-01	42.0000D-01	94.5745D-01	70.9059D-02
30.0000D-01	-11.5986D-01	41.1493D-01	30.0000D-01	41.5986D-01	-11.1493D-01
51.0000D-01	48.8209D-01	49.5555D-01	51.0000D-01	21.7908D-02	14.4449D-02
10.0000D-01	40.9506D-01	14.6541D-01	10.0000D-01	-30.9506D-01	-46.5406D-02
-34.0000D-01	99.8558D-02	-28.4812D-01	-34.0000D-01	-43.9856D-01	-55.1881D-02
-62.0000D-01	-22.4616D-01	-60.9379D-01	-62.0000D-01	-39.5384D-01	-10.6214D-02
-51.0000D-01	-22.2841D-01	-51.6317D-01	-51.0000D-01	-28.7159D-01	63.1688D-03
-30.0000D-01	-59.4003D-02	-29.9073D-01	-30.0000D-01	-24.0600D-01	-92.6983D-04
-13.0000D-01	-16.4380D-02	-14.3394D-01	-13.0000D-01	-11.3562D-01	13.3935D-02
21.0000D-01	-21.0458D-01	71.1894D-02	21.0000D-01	42.0458D-01	13.8811D-01
20.0000D-01	-13.5116D-01	13.7726D-01	20.0000D-01	33.5116D-01	62.2737D-02
-19.0000D-01	27.0710D-01	-18.9375D-02	-19.0000D-01	-46.0710D-01	-17.1062D-01
13.0000D-01	47.2067D-01	66.7108D-02	13.0000D-01	-34.2067D-01	63.2892D-02
33.0000D-01	40.4474D-01	26.7919D-01	33.0000D-01	-74.4742D-02	62.0813D-02

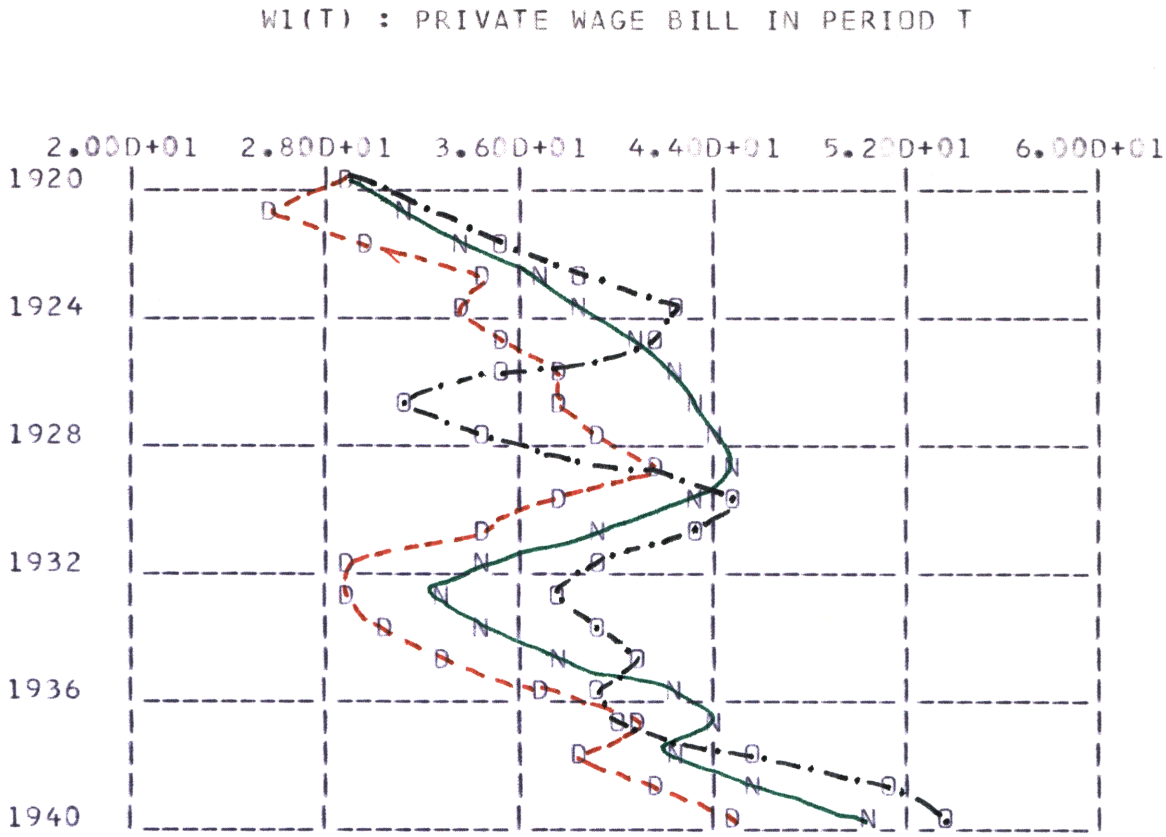
QUADRATIC ERROR OLD MODEL: 2976.4676D-01

QUADRATIC ERROR NEW MODEL: 1466.7291D-02

<u>Table 4.30</u>

I(T) : Net Investment in Period T

<u>Sensitivity Experiment for OLS2 Structure</u>



<u>Figure 4.30</u>

W1(T) : Private Wage Bill in Period T

<u>Sensitivity Experiment for OLS2 Structure</u>

W1(T) : PRIVATE WAGE BILL IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
28.8000D+00	28.8000D+00	28.8000D+00	28.8000D+00	0.0	0.0
25.5000D+00	31.5707D+00	30.9255D+00	25.5000D+00	-60.7072D-01	-54.2546D-01
29.3000D+00	35.3759D+00	33.8132D+00	29.3000D+00	-60.7593D-01	-45.1322D-01
34.1000D+00	38.6385D+00	36.9934D+00	34.1000D+00	-45.3849D-01	-28.9342D-01
33.9000D+00	42.0276D+00	38.4337D+00	33.9000D+00	-81.2757D-01	-45.3375D-01
35.4000D+00	41.4960D+00	40.7124D+00	35.4000D+00	-60.9599D-01	-53.1235D-01
37.4000D+00	35.5608D+00	42.7463D+00	37.4000D+00	18.3921D-01	-53.4634D-01
37.9000D+00	31.1047D+00	43.4003D+00	37.9000D+00	67.9532D-01	-55.0033D-01
39.2000D+00	34.2940D+00	43.8068D+00	39.2000D+00	49.0603D-01	-46.0682D-01
41.3000D+00	41.8455D+00	45.0980D+00	41.3000D+00	-54.5452D-02	-37.9796D-01
37.9000D+00	44.6438D+00	43.2066D+00	37.9000D+00	-67.4376D-01	-53.0656D-01
34.5000D+00	43.5297D+00	39.1087D+00	34.5000D+00	-90.2973D-01	-46.0874D-01
29.0000D+00	39.4938D+00	34.1294D+00	29.0000D+00	-10.4938D+00	-51.2943D-01
28.5000D+00	37.6882D+00	32.8947D+00	28.5000D+00	-91.8822D-01	-43.9469D-01
30.6000D+00	39.1814D+00	34.7954D+00	30.6000D+00	-85.8139D-01	-41.9540D-01
33.2000D+00	40.8627D+00	37.8959D+00	33.2000D+00	-76.6271D-01	-46.9593D-01
36.8000D+00	39.2302D+00	42.1330D+00	36.8000D+00	-24.3022D-01	-53.3296D-01
41.0000D+00	40.1230D+00	43.6130D+00	41.0000D+00	87.7049D-02	-26.13[illegible]4D-01
38.2000D+00	45.9625D+00	42.6594D+00	38.2000D+00	-77.6248D-01	-44.5937D-01
41.6000D+00	51.3422D+00	45.7193D+00	41.6000D+00	-97.4221D-01	-41.1929D-01
45.0000D+00	53.3562D+00	50.0326D+00	45.0000D+00	-83.5624D-01	-50.3263D-01

QUADRATIC ERROR OLD MODEL: 9570.9607D-01

QUADRATIC ERROR NEW MODEL: 4335.6475D-01

Table 4.31

W1(T) : Private Wage Bill in Period T

Sensitivity Experiment for OLS2 Structure

Y(T) : NATIONAL INCOME IN PERIOD T

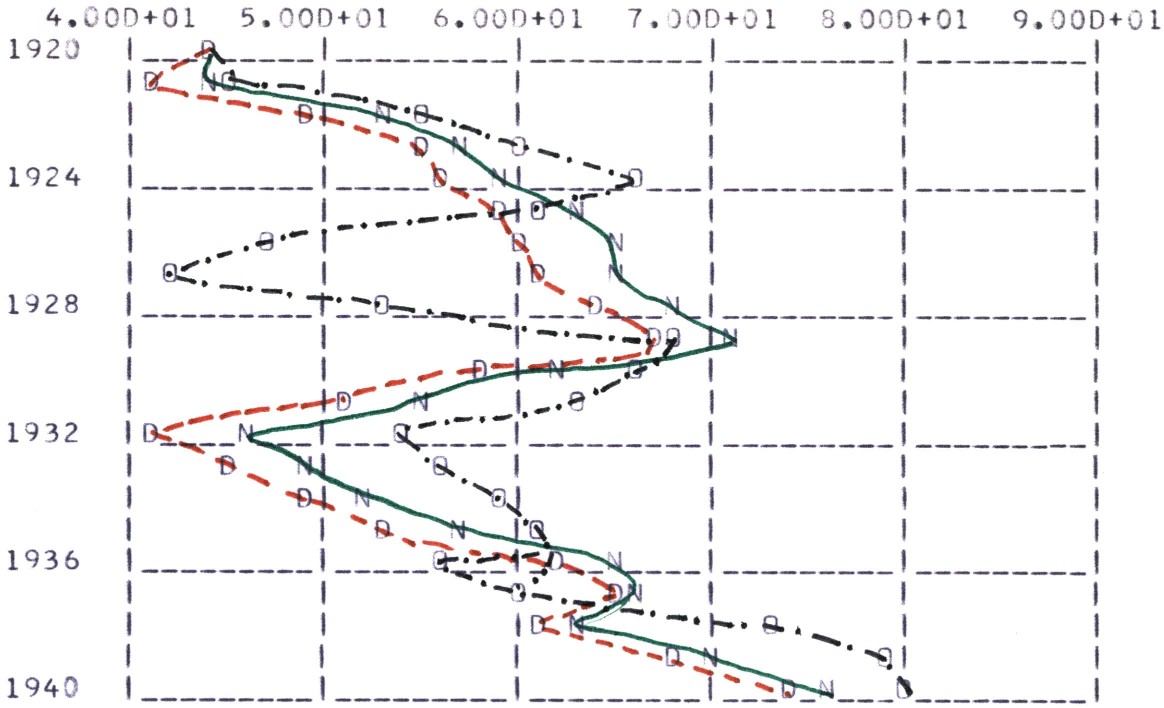


Figure 4.31

Y(T) : National Income in Period T

Sensitivity Experiment for OLS2 Structure

Y(T) : NATIONAL INCOME IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
43.7000D+00	43.7000D+00	43.7000D+00	43.7000D+00	0.0	0.0
40.6000D+00	44.6513D+00	43.6914D+00	40.6000D+00	-40.5131D-01	-30.9142D-01
49.1000D+00	55.4349D+00	52.6405D+00	49.1000D+00	-63.3494D-01	-35.4050D-01
55.4000D+00	59.5287D+00	57.1516D+00	55.4000D+00	-41.0866D-01	-17.5157D-01
56.4000D+00	66.4047D+00	59.3729D+00	56.4000D+00	-10.0047D+00	-29.7291D-01
58.7000D+00	61.3733D+00	62.9653D+00	58.7000D+00	-26.7328D-01	-42.6530D-01
60.3000D+00	47.3118D+00	64.8099D+00	60.3000D+00	12.9882D+00	-45.0991D-01
61.3000D+00	41.6822D+00	65.4667D+00	61.3000D+00	19.6178D+00	-41.6673D-01
64.0000D+00	53.3124D+00	68.1897D+00	64.0000D+00	10.6876D+00	-41.8972D-01
67.0000D+00	67.6988D+00	71.1432D+00	67.0000D+00	-69.8844D-02	-41.4320D-01
57.7000D+00	65.6565D+00	62.3469D+00	57.7000D+00	-79.5654D-01	-46.4693D-01
50.7000D+00	63.1410D+00	55.1435D+00	50.7000D+00	-12.4410D+00	-44.4346D-01
41.3000D+00	54.4627D+00	45.7959D+00	41.3000D+00	-13.1627D+00	-44.9590D-01
45.3000D+00	56.0413D+00	48.8044D+00	45.3000D+00	-10.7413D+00	-35.0443D-01
48.9000D+00	58.6811D+00	51.7830D+00	48.9000D+00	-97.8111D-01	-28.8296D-01
53.3000D+00	60.7012D+00	57.0313D+00	53.3000D+00	-74.0124D-01	-37.3131D-01
61.8000D+00	56.1195D+00	65.2011D+00	61.8000D+00	56.8049D-01	-34.0115D-01
65.0000D+00	60.3430D+00	65.8847D+00	65.0000D+00	46.5700D-01	-88.4666D-02
61.2000D+00	72.5299D+00	63.2228D+00	61.2000D+00	-11.3299D+00	-20.2278D-01
68.4000D+00	79.1257D+00	69.9528D+00	68.4000D+00	-10.7257D+00	-15.5281D-01
74.1000D+00	80.2558D+00	76.2380D+00	74.1000D+00	-61.5578D-01	-21.3800D-01

QUADRATIC ERROR OLD MODEL: 1841.3514D+00

QUADRATIC ERROR NEW MODEL: 2441.0277D-01

Table 4.32

Y(T) : National Income in Period T

Sensitivity Experiment for OLS2 Structure

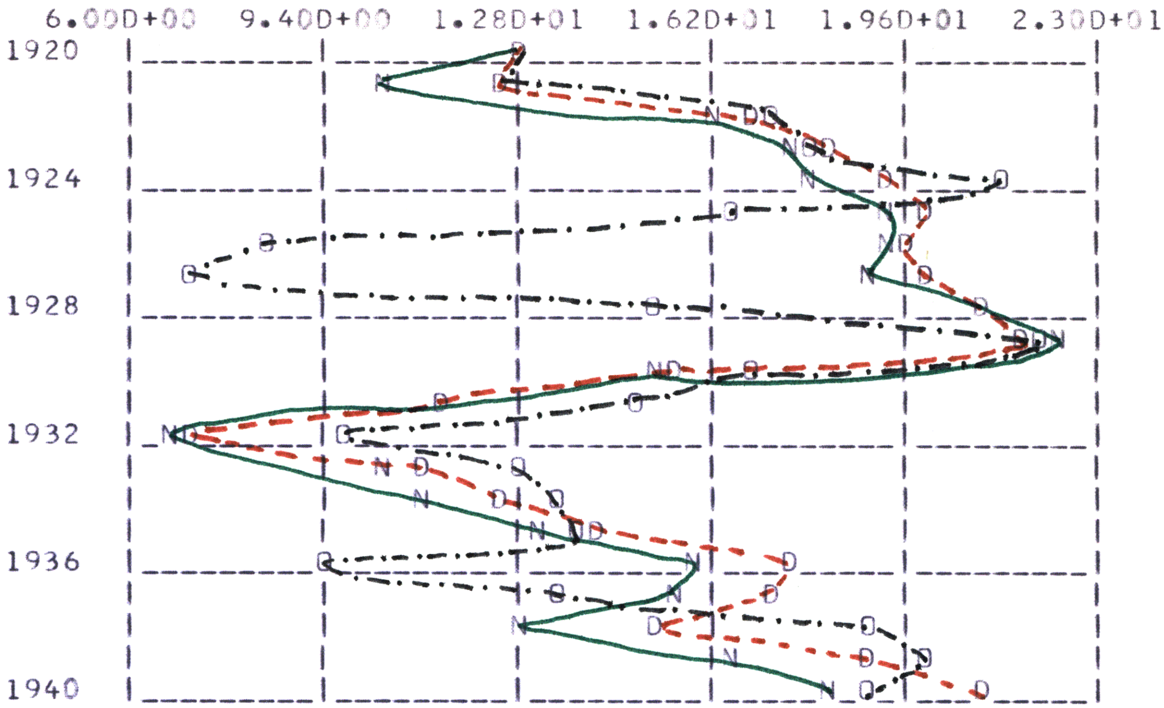


Figure 4.32

P(T) : Non-Wage Income(Profits) in Period T

Sensitivity Experiment for OLS2 Structure

P(T) : NON-WAGE INCOME(PROFITS) IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
12.7000D+00	12.7000D+00	12.7000D+00	12.7000D+00	0.0	0.0
12.4000D+00	10.3806D+00	10.2700D+00	12.4000D+00	20.1941D-01	21.2996D-01
16.9000D+00	17.1599D+00	16.1680D+00	16.9000D+00	-25.9011D-02	73.2015D-02
18.4000D+00	17.9702D+00	17.4129D+00	18.4000D+00	42.9831D-02	98.7121D-02
19.4000D+00	21.2772D+00	17.9644D+00	19.4000D+00	-18.7717D-01	14.3559D-01
20.1000D+00	16.6773D+00	19.3397D+00	20.1000D+00	34.2270D-01	76.0303D-02
19.6000D+00	84.5105D-01	19.0990D+00	19.6000D+00	11.1490D+00	5[illegible].1[illegible]14D-02
19.8000D+00	69.7754D-01	18.7516D+00	19.8000D+00	12.8225D+00	10.4842D-01
21.1000D+00	15.3184D+00	2[illegible].8989D+00	21.1000D+00	57.8161D-01	2[illegible].1094D-02
21.7000D+00	21.8534D+00	22.3048D+00	21.7000D+00	-15.3393D-02	-6[illegible].4757D-02
15.6000D+00	16.8128D+00	15.2070D+00	15.6000D+00	-12.1278D-01	39.3000D-02
11.4000D+00	14.8113D+00	11.4836D+00	11.4000D+00	-34.1130D-01	-83.6443D-03
70.0000D-01	96.6887D-01	66.3828D-01	70.0000D-01	-26.6887D-01	36.1724D-02
11.2000D+00	12.7530D+00	1[illegible].5226D+00	11.2000D+00	-15.5303D-01	67.7364D-02
12.3000D+00	13.4997D+00	11.1514D+00	12.3000D+00	-11.9972D-01	11.4856D-01
14.0000D+00	13.7385D+00	13.2635D+00	14.0000D+00	26.1472D-02	73.6466D-02
17.6000D+00	94.8928D-01	15.9366D+00	17.6000D+00	81.1072D-01	16.6338D-01
17.3000D+00	13.5201D+00	15.6337D+00	17.3000D+00	37.7995D-01	16.6630D-01
15.3000D+00	18.8674D+00	12.8988D+00	15.3000D+00	-35.6741D-01	24.0125D-01
19.0000D+00	19.9835D+00	16.5393D+00	19.0000D+00	-98.3486D-02	24.6[illegible]69D-01
21.1000D+00	18.8995D+00	18.3619D+00	21.1000D+00	22.0046D-01	27.3[illegible]6D-01

QUADRATIC ERROR OLD MODEL: 4644.9149D-01

QUADRATIC ERROR NEW MODEL: 3791.6382D-02

Table 4.33

P(T) : Non-Wage Income(Profits) in Period T

Sensitivity Experiment for OLS2 Structure

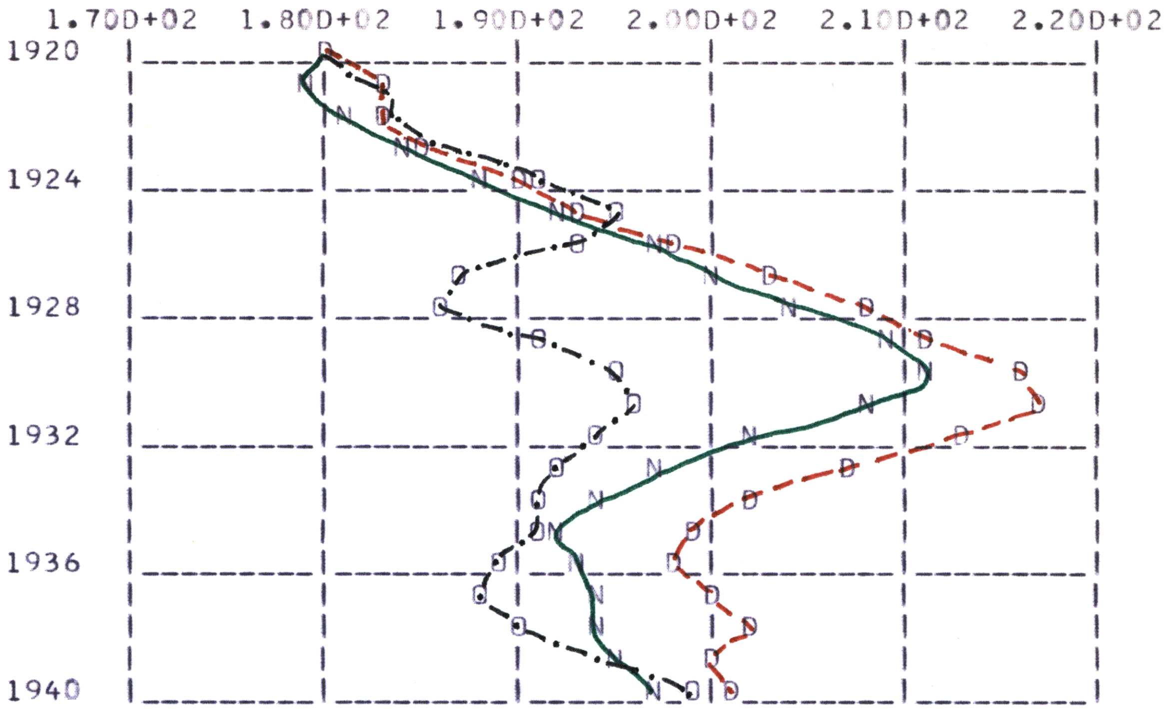


Figure 4.33

K(T) : Capital Stock End of Period T

Sensitivity Experiment for OLS2 Structure

K(T) : CAPITAL STOCK END OF PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
18.0100D+01	18.0100D+01	18.0100D+01	18.0100D+01	0.0	0.0
18.2800D+01	17.9301D+01	17.9248D+01	18.2800D+01	34.9903D-01	35.5205D-01
18.2600D+01	18.1070D+01	18.0511D+01	18.2600D+01	15.2998D-01	20.8923D-01
18.4500D+01	18.5288D+01	18.4194D+01	18.4500D+01	-78.7850D-02	30.6233D-02
18.9700D+01	19.0890D+01	18.8144D+01	18.9700D+01	-11.9049D-01	15.5582D-01
19.2700D+01	19.4762D+01	19.2496D+01	19.2700D+01	-20.6189D-01	20.3701D-02
19.7800D+01	19.2723D+01	19.6704D+01	19.7800D+01	50.7707D-01	10.9553D-01
20.3400D+01	18.7465D+01	20.0195D+01	20.3400D+01	15.9345D+00	32.0459D-01
20.7600D+01	18.6306D+01	20.4210D+01	20.7600D+01	21.2944D+00	33.8966D-01
21.0600D+01	19.1188D+01	20.9166D+01	21.0600D+01	19.4123D+00	14.3411D-01
21.5700D+01	19.5283D+01	21.0631D+01	21.5700D+01	20.4172D+00	50.6870D-01
21.6700D+01	19.6281D+01	20.7783D+01	21.6700D+01	20.4187D+00	89.1682D-01
21.3300D+01	19.4035D+01	20.1689D+01	21.3300D+01	19.2648D+00	11.6106D+00
20.7100D+01	19.1807D+01	19.6526D+01	20.7100D+01	15.2932D+00	10.5738D+00
20.2000D+01	19.1213D+01	19.3535D+01	20.2000D+01	10.7872D+00	84.6450D-01
19.9000D+01	19.1048D+01	19.2102D+01	19.9000D+01	79.5162D-01	68.9844D-01
19.7700D+01	18.8944D+01	19.2813D+01	19.7700D+01	87.5620D-01	48.8655D-01
19.9800D+01	18.7593D+01	19.4191D+01	19.9800D+01	12.2074D+00	56.0928D-01
20.1800D+01	19.0300D+01	19.4001D+01	20.1800D+01	11.5003D+00	77.9866D-01
19.9900D+01	19.5020D+01	19.4668D+01	19.9900D+01	48.7958D-01	52.3155D-01
20.1200D+01	19.9065D+01	19.7348D+01	20.1200D+01	21.3484D-01	38.5236D-01

QUADRATIC ERROR OLD MODEL: 3135.5558D+00

QUADRATIC ERROR NEW MODEL: 6739.7367D-01

Table 4.34

K(T) : Capital Stock End of Period T

Sensitivity Experiment for OLS2 Structure

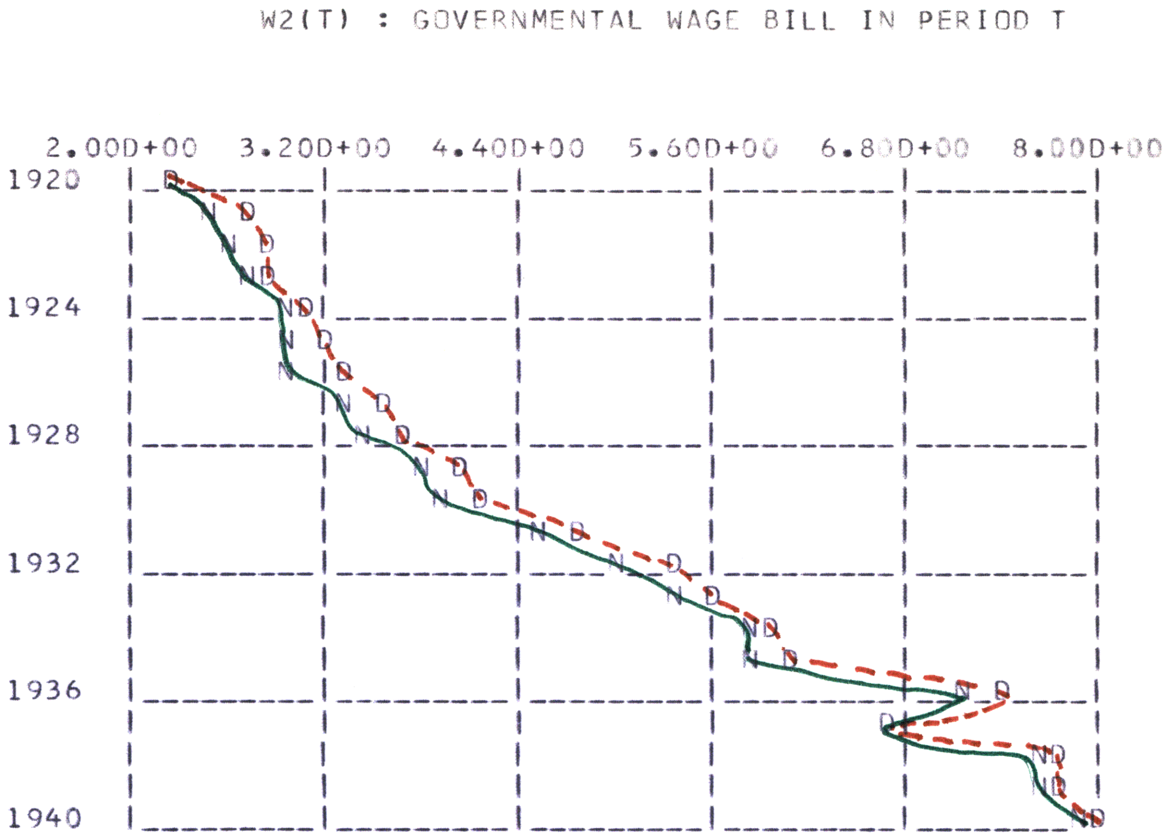


Figure 4.34

W2(T) : Governmental Wage Bill in Period T

Sensitivity Experiment for OLS2 Structure

W2(T) : GOVERNMENTAL WAGE BILL IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
22.0000D-01	22.0000D-01	22.0000D-01	22.0000D-01	0.0	0.0
27.0000D-01	27.0000D-01	24.9592D-01	27.0000D-01	0.0	20.4083D-02
29.0000D-01	29.0000D-01	26.5930D-01	29.0000D-01	0.0	24.0700D-02
29.0000D-01	29.0000D-01	27.4528D-01	29.0000D-01	0.0	15.4724D-02
31.0000D-01	31.0000D-01	29.7475D-01	31.0000D-01	0.0	12.5247D-02
32.0000D-01	32.0000D-01	29.1325D-01	32.0000D-01	0.0	28.6751D-02
33.0000D-01	33.0000D-01	29.6458D-01	33.0000D-01	0.0	33.5420D-02
36.0000D-01	36.0000D-01	33.1483D-01	36.0000D-01	0.0	28.5174D-02
37.0000D-01	37.0000D-01	34.8400D-01	37.0000D-01	0.0	21.6000D-02
40.0000D-01	40.0000D-01	37.4048D-01	40.0000D-01	0.0	25.9519D-02
42.0000D-01	42.0000D-01	39.3338D-01	42.0000D-01	0.0	26.6624D-02
48.0000D-01	48.0000D-01	45.5107D-01	48.0000D-01	0.0	24.8929D-02
53.0000D-01	53.0000D-01	50.2819D-01	53.0000D-01	0.0	27.1805D-02
56.0000D-01	56.0000D-01	53.8711D-01	56.0000D-01	0.0	21.2890D-02
60.0000D-01	60.0000D-01	58.3611D-01	60.0000D-01	0.0	16.3886D-02
61.0000D-01	61.0000D-01	58.7184D-01	61.0000D-01	0.0	22.8157D-02
74.0000D-01	74.0000D-01	71.3157D-01	74.0000D-01	0.0	26.8431D-02
67.0000D-01	67.0000D-01	66.3793D-01	67.0000D-01	0.0	62.0706D-03
77.0000D-01	77.0000D-01	76.6466D-01	77.0000D-01	0.0	35.3424D-03
78.0000D-01	78.0000D-01	76.9420D-01	78.0000D-01	0.0	10.5797D-02
80.0000D-01	80.0000D-01	78.4345D-01	80.0000D-01	0.0	15.6553D-02

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 9733.0506D-04

Table 4.35

W2(T) : Governmental Wage Bill in Period T

Sensitivity Experiment for OLS2 Structure

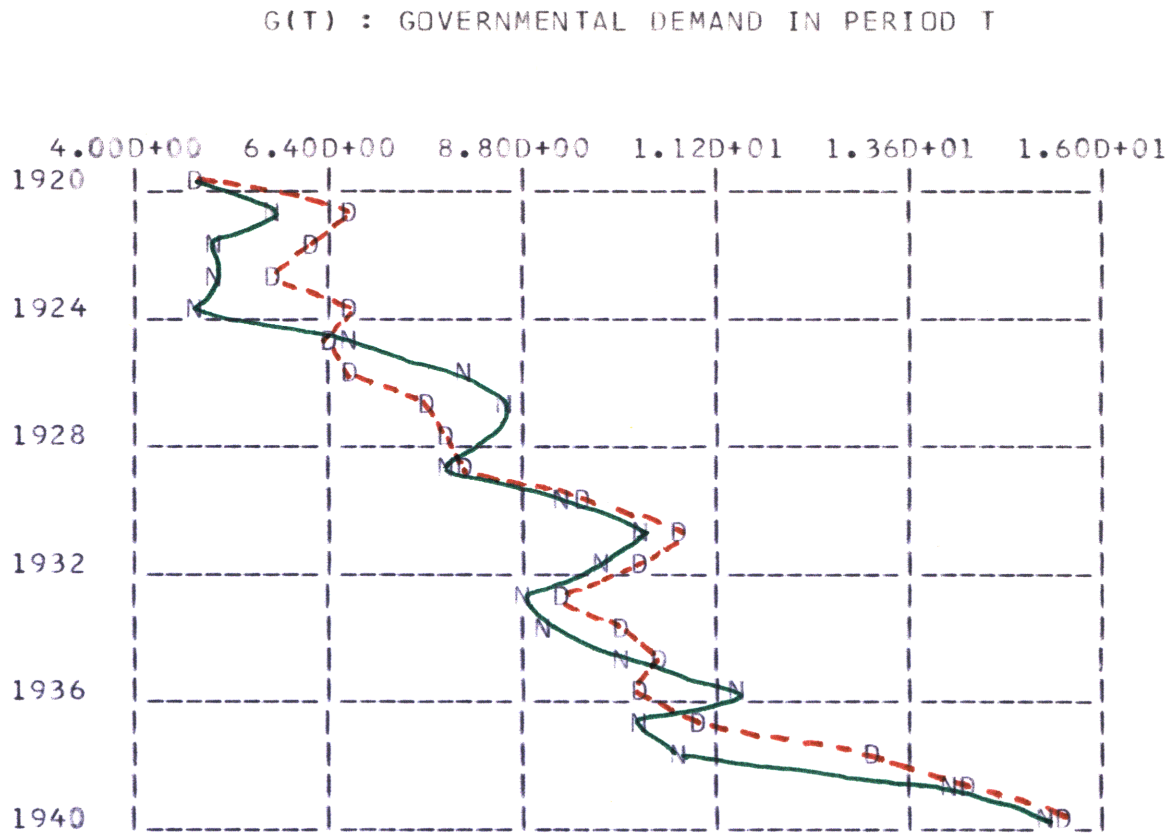


Figure 4.35

G(T) : Governmental Demand in Period T

Sensitivity Experiment for OLS2 Structure

G(T) : GOVERNMENTAL DEMAND IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
46.0000D-01	46.0000D-01	46.0000D-01	46.0000D-01	0.0	0.0
66.0000D-01	66.0000D-01	56.8942D-01	66.0000D-01	0.0	91.0576D-02
61.0000D-01	61.0000D-01	49.9319D-01	61.0000D-01	0.0	11.0681D-01
57.0000D-01	57.0000D-01	49.4088D-01	57.0000D-01	0.0	75.9119D-02
66.0000D-01	66.0000D-01	46.7221D-01	66.0000D-01	0.0	19.2779D-01
65.0000D-01	65.0000D-01	65.5628D-01	65.0000D-01	0.0	-56.2799D-03
66.0000D-01	66.0000D-01	79.8209D-01	66.0000D-01	0.0	-13.8209D-01
76.0000D-01	76.0000D-01	85.7863D-01	76.0000D-01	0.0	-97.8630D-02
79.0000D-01	79.0000D-01	77.7108D-01	79.0000D-01	0.0	12.8920D-02
81.0000D-01	81.0000D-01	79.5282D-01	81.0000D-01	0.0	14.7179D-02
94.0000D-01	94.0000D-01	93.6345D-01	94.0000D-01	0.0	36.5532D-03
10.7000D+00	10.7000D+00	10.2078D+00	10.7000D+00	0.0	49.2194D-02
10.2000D+00	10.2000D+00	97.3789D-01	10.2000D+00	0.0	46.2107D-02
93.0000D-01	93.0000D-01	87.9255D-01	93.0000D-01	0.0	50.7448D-02
10.0000D+00	10.0000D+00	90.9068D-01	10.0000D+00	0.0	99.9317D-02
10.5000D+00	10.5000D+00	99.2897D-01	10.5000D+00	0.0	57.1035D-02
10.3000D+00	10.3000D+00	11.5131D+00	10.3000D+00	0.0	-12.1315D-01
11.0000D+00	11.0000D+00	10.1977D+00	11.0000D+00	0.0	80.2301D-02
13.0000D+00	13.0000D+00	10.7715D+00	13.0000D+00	0.0	22.2847D-01
14.4000D+00	14.4000D+00	14.0978D+00	14.4000D+00	0.0	30.2237D-02
15.4000D+00	15.4000D+00	15.2041D+00	15.4000D+00	0.0	19.5859D-02

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 1833.4902D-02

Table 4.36

G(T) : Governmental Demand in Period T

Sensitivity Experiment for OLS2 Structure

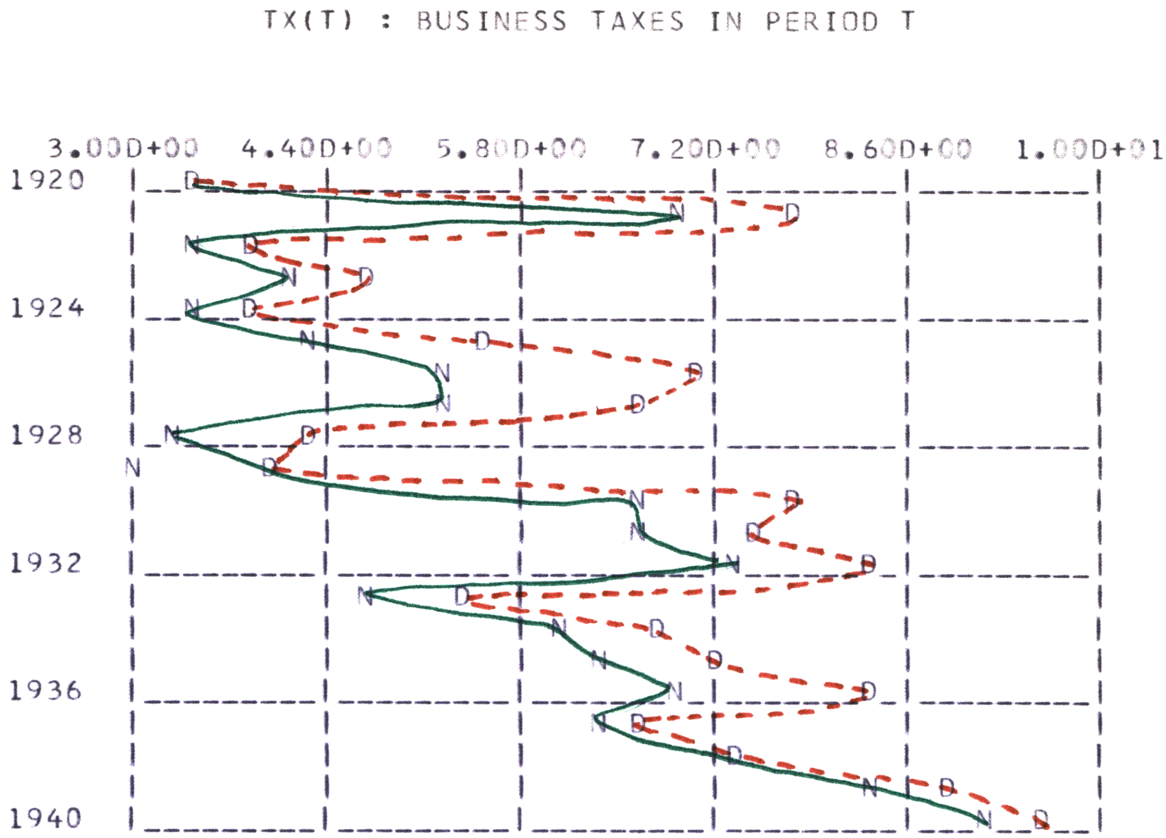


Figure 4.36

TX(T) : Business Taxes in Period T

Sensitivity Experiment for OLS2 Structure

TX(T) : BUSINESS TAXES IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
34.0000D-01	34.0000D-01	34.0000D-01	34.0000D-01	0.0	0.0
77.0000D-01	77.0000D-01	69.8759D-01	77.0000D-01	0.0	71.2411D-02
39.0000D-01	39.0000D-01	33.8568D-01	39.0000D-01	0.0	51.4320D-02
47.0000D-01	47.0000D-01	41.7838D-01	47.0000D-01	0.0	52.1624D-02
38.0000D-01	38.0000D-01	34.3409D-01	38.0000D-01	0.0	36.5905D-02
55.0000D-01	55.0000D-01	42.5414D-01	55.0000D-01	0.0	12.4586D-01
70.0000D-01	70.0000D-01	53.0637D-01	70.0000D-01	0.0	16.9363D-01
67.0000D-01	67.0000D-01	52.4620D-01	67.0000D-01	0.0	14.5380D-01
42.0000D-01	42.0000D-01	32.3908D-01	42.0000D-01	0.0	96.0917D-02
40.0000D-01	40.0000D-01	30.0199D-01	40.0000D-01	0.0	99.8014D-02
77.0000D-01	77.0000D-01	65.7384D-01	77.0000D-01	0.0	11.2616D-01
75.0000D-01	75.0000D-01	65.7409D-01	75.0000D-01	0.0	92.5909D-02
83.0000D-01	83.0000D-01	73.7058D-01	83.0000D-01	0.0	92.9415D-02
54.0000D-01	54.0000D-01	46.1430D-01	54.0000D-01	0.0	78.5703D-02
68.0000D-01	68.0000D-01	61.4876D-01	68.0000D-01	0.0	65.1242D-02
72.0000D-01	72.0000D-01	63.4466D-01	72.0000D-01	0.0	85.5337D-02
83.0000D-01	83.0000D-01	69.8241D-01	83.0000D-01	0.0	13.1759D-01
67.0000D-01	67.0000D-01	63.6919D-01	67.0000D-01	0.0	33.0811D-02
74.0000D-01	74.0000D-01	74.0409D-01	74.0000D-01	0.0	-40.9194D-04
89.0000D-01	89.0000D-01	82.5142D-01	89.0000D-01	0.0	64.8579D-02
96.0000D-01	96.0000D-01	91.2626D-01	96.0000D-01	0.0	47.3738D-02

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 1688.4508D-02

Table 4.37

TX(T) : Business Taxes in Period T

Sensitivity Experiment for OLS2 Structure

4.4.2 Two Stage Least Squares Structure Two (2SLS2)

For this run, The "old" model was obtained by re-estimating the model obtained with the 2SLS procedure once we have dropped the variables with coefficients not significantly different from zero. In this case the value for profits (P) in the consumption equation (equation 3.4) was eliminated.

The results for this run are shown numerically and graphically on the following pages. As usual, the symbols used to plot the variables are the same as other runs.

C(T) : CONSUMPTION IN PERIOD T

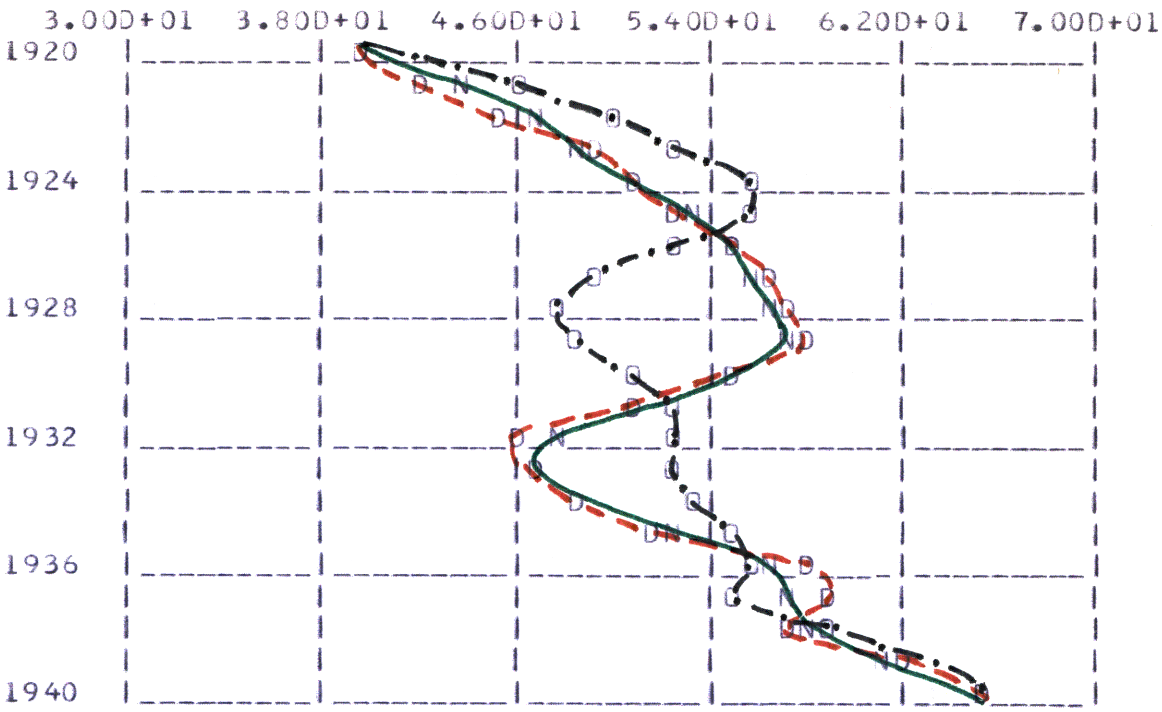


Figure 4.37

C(T) : Consumption in Period T

Sensitivity Experiment for 2SLS2 Structure

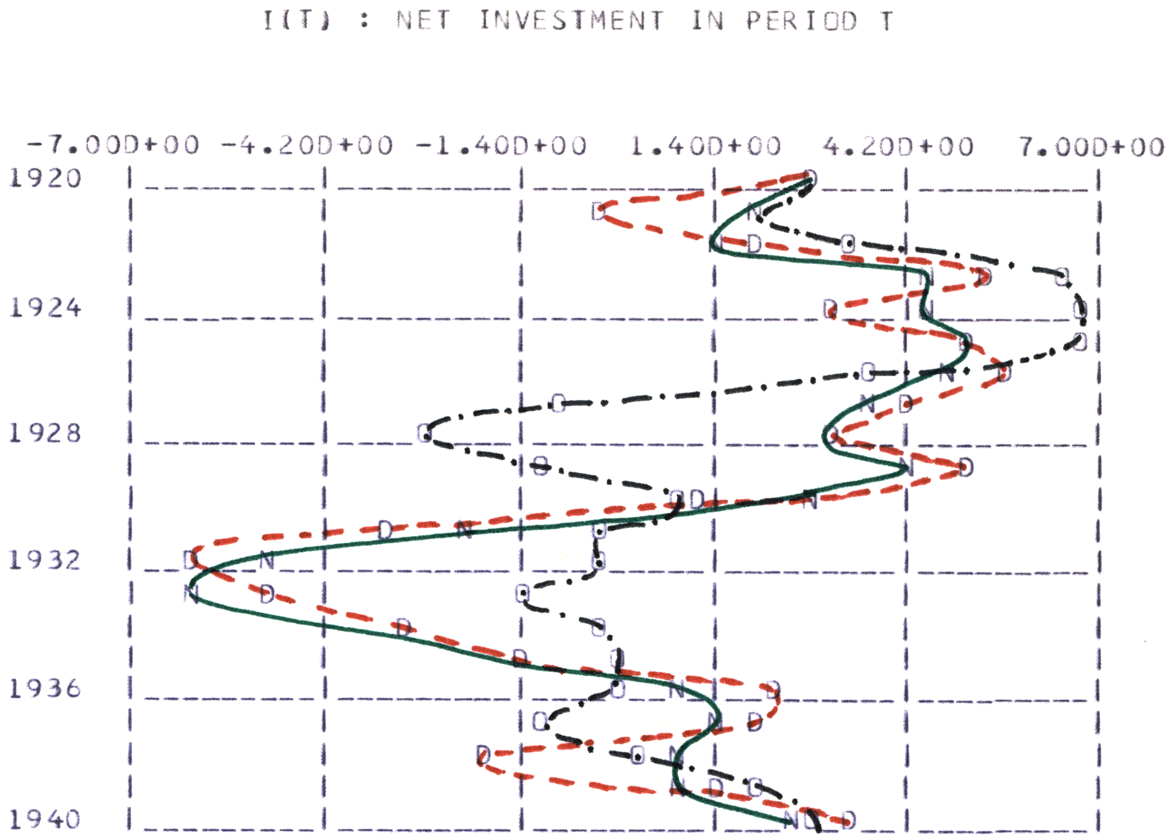


Figure 4.38

I(T) : Net Investment in Period T

Sensitivity Experiment for 2SLS2 Structure

C(T) : CONSUMPTION IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
39.8000D+00	39.8000D+00	39.8000D+00	39.8000D+00	0.0	0.0
41.9000D+00	45.6967D+00	43.8185D+00	41.9000D+00	-37.9673D-01	-19.1850D-01
45.0000D+00	49.6127D+00	46.4002D+00	45.0000D+00	-46.1265D-01	-14.0022D-01
49.2000D+00	52.7140D+00	48.6236D+00	49.2000D+00	-35.1397D-01	57.6397D-02
50.6000D+00	55.4774D+00	50.7584D+00	50.6000D+00	-48.7738D-01	-15.8355D-02
52.6000D+00	55.7142D+00	52.9105D+00	52.6000D+00	-31.1421D-01	-31.0498D-02
55.1000D+00	52.7372D+00	54.4236D+00	55.1000D+00	23.6284D-01	67.6443D-02
56.2000D+00	48.9862D+00	55.3429D+00	56.2000D+00	72.1385D-01	85.7119D-02
57.3000D+00	47.2289D+00	56.3766D+00	57.3000D+00	10.0711D+00	92.3365D-02
57.8000D+00	48.6282D+00	56.9158D+00	57.8000D+00	91.7184D-01	88.4191D-02
55.0000D+00	50.7967D+00	54.6636D+00	55.0000D+00	42.0326D-01	33.6376D-02
50.9000D+00	52.7125D+00	51.0975D+00	50.9000D+00	-18.1248D-01	-19.7466D-02
45.6000D+00	52.7933D+00	47.3598D+00	45.6000D+00	-71.9331D-01	-17.5984D-01
46.5000D+00	52.4042D+00	46.6071D+00	46.5000D+00	-59.0422D-01	-10.7077D-02
48.7000D+00	53.3449D+00	48.6948D+00	48.7000D+00	-46.4487D-01	52.4783D-04
51.3000D+00	54.6154D+00	52.2902D+00	51.3000D+00	-33.1538D-01	-99.0202D-02
57.7000D+00	55.4669D+00	56.7491D+00	57.7000D+00	22.3313D-01	95.0938D-02
58.7000D+00	55.1399D+00	57.0982D+00	58.7000D+00	35.6009D-01	16.0183D-01
57.5000D+00	58.5338D+00	58.2250D+00	57.5000D+00	-10.3382D-01	-72.4974D-02
61.6000D+00	62.1630D+00	61.2531D+00	61.6000D+00	-56.2976D-02	34.6862D-02
65.0000D+00	64.9838D+00	64.9655D+00	65.0000D+00	16.1744D-03	34.5109D-03

QUADRATIC ERROR OLD MODEL: 4838.6959D-01

QUADRATIC ERROR NEW MODEL: 1728.0014D-02

Table 4.38

C(T) : Consumption in Period T

Sensitivity Experiment for 2SLS2 Structure

I(T) : NET INVESTMENT IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
27.0000D-01	27.0000D-01	27.0000D-01	27.0000D-01	0.0	0.0
-20.0000D-02	20.4700D-01	18.6171D-01	-20.0000D-02	-22.4700D-01	-20.6171D-01
19.0000D-01	34.4212D-01	13.8040D-01	19.0000D-01	-15.4212D-01	51.9601D-02
52.0000D-01	65.4304D-01	44.4453D-01	52.0000D-01	-13.4304D-01	75.5470D-02
30.0000D-01	67.2561D-01	43.6364D-01	30.0000D-01	-37.2561D-01	-13.6364D-01
51.0000D-01	67.1777D-01	50.3512D-01	51.0000D-01	-16.1777D-01	64.8778D-03
56.0000D-01	35.1767D-01	47.7036D-01	56.0000D-01	20.8233D-01	82.9636D-02
42.0000D-01	-95.4857D-02	35.4495D-01	42.0000D-01	51.5486D-01	65.5053D-02
30.0000D-01	-28.8973D-01	31.5752D-01	30.0000D-01	58.8973D-01	-15.7522D-02
51.0000D-01	-11.0803D-01	42.8073D-01	51.0000D-01	62.0803D-01	81.9272D-02
10.0000D-01	72.3481D-02	27.9373D-01	10.0000D-01	27.6519D-02	-17.9373D-01
-34.0000D-01	-32.1743D-02	-22.4990D-01	-34.0000D-01	-30.7826D-01	-11.5010D-01
-62.0000D-01	-33.3329D-02	-49.5965D-01	-62.0000D-01	-58.6667D-01	-12.4035D-01
-51.0000D-01	-14.0621D-01	-60.9792D-01	-51.0000D-01	-36.9379D-01	99.7916D-02
-30.0000D-01	-22.1290D-02	-31.0525D-01	-30.0000D-01	-27.7871D-01	10.5250D-02
-13.0000D-01	96.2851D-03	-12.6396D-01	-13.0000D-01	-13.9629D-01	-36.0432D-03
21.0000D-01	89.3999D-03	92.8297D-02	21.0000D-01	20.1060D-01	11.7170D-01
20.0000D-01	-11.9215D-01	14.5985D-01	20.0000D-01	31.9215D-01	54.0147D-02
-19.0000D-01	18.7722D-02	73.0661D-02	-19.0000D-01	-20.8772D-01	-26.3066D-01
13.0000D-01	20.6419D-01	90.5067D-02	13.0000D-01	-76.4191D-02	39.4933D-02
33.0000D-01	26.9497D-01	26.0841D-01	33.0000D-01	60.5034D-02	69.1585D-02

QUADRATIC ERROR OLD MODEL: 2166.9132D-01

QUADRATIC ERROR NEW MODEL: 2507.4673D-02

Table 4.39

I(T) : Net Investment in Period T

Sensitivity Experiment for 2SLS2 Structure

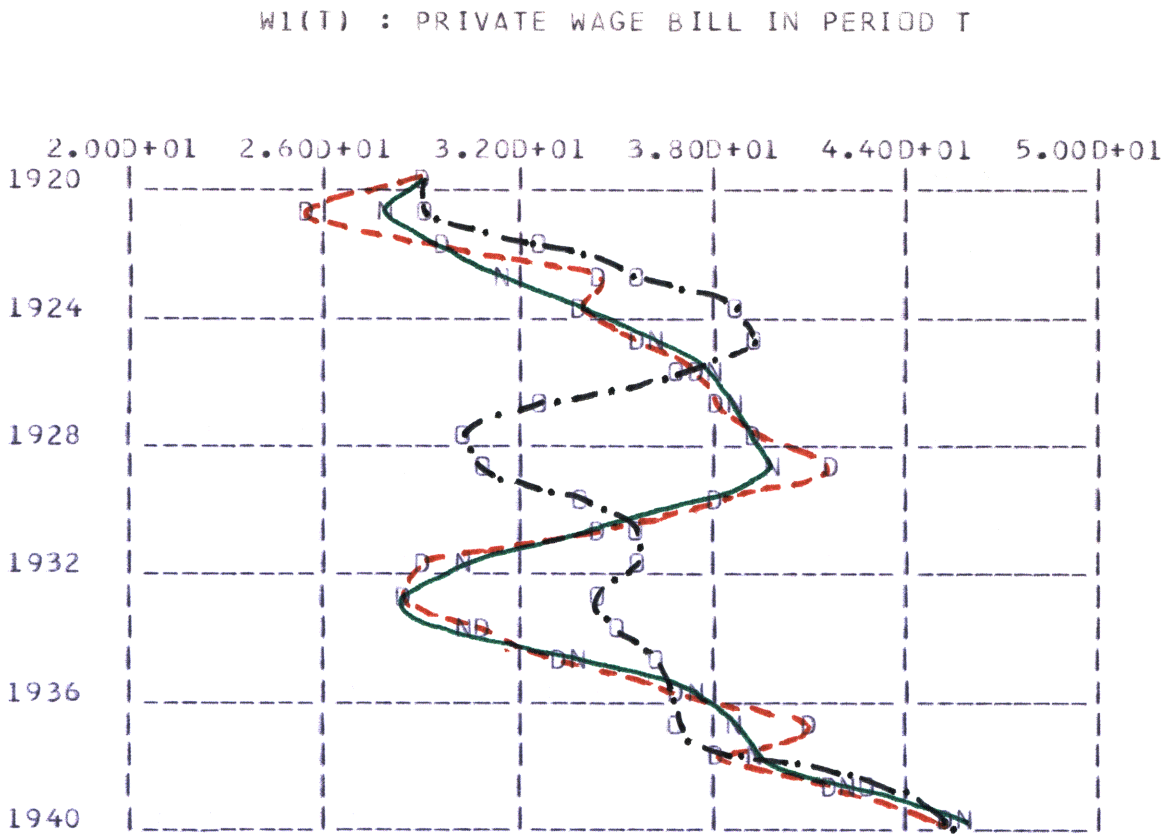


Figure 4.39

W1(T) : Private Wage Bill in Period T

Sensitivity Experiment for 2SLS2 Structure

W1(T) : PRIVATE WAGE BILL IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
28.8000D+00	28.8000D+00	28.8000D+00	28.8000D+00	0.0	0.0
25.5000D+00	29.2209D+00	27.6884D+00	25.5000D+00	-37.2091D-01	-21.8843D-01
29.3000D+00	32.4349D+00	29.3971D+00	29.3000D+00	-31.3494D-01	-97.1005D-03
34.1000D+00	35.7456D+00	31.6757D+00	34.1000D+00	-16.4556D-01	24.2425D-01
33.9000D+00	38.4006D+00	33.6716D+00	33.9000D+00	-45.0062D-01	22.8416D-02
35.4000D+00	39.2079D+00	36.0500D+00	35.4000D+00	-38.0789D-01	-64.9978D-02
37.4000D+00	36.8596D+00	37.9351D+00	37.4000D+00	54.0431D-02	-53.5054D-02
37.9000D+00	32.8504D+00	38.7327D+00	37.9000D+00	50.4964D-01	-83.2712D-02
39.2000D+00	30.2254D+00	39.2630D+00	39.2000D+00	89.7460D-01	-62.9658D-03
41.3000D+00	30.9788D+00	39.5954D+00	41.3000D+00	10.3212D+00	17.0460D-01
37.9000D+00	33.7305D+00	38.2759D+00	37.9000D+00	41.6948D-01	-37.5935D-02
34.5000D+00	35.4217D+00	34.4304D+00	34.5000D+00	-92.1670D-02	69.6351D-03
29.0000D+00	35.4679D+00	30.3949D+00	29.0000D+00	-64.6792D-01	-13.9492D-01
28.5000D+00	34.3652D+00	28.4036D+00	28.5000D+00	-58.6518D-01	96.3621D-03
30.6000D+00	35.0036D+00	30.0823D+00	30.6000D+00	-44.0356D-01	51.7655D-02
33.2000D+00	36.3816D+00	33.7508D+00	33.2000D+00	-31.8157D-01	-55.0807D-02
36.8000D+00	36.6141D+00	37.4498D+00	36.8000D+00	18.5870D-02	-64.9769D-02
41.0000D+00	36.5510D+00	38.4978D+00	41.0000D+00	44.4903D-01	25.0223D-01
38.2000D+00	38.9822D+00	39.0506D+00	38.2000D+00	-78.2215D-02	-85.0638D-02
41.6000D+00	42.9071D+00	41.9625D+00	41.6000D+00	-13.0710D-01	-36.2498D-02
45.0000D+00	45.9872D+00	45.8017D+00	45.0000D+00	-98.7241D-02	-80.1743D-02

QUADRATIC ERROR OLD MODEL: 4211.0461D-01

QUADRATIC ERROR NEW MODEL: 2589.3349D-02

Table 4.40

W1(T) : Private Wage Bill in Period T

Sensitivity Experiment for 2SLS2 Structure

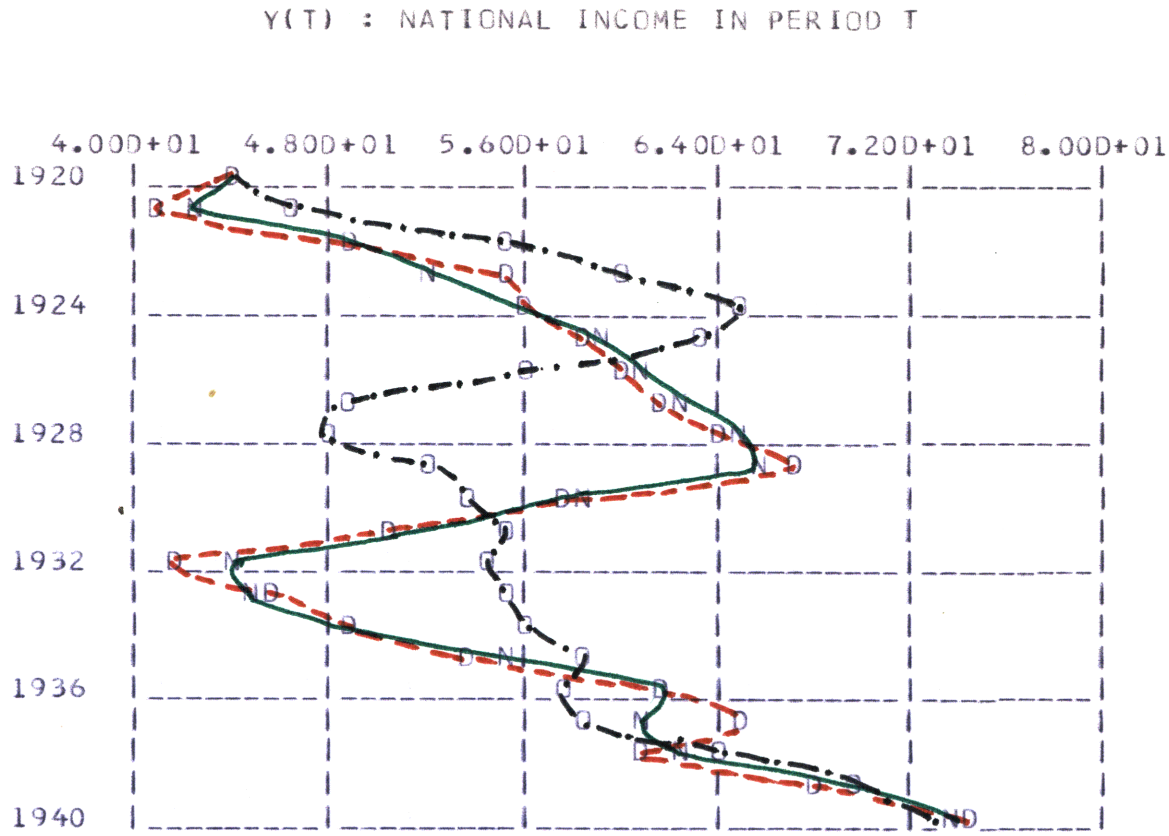


Figure 4.40

Y(T) : National Income in Period T

Sensitivity Experiment for 2SLS2 Structure

Y(T) : NATIONAL INCOME IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
43.7000D+00	43.7000D+00	43.7000D+00	43.7000D+00	0.0	0.0
40.6000D+00	46.6437D+00	42.3348D+00	40.6000D+00	-60.4373D-01	-17.3483D-01
49.1000D+00	55.2548D+00	48.9856D+00	49.1000D+00	-61.5477D-01	11.4373D-02
55.4000D+00	60.2570D+00	52.2517D+00	55.4000D+00	-48.5701D-01	31.4832D-01
56.4000D+00	65.0030D+00	56.2937D+00	56.4000D+00	-86.0298D-01	10.6334D-02
58.7000D+00	63.4320D+00	59.5717D+00	58.7000D+00	-47.3198D-01	-87.1707D-02
60.3000D+00	55.8548D+00	60.9333D+00	60.3000D+00	44.4517D-01	-63.3304D-02
61.3000D+00	48.9313D+00	62.0920D+00	61.3000D+00	12.3687D+00	-79.1970D-02
64.0000D+00	48.0391D+00	65.1827D+00	64.0000D+00	15.9609D+00	-11.8271D-01
67.0000D+00	51.6201D+00	65.4649D+00	67.0000D+00	15.3799D+00	15.3506D-01
57.7000D+00	53.2202D+00	58.0766D+00	57.7000D+00	44.7978D-01	-37.6575D-02
50.7000D+00	55.5907D+00	50.6467D+00	50.7000D+00	-48.9073D-01	53.2592D-03
41.3000D+00	54.3600D+00	43.7907D+00	41.3000D+00	-13.0600D+00	-24.9071D-01
45.3000D+00	54.8980D+00	44.9048D+00	45.3000D+00	-95.9801D-01	39.5178D-02
48.9000D+00	56.3236D+00	48.6521D+00	48.9000D+00	-74.2358D-01	24.7908D-02
53.3000D+00	58.0117D+00	55.0609D+00	53.3000D+00	-47.1167D-01	-17.6086D-01
61.8000D+00	57.5563D+00	61.2446D+00	61.8000D+00	42.4373D-01	55.5370D-02
65.0000D+00	58.2478D+00	61.1223D+00	65.0000D+00	67.5224D-01	38.7772D-01
61.2000D+00	64.3215D+00	62.6227D+00	61.2000D+00	-31.2154D-01	-14.2274D-01
68.4000D+00	69.7272D+00	68.1614D+00	68.4000D+00	-13.2717D-01	23.8577D-02
74.1000D+00	73.4788D+00	73.9938D+00	74.1000D+00	62.1209D-02	10.6167D-02

QUADRATIC ERROR OLD MODEL: 1317.9109D+00

QUADRATIC ERROR NEW MODEL: 4559.3378D-02

Table 4.41

Y(T) : National Income in Period T

Sensitivity Experiment for 2SLS2 Structure

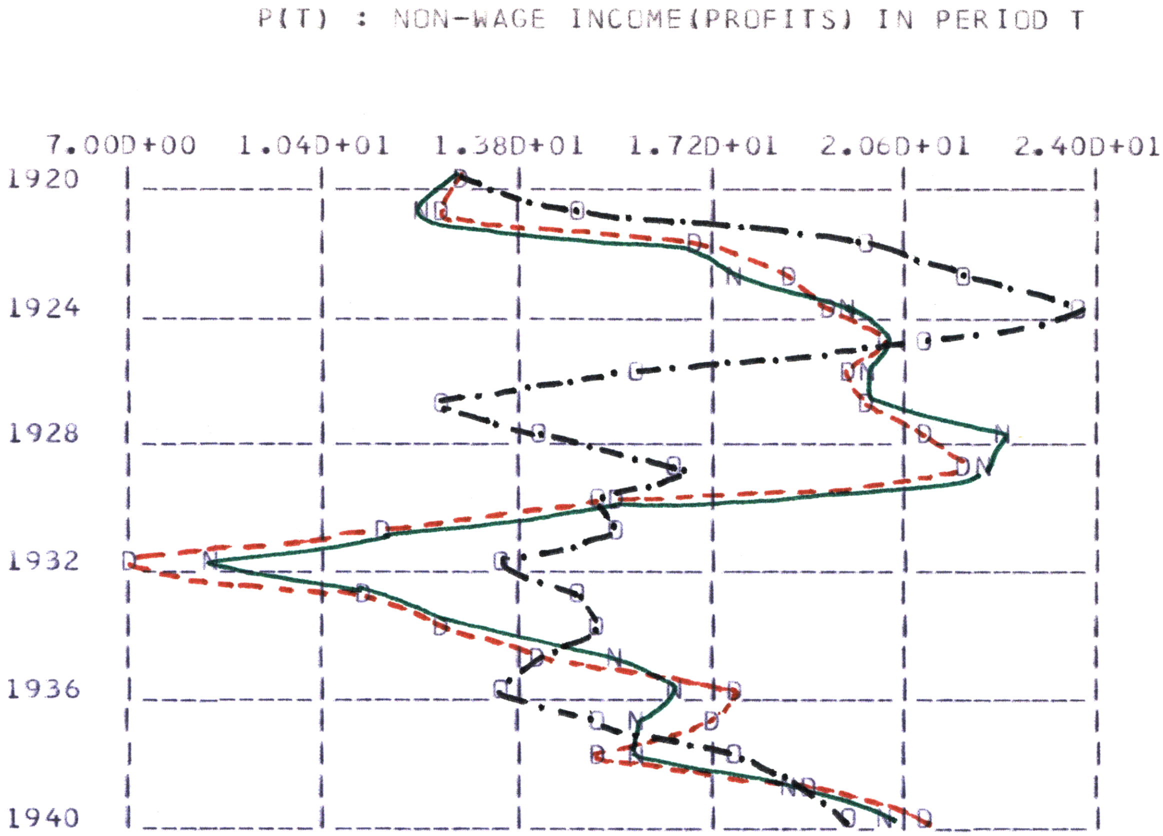


Figure 4.41

P(T) : Non-Wage income(Profits) in Period T

Sensitivity Experiment for 2SLS2 Structure

P(T) : NON-WAGE INCOME(PROFITS) IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
12.7000D+00	12.7000D+00	12.7000D+00	12.7000D+00	0.0	0.0
12.4000D+00	14.7228D+00	11.9912D+00	12.4000D+00	-23.2281D-01	40.8846D-02
16.9000D+00	19.9198D+00	16.7162D+00	16.9000D+00	-30.1984D-01	18.3819D-02
18.4000D+00	21.6115D+00	17.4999D+00	18.4000D+00	-32.1145D-01	90.0147D-02
19.4000D+00	23.5024D+00	19.4626D+00	19.4000D+00	-41.0236D-01	-62.6415D-03
20.1000D+00	21.0241D+00	20.3788D+00	20.1000D+00	-92.4086D-02	-27.8775D-02
19.6000D+00	15.6953D+00	19.7633D+00	19.6000D+00	39.0474D-01	-16.3338D-02
19.8000D+00	12.4809D+00	19.8295D+00	19.8000D+00	73.1907D-01	-29.5272D-03
21.1000D+00	14.1137D+00	22.2922D+00	21.1000D+00	69.8627D-01	-11.9219D-01
21.7000D+00	16.6414D+00	21.7983D+00	21.7000D+00	50.5862D-01	-98.3205D-03
15.6000D+00	15.2897D+00	15.5558D+00	15.6000D+00	31.0301D-02	44.2463D-03
11.4000D+00	15.3691D+00	11.3659D+00	11.4000D+00	-39.6906D-01	34.1321D-03
70.0000D-01	13.5921D+00	82.1990D-01	70.0000D-01	-65.9206D-01	-12.1990D-01
11.2000D+00	14.9328D+00	10.9130D+00	11.2000D+00	-37.3283D-01	28.6963D-02
12.3000D+00	15.3200D+00	12.5551D+00	12.3000D+00	-30.2002D-01	-25.5084D-02
14.0000D+00	15.5301D+00	15.3300D+00	14.0000D+00	-15.3009D-01	-13.3003D-01
17.6000D+00	13.5421D+00	16.4041D+00	17.6000D+00	40.5786D-01	11.9594D-01
17.3000D+00	14.9968D+00	15.6837D+00	17.3000D+00	23.0321D-01	16.1631D-01
15.3000D+00	17.6393D+00	15.8684D+00	15.3000D+00	-23.3933D-01	-56.8401D-02
19.0000D+00	19.0201D+00	18.3926D+00	19.0000D+00	-20.0621D-03	60.7368D-02
21.1000D+00	19.4916D+00	20.2086D+00	21.1000D+00	16.0845D-01	89.1435D-02

QUADRATIC ERROR OLD MODEL: 3002.5669D-01

QUADRATIC ERROR NEW MODEL: 1148.8414D-02

Table 4.42

P(T) : Non-Wage Income(Profits) in Period T

Sensitivity Experiment for 2SLS2 Structure

K(T) : CAPITAL STOCK END OF PERIOD T

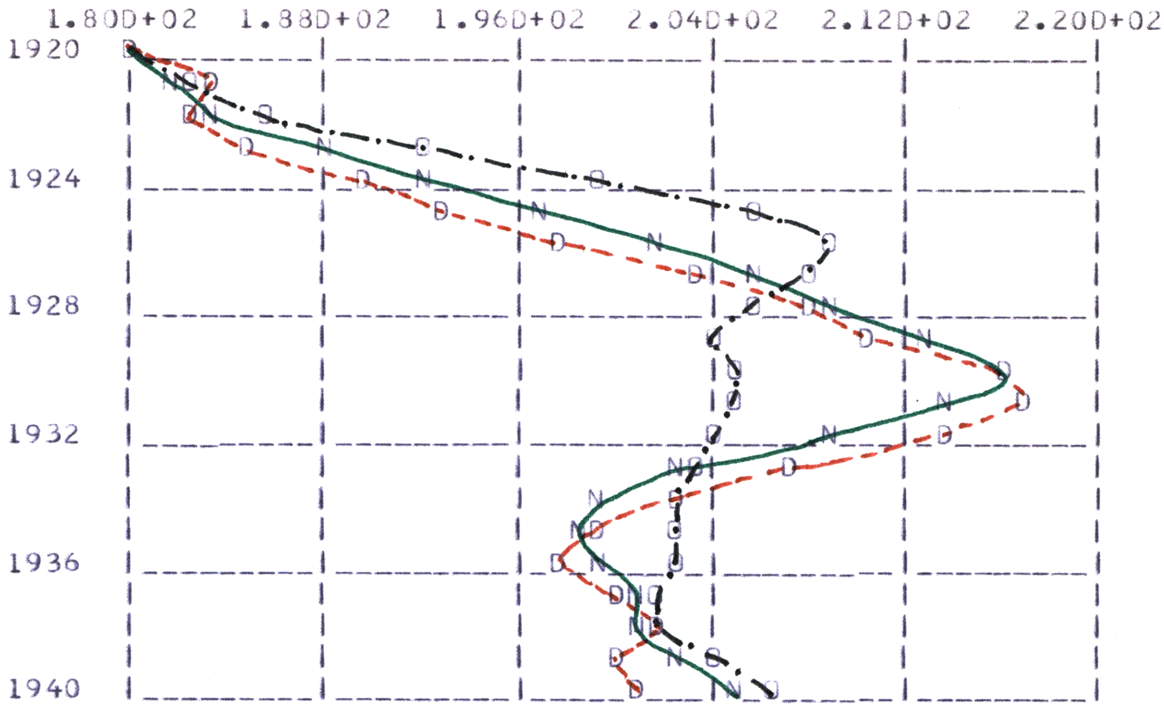


Figure 4.42

K(T) : Capital Stock End of Period T

Sensitivity Experiment for 2SLS2 Structure

K(T) : CAPITAL STOCK END OF PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
18.0100D+01	18.0100D+01	18.0100D+01	18.0100D+01	0.0	0.0
18.2800D+01	18.2147D+01	18.1962D+01	18.2800D+01	65.2999D-02	83.8287D-02
18.2600D+01	18.5589D+01	18.3342D+01	18.2600D+01	-29.8912D-01	-74.2112D-02
18.4500D+01	19.2132D+01	18.7787D+01	18.4500D+01	-76.3216D-01	-32.8664D-01
18.9700D+01	19.8858D+01	19.2150D+01	18.9700D+01	-91.5777D-01	-24.5028D-01
19.2700D+01	20.5576D+01	19.7185D+01	19.2700D+01	-12.8755D+00	-44.8541D-01
19.7800D+01	20.9093D+01	20.1956D+01	19.7800D+01	-11.2932D+00	-41.5577D-01
20.3400D+01	20.8138D+01	20.5501D+01	20.3400D+01	-47.3835D-01	-21.0072D-01
20.7600D+01	20.5249D+01	20.8658D+01	20.7600D+01	23.5133D-01	-10.5824D-01
21.0600D+01	20.4141D+01	21.2939D+01	21.0600D+01	64.5941D-01	-23.3897D-01
21.5700D+01	20.4864D+01	21.5733D+01	21.5700D+01	10.8359D+00	-32.6959D-03
21.6700D+01	20.4542D+01	21.3483D+01	21.6700D+01	12.1577D+00	32.1721D-01
21.3300D+01	20.4209D+01	20.8523D+01	21.3300D+01	90.9100D-01	47.7686D-01
20.7100D+01	20.2803D+01	20.2425D+01	20.7100D+01	42.9721D-01	46.7477D-01
20.2000D+01	20.2582D+01	19.9320D+01	20.2000D+01	-58.1502D-02	26.8002D-01
19.9000D+01	20.2678D+01	19.8056D+01	19.9000D+01	-36.7779D-01	94.3981D-02
19.7700D+01	20.2767D+01	19.8984D+01	19.7700D+01	-50.6719D-01	-12.8432D-01
19.9800D+01	20.1575D+01	20.0444D+01	19.9800D+01	-17.7504D-01	-64.4169D-02
20.1800D+01	20.1763D+01	20.1175D+01	20.1800D+01	37.2420D-03	62.5171D-02
19.9900D+01	20.3827D+01	20.2080D+01	19.9900D+01	-39.2695D-01	-21.7990D-01
20.1200D+01	20.6522D+01	20.4688D+01	20.1200D+01	-53.2191D-01	-34.8831D-01

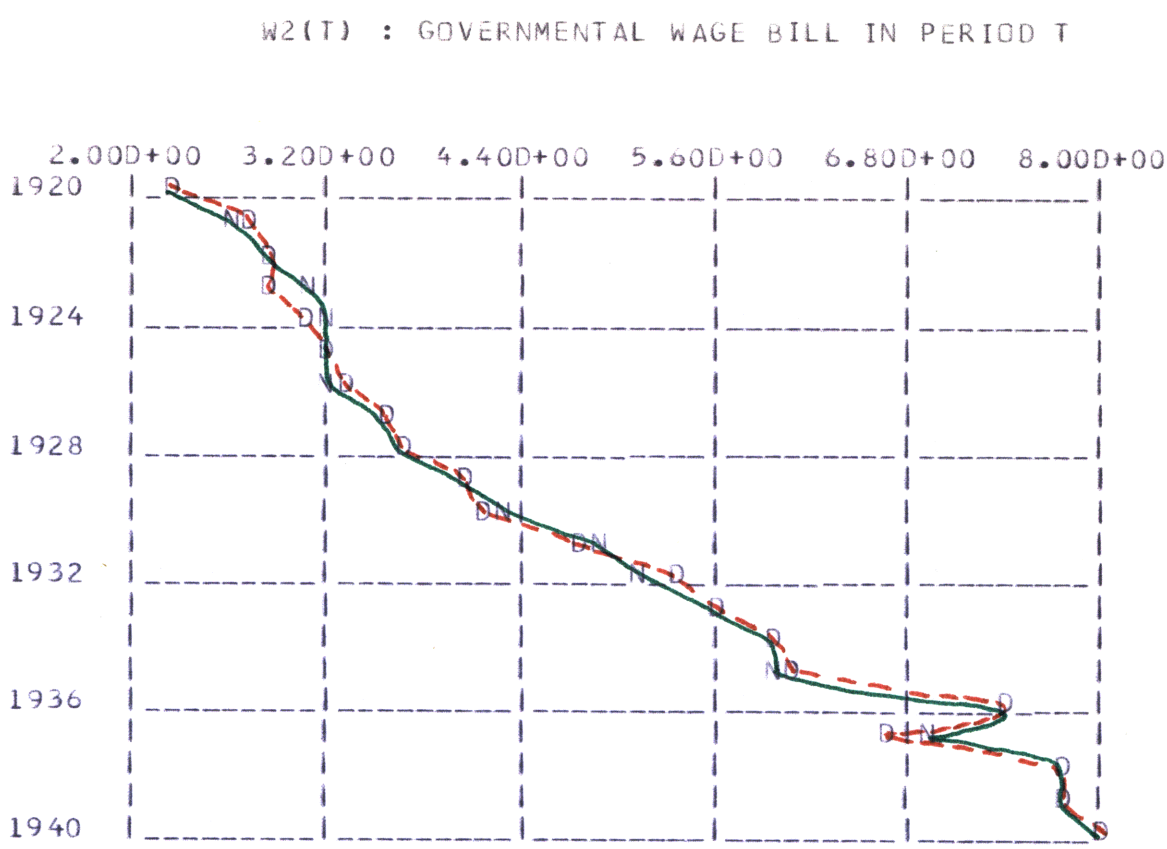
QUADRATIC ERROR OLD MODEL: 9672.7200D-01

QUADRATIC ERROR NEW MODEL: 1489.2481D-01

Table 4.43

K(T) : Capital Stock End of Period T

Sensitivity Experiment for 2SLS2 Structure



<u>Figure 4.43</u>

W2(T) : Governmental Wage Bill in Period T

<u>Sensitivity Experiment for 2SLS2 Structure</u>

W2(T) : GOVERNMENTAL WAGE BILL IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
22.0000D-01	22.0000D-01	22.0000D-01	22.0000D-01	0.0	0.0
27.0000D-01	27.0000D-01	26.5525D-01	27.0000D-01	0.0	44.7457D-03
29.0000D-01	29.0000D-01	28.7235D-01	29.0000D-01	0.0	27.6549D-03
29.0000D-01	29.0000D-01	30.7608D-01	29.0000D-01	0.0	-17.6079D-02
31.0000D-01	31.0000D-01	31.5944D-01	31.0000D-01	0.0	-59.4407D-03
32.0000D-01	32.0000D-01	31.4295D-01	32.0000D-01	0.0	57.0456D-03
33.0000D-01	33.0000D-01	32.3491D-01	33.0000D-01	0.0	65.0877D-03
36.0000D-01	36.0000D-01	35.2973D-01	36.0000D-01	0.0	70.2690D-03
37.0000D-01	37.0000D-01	36.2756D-01	37.0000D-01	0.0	72.4450D-03
40.0000D-01	40.0000D-01	40.7122D-01	40.0000D-01	0.0	-71.2223D-03
42.0000D-01	42.0000D-01	42.4489D-01	42.0000D-01	0.0	-44.8857D-03
48.0000D-01	48.0000D-01	48.5051D-01	48.0000D-01	0.0	-50.5080D-03
53.0000D-01	53.0000D-01	51.7589D-01	53.0000D-01	0.0	12.4107D-02
56.0000D-01	56.0000D-01	55.8815D-01	56.0000D-01	0.0	11.8536D-03
60.0000D-01	60.0000D-01	60.1466D-01	60.0000D-01	0.0	-14.6621D-03
61.0000D-01	61.0000D-01	59.8002D-01	61.0000D-01	0.0	11.9979D-02
74.0000D-01	74.0000D-01	73.9080D-01	74.0000D-01	0.0	92.0093D-04
67.0000D-01	67.0000D-01	69.4083D-01	67.0000D-01	0.0	-24.0825D-02
77.0000D-01	77.0000D-01	77.0371D-01	77.0000D-01	0.0	-37.0577D-04
78.0000D-01	78.0000D-01	78.0629D-01	78.0000D-01	0.0	-62.9310D-04
80.0000D-01	80.0000D-01	79.8352D-01	80.0000D-01	0.0	16.4753D-03

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 1531.7803D-04

Table 4.44

W2(T) : Governmental Wage Bill in Period T

Sensitivity Experiment for 2SLS2 Structure

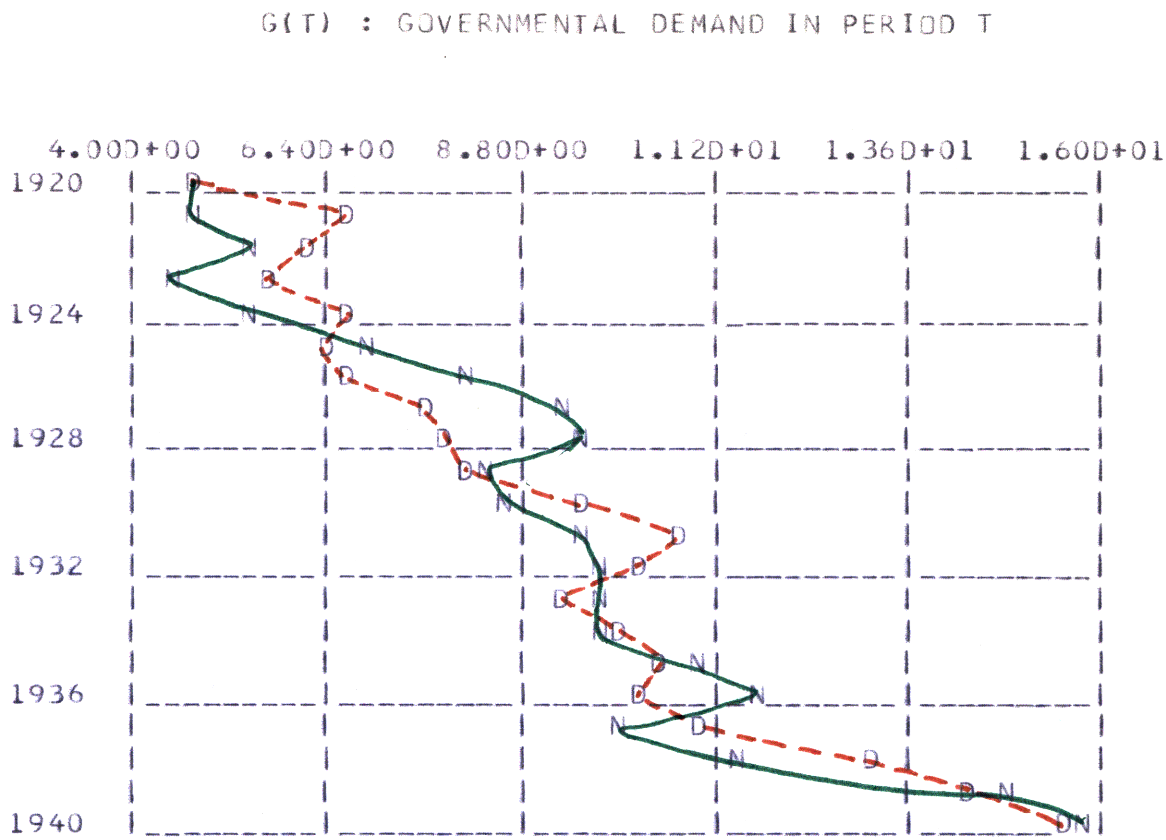


Figure 4.44

G(T) : Governmental Demand in Period T

Sensitivity Experiment for 2SLS2 Structure

G(T) : GOVERNMENTAL DEMAND IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
46.0000D-01	46.0000D-01	46.0000D-01	46.0000D-01	0.0	0.0
66.0000D-01	66.0000D-01	48.2088D-01	66.0000D-01	0.0	17.7912D-01
61.0000D-01	61.0000D-01	55.1292D-01	61.0000D-01	0.0	58.7078D-02
57.0000D-01	57.0000D-01	45.8238D-01	57.0000D-01	0.0	11.1762D-01
66.0000D-01	66.0000D-01	53.6005D-01	66.0000D-01	0.0	12.3995D-01
65.0000D-01	65.0000D-01	68.4324D-01	65.0000D-01	0.0	-34.3241D-02
66.0000D-01	66.0000D-01	80.8468D-01	66.0000D-01	0.0	-14.8468D-01
76.0000D-01	76.0000D-01	92.4781D-01	76.0000D-01	0.0	-16.4781D-01
79.0000D-01	79.0000D-01	94.1802D-01	79.0000D-01	0.0	-15.1802D-01
81.0000D-01	81.0000D-01	83.5793D-01	81.0000D-01	0.0	-25.7928D-02
94.0000D-01	94.0000D-01	85.8554D-01	94.0000D-01	0.0	81.4461D-02
10.7000D+00	10.7000D+00	95.7085D-01	10.7000D+00	0.0	11.2915D-01
10.2000D+00	10.2000D+00	96.7124D-01	10.2000D+00	0.0	52.8758D-02
93.0000D-01	93.0000D-01	96.7292D-01	93.0000D-01	0.0	-37.2920D-02
10.0000D+00	10.0000D+00	98.6203D-01	10.0000D+00	0.0	13.7971D-02
10.5000D+00	10.5000D+00	10.9762D+00	10.5000D+00	0.0	-47.6198D-02
10.3000D+00	10.3000D+00	11.6193D+00	10.3000D+00	0.0	-13.1930D-01
11.0000D+00	11.0000D+00	99.1571D-01	11.0000D+00	0.0	10.8429D-01
13.0000D+00	13.0000D+00	11.4731D+00	13.0000D+00	0.0	15.2692D-01
14.4000D+00	14.4000D+00	14.7129D+00	14.4000D+00	0.0	-31.2907D-02
15.4000D+00	15.4000D+00	15.8152D+00	15.4000D+00	0.0	-41.5207D-02

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 2132.5580D-02

Table 4.45

G(T) : Governmental Demand in Period T

Sensitivity Experiment for 2SLS2 Structure

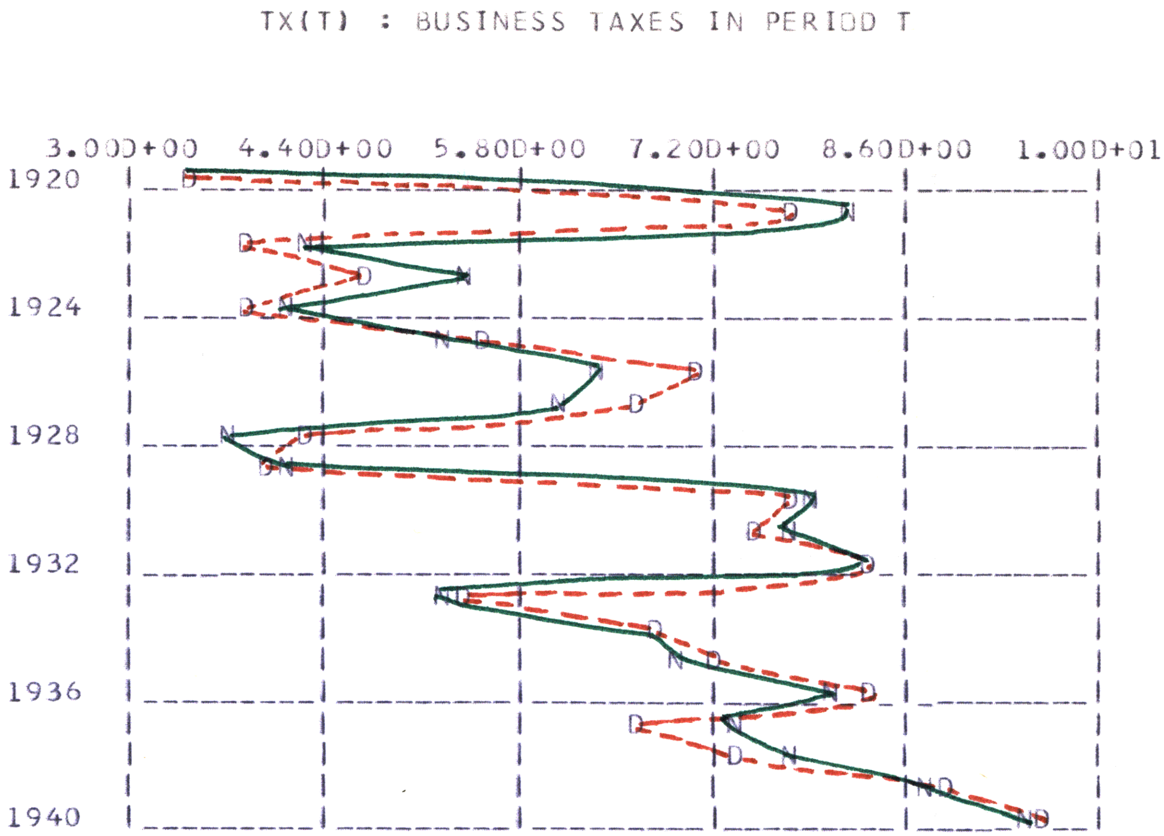


Figure 4.45

TX(T) : Business Taxes in Period T

Sensitivity Experiment for 2SLS2 Structure

TX(T) : BUSINESS TAXES IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
34.0000D-01	34.0000D-01	34.0000D-01	34.0000D-01	0.0	0.0
77.0000D-01	77.0000D-01	81.6626D-01	77.0000D-01	0.0	-45.6263D-02
39.0000D-01	39.0000D-01	43.0792D-01	39.0000D-01	0.0	-40.7917D-02
47.0000D-01	47.0000D-01	53.9883D-01	47.0000D-01	0.0	-69.8828D-02
38.0000D-01	38.0000D-01	41.8838D-01	38.0000D-01	0.0	-38.8380D-02
55.0000D-01	55.0000D-01	52.1715D-01	55.0000D-01	0.0	28.2846D-02
70.0000D-01	70.0000D-01	63.4530D-01	70.0000D-01	0.0	65.4700D-02
67.0000D-01	67.0000D-01	60.4367D-01	67.0000D-01	0.0	65.6328D-02
42.0000D-01	42.0000D-01	37.6947D-01	42.0000D-01	0.0	43.0533D-02
40.0000D-01	40.0000D-01	40.8952D-01	40.0000D-01	0.0	-89.5218D-03
77.0000D-01	77.0000D-01	79.6632D-01	77.0000D-01	0.0	-26.6319D-02
75.0000D-01	75.0000D-01	77.7167D-01	75.0000D-01	0.0	-27.1674D-02
83.0000D-01	83.0000D-01	82.8072D-01	83.0000D-01	0.0	19.2784D-03
54.0000D-01	54.0000D-01	52.7726D-01	54.0000D-01	0.0	12.2740D-02
68.0000D-01	68.0000D-01	67.9944D-01	68.0000D-01	0.0	55.0404D-05
72.0000D-01	72.0000D-01	69.4158D-01	72.0000D-01	0.0	25.8416D-02
83.0000D-01	83.0000D-01	80.5203D-01	83.0000D-01	0.0	24.7971D-02
67.0000D-01	67.0000D-01	73.5145D-01	67.0000D-01	0.0	-65.1447D-02
74.0000D-01	74.0000D-01	78.0597D-01	74.0000D-01	0.0	-40.5971D-02
89.0000D-01	89.0000D-01	87.0969D-01	89.0000D-01	0.0	19.0311D-02
96.0000D-01	96.0000D-01	93.9528D-01	96.0000D-01	0.0	20.4723D-02

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 3111.5325D-03

Table 4.46

TX(T) : Business Taxes in Period T

Sensitivity Experiment for 2SLS2 Structure

4.5 Interpretation of Results

Up to this point, the sensitivity of the "new" model has been tested to three different estimation procedures and two different structures. In previous sections numerical results and some interpretations of each particular experiment were given. In this section we shall interpret the results as a whole.

In table 4.47 the quadratic errors for both the "old" and "new" model are tabulated for every variable and each estimation procedure. From a detailed analysis of this table we can conclude that in general the behavior of the "new" model is not affected significantly by the use of different estimation procedures. However, it is noted that statistical accuracy on the original structures improves the performance of the new model. In this context, we note, that the OLS, the structure with the worst statistical properties, is the one that originates the new structure with the worst performance. Furthermore, FIML, the structure with the worst performance in reproducing the historical values gives us the best performance for the new structure. This could be explained by the fact that small samples and possible misspecification low down the performance of FIML, but still it is FIML, the procedure with more statistical information, and therefore the new model corresponding to this structure is the one that is going to perform the best.

Another interesting observation is related to the rule of thumb used very often by forecasters: "Do not drop any variable with coefficient not significantly different from zero, because

TABLE 4.47

QUADRATIC ERRORS FOR DIFFERENT ESTIMATION PROCEDURES AND MODEL STRUCTURES

Variable	MODEL	OLS	2SLS	FIML	OLS2	2SLS2
Consumption (C)	OLD	726.41	354.29	1243.20	795.08	483.87
	NEW	204.11	21.25	7.158	203.84	17.28
Investment (I)	OLD	265.68	164.98	572.55	297.04	216.69
	NEW	14.94	24.65	13.37	14.62	25.07
Private Wage (W1)	OLD	893.26	315.11	1027.93	957.96	421.10
	NEW	435.38	29.21	20.91	433.56	25.89
Income (Y)	OLD	1650.04	976.16	3420.99	1841.35	1317.91
	NEW	247.26	54.54	22.13	244.10	45.59
Profits (P)	OLD	418.24	223.72	856.44	464.49	300.25
	NEW	37.39	13.08	7.534	37.91	11.48
Capital Stock (K)	OLD	3166.62	729.12	1952.0	3135.55	967.27
	NEW	673.99	157.55	198.91	673.97	148.92
Public Wage (W2)	OLD	0.0	0.0	0.0	0.0	0.0
	NEW	0.9798	0.1702	0.1167	0.9733	0.1531
Government Expenditure (G)	OLD	0.0	0.0	0.0	0.0	0.0
	NEW	17.67	23.41	16.86	18.33	21.82
Taxes (TX)	OLD	0.0	0.0	0.0	0.0	0.0
	NEW	16.77	3.155	3.401	16.88	3.111

this degrades the performance of your model." It turns out, that this rule of thumb is true for the original structures, but it is not valid for the new model. The new structures OLS2 and 2LSS2 were obtained by dropping the variables with coefficients not significantly different from zero, by doing this their performance dicreased compared with the original structures OLS and 2SLS, but the new structures obtained with these models improved their performance with respect to the new structures obtained with OLS and 2SLS. Again, this could be explained by the fact, that dropping variables and estimating the models again, increases the statistical accuracy of the models, and therefore the new structures are going to perform better.

In solving the finite horizon optimal control problem the solution for the optimal control was given by equation (2.10):

$$\mu^*(t) = -G(t)x(t) + h(t) \tag{4.5}$$

Where G(t) was obtained from the solution of the Ricatti Equation given by equation (2.13)

$$P(t) = A^T P(t+1)A + C^T Q(t)C - G^T(t)M^{-1}(t)G(t) \tag{4.6}$$

This equation was solved backwards on time and a typical result for the different elements of matrix G(t) is given in Figure (4.46). In this figure iteration 1 corresponds to the year 1940 and iteration 20 to the year 1920. From this figure we see that the system goes to the steady state relatively fast, therefore, the results obtained in Chapter 3 for the infinite time optimal control problem can be utilized in this case to study the results. Note that for our experiments the cost matrices Q(t) and R(t) were chosen

TABLE 4.48

STEADY STATE VALUES OF THE GAIN MATRIX G(t) CORRESPONDING TO DIFFERENT ESTIMATION PROCEDURES AND MODEL STRUCTURES.

	OLS	2SLS	FIML	OLS1	2SLS1
G(1.4)*	0.008080	0.01247	0.01138	0.007737	0.01164
G(1.5)	-0.01487	-0.001665	-0.01977	-0.01728	-0.008125
G(1.6)	-0.006368	-0.001065	-0.003201	-0.006716	-0.001597
G(1.7)	-0.008080	-0.01247	-0.01138	-0.007737	-0.01164
G(1.9)	0.008080	0.01247	0.01138	0.007737	0.01164
G(2.4)	0.008524	0.0272	0.001632	0.007246	0.02631
G(2.5)	0.3192	0.5327	0.3396	0.2529	0.4492
G(2.6)	-0.05929	-0.0882	-0.08070	-0.06443	-0.09336
G(2.7)	-0.008524	-0.0272	-0.001632	-0.007246	-0.02631
G(2.9)	+0.008524	+0.0272	+0.001632	0.007246	0.02631
G(3.4)	0.02129	0.02067	0.02685	0.02137	0.02003
G(3.5)	-0.1182	-0.1561	-0.1250	-0.1006	-0.1401
G(3.6)	-0.--3813	0.01634	0.01052	-0.002936	0.01706
G(3.7)	-0.02129	-0.02067	-0.02685	-0.02137	-0.02003
G(3.8)	+0.02129	0.02067	0.02685	0.02137	0.02003

*The remaining elements of the gain matrix are zero.

to be constant. This is the main reason why we have obtained steady state solutions, besides the already known stability properties of the model.

Utilizing the results for the infinite time optimal control problem the values for the gain matrix (G) were obtained and are shown on Table 4.48.

By studying the steady state values for the different gains corresponding to the different structures (Table 4.3) we note that the elements of the gain matrix that relate the "policy" variable and profits (P) are significantly higher than other elements, specially for the government expenditure policy variable (G). A possible explanation for this could be given by the fact that the original model does not explain correctly for profits, therefore the new structure in order to disclose this "hidden" relationship among the different variables and profits, includes in the close loop specification a higher information for this particular variable via its gains.

Using the steady state value for the gain matrix and the elements of the original models (matrices A and B) the steady state solution for the new model was obtained using equation (2.36).

$$A_u = \{A - BG_{1.T}\} \qquad (4.7)$$

(the values of matrices A and B for the different structures are shown on Tables 4.49 and 4.50).

Now, we will try to give an interpretation from the point of view of control theory of why our new model has a very low sensitivity to the different estimation procedures and the different structures.

TABLE 4.49

VALUE OF ELEMENTS OF MATRIX A FOR DIFFERENT ESTIMATION PROCEDURES AND MODEL STRUCTURES

	OLS	2SLS	FIML	OLS1	2SLS1
A(1,4)	0.1184	0.2159	0.1340	0.1030	0.2037
A(1.5)	0.7993	0.6980	0.8138	0.6921	0.6304
A(1.6)	-0.1875	-0.1059	-0.2353	-0.2323	0.1554
A(1.7)	-0.1184	-0.2159	-0.1340	-0.1030	0.2037
A(1.9)	0.1184	0.2159	0.1340	0.1030	0.2037
A(2.4)	-0.05225	-0.003625	-0.06174	-0.05791	0.004141
A(2.5)	0.7494	0.7451	0.7969	0.7100	0.7422
A(2.6)	-0.2218	-0.1808	-0.2560	-0.2383	0.1829
A(2.7)	0.05225	0.003625	0.06174	0.05791	0.004141
A(2.9)	-0.05225	-0.003625	-0.06174	-0.05791	-0.004141
A(3.4)	0.1751	0.2657	0.2344	0.1658	0.2606
A(3.5)	0.6806	0.5823	0.5968	0.6162	0.5539
A(3.6)	-0.1799	-0.1157	-0.1820	-0.2068	-0.1365
A(3.7)	-0.1751	-0.2657	-0.2344	-0.1658	-0.2606
A(3.9)	0.1751	0.2657	0.2344	0.1658	0.2606
A(4.4)	0.06611	0.2123	0.07221	0.04507	0.1995
A(4.5)	1.549	1.443	1.611	1.402	1.3730
A(4.6)	-0.4094	-0.2867	-0.4913	-0.4706	-0.3383
A(4.7)	-0.0611	-0.2123	-0.07221	-0.04507	-0.1995
A(4.9)	0.0611	0.2123	0.07221	+0.04507	0.1995
A(5.4)	-0.1089	-0.05344	-0.1622	-0.1207	-0.06105
A(5.5)	0.8681	0.8608	1.014	0.7859	0.8187
A(5.6)	-0.2295	-0.1710	-0.3092	-0.2638	-0.2018
A(5.7)	0.1089	0.05344	0.1622	0.1207	0.06105
A(5.9)	-0.1089	-0.05344	-0.1622	-0.1207	-0.06105

TABLE 4.49

VALUE OF ELEMENTS OF MATRIX A FOR DIFFERENT ESTIMATION PROCEDURES AND MODEL STRUCTURES

(Cont.)

	OLS	2SLS	FIML	OLS1	2SLS1
A(6.4)	-0.05225	-0.003625	-0.06174	-0.05791	-0.004141
A(6.5)	0.7494	0.7451	0.7969	0.7100	0.7422
A(6.6)	0.7782	0.8192	0.744	0.7617	0.8171
A(6.7)	0.05225	0.003625	0.06174	0.05791	0.004141
A(6.9)	-0.05225	-0.003625	-0.06174	-0.05791	0.004141

*The remaining elements are equal to zero

TABLE 4.50

VALUE OF ELEMENTS OF MATRIX B FOR DIFFERENT ESTIMATION PROCEDURES AND MODEL STRUCTURES

	OLS	2SLS	FIML	OLS1	2SLS1
B(1,1)	0.4544	0.7152	0.04061	0.3728	0.6640
B(1,2)	1,677	0.6257	1.702	2.078	0.918
B(1.3)	-1.321	-0.1419	-1.463	-1.768	-0.4616
B(2.1)	-0.2006	-0.01201	-0.1872	-0.2306	-0.01417
B(2.2)	0.9845	0.06855	0.8515	1.132	0.08088
B(2.3)	-1.142	-0.07667	-0.9616	-1.306	-0.09015
B(3.1)	-0.3279	-0.1198	-0.2894	-0.3770	-0.1413
B(3.2)	1.609	0.6836	1.316	1.850	0.8066
B(3.3)	-1.082	-0.08818	-0.8982	-1.351	-0.2226
B(4.1)	0.2538	0.7032	0.2189	0.1421	0.6499
B(4.2)	3.662	1.694	3.553	4.210	1.999
B(4.3)	-3.463	-1.219	-3.424	-4.074	-1.552
B(5.1)	-0.4183	-0.1770	-0.4917	-0.4809	-0.2089
B(5.2)	2.053	1.011	2.237	2.360	1.192
B(5.3)	-2.38	-1.130	-2.526	-2.723	-1.329
B(6.1)	-0.2006	-0.01201	-0.1872	-0.2306	-0.01417
B(6.2)	0.9845	0.06855	0.8515	1.132	0.08088
B(6.3)	-1.142	-0.07667	-0.9616	-1.306	-0.09015
B(7.1)	1.0	1.0	1.0	1.0	1.0
B(8.2)	1.0	1.0	1.0	1.0	1.0
B(9.3)	1.0	1.0	1.0	1.0	1.0

TABLE 4.51

EIGENVALUES FOR THE "OLD" AND "NEW" MODELS FOR THE DIFFERENT ESTIMATION PROCEDURES AND MODEL STRUCTURES.

		OLS	OLS2
FIRST ROOT	OLD	0.24015	0.35756
	NEW	0.8084	0.8080
SECOND ROOT	OLD	0.2507+j0.9253	0.6175±j0.3492
	NEW	0.0181+j0.0938	0.0074+j0.0569
THIRD ROOT	OLD	0.2507-j0.9253	0.6175-j0.3492
	NEW	0.0181-j0.09032	0.0074-j0.0569

		2SLS	2SLS2	FIML
FIRST ROOT	OLD	0.3426	0.3483	0.4446
	NEW	0.7748	0.7757	0.798316
SECOND ROOT	OLD	0.7752+j 0.3666	0.7434+j 0.3959	0.6928+j 0.5125
	NEW	0.1858+j 0.1978	0.1541+j 0.1936	0.04657+j 0.1004
THIRD ROOT	OLD	0.7752-j 0.3666	0.7434-j 0.3959	0.6928-j 0.5125
	NEW	0.1858-j 0.1978	0.1541-j 0.1936	0.04657-j 0.1084

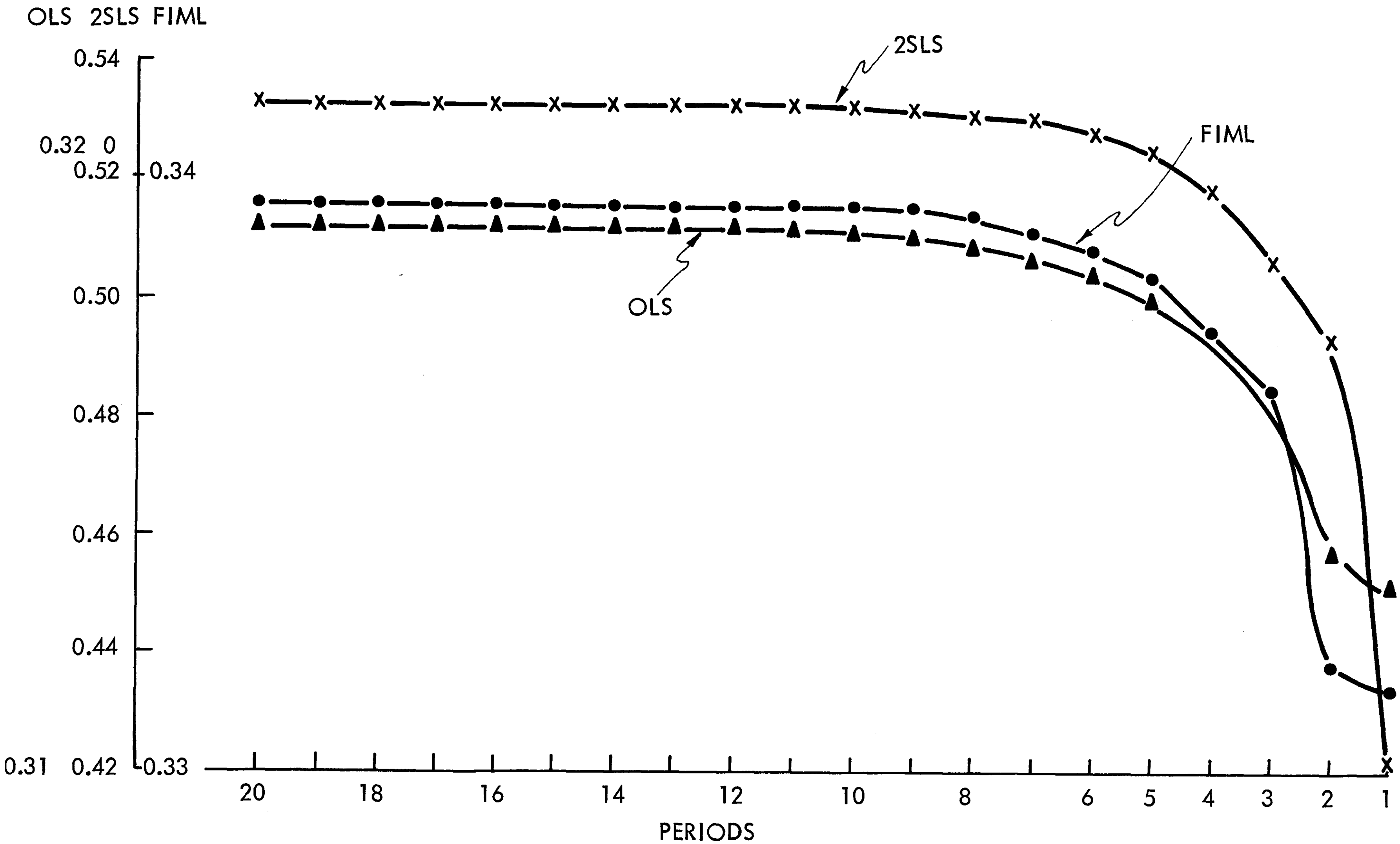


Figure 4.55

Selected Feedback Gain Values For Different Estimation Procedures

In Chapter three, we pointed out that the stability properties of a model are given by the position of the eigenvalues of the matrix A in the "z" plane. So, now, we would like to compare the position of the eigenvalues of the original models and the position of the eigenuvalues of the steady state solution of matrix A_u ("new" model).

The eigenvalues of the "old" models and of their corresponding "new" structures are shown in Table 4.51 and Figure (4.47)

From these figures we obtain surprisingly results. First, we observe that for the old model the positions of the complex roots vary with the different estimation procedure and with different structure. The same remark can be applied to the real roots. These facts give us a clear idea of the reason of obtaining different simulation results with the different versions of the model. Besides the module of the complex roots is very near to the unity and therefore, the stability of this models could be questioned. On the other hand, the position of all the roots corresponding to the new structures are all concentrated in small regions of the "z" plane. This fact explains clearly why the "new" structures behave in a very similar fashion independently of the estimation procedures or different structure.

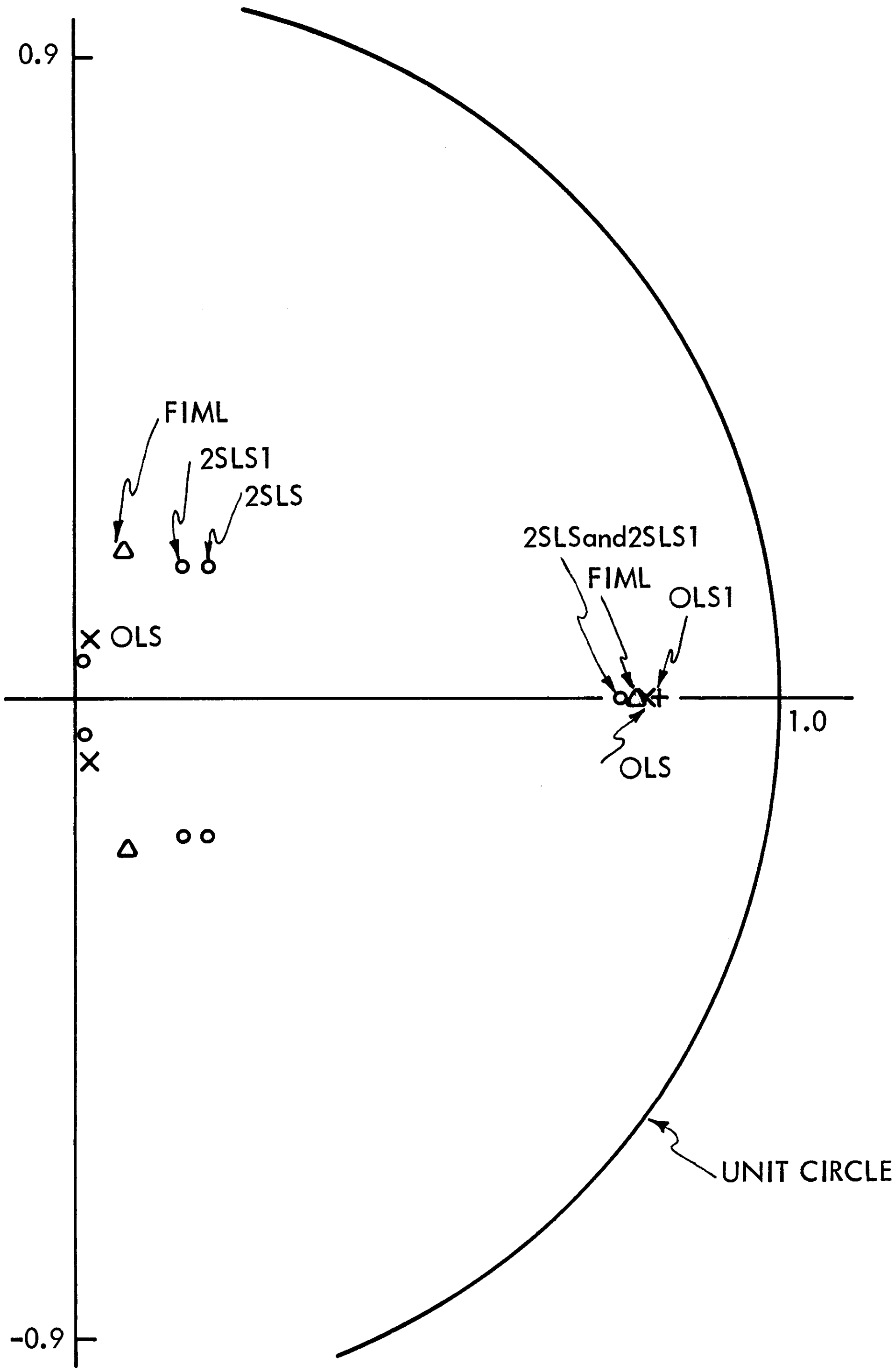


Figure 4.56

Eigenvalues position for "Old" Model for

Different Estimation Procedures and Different structures

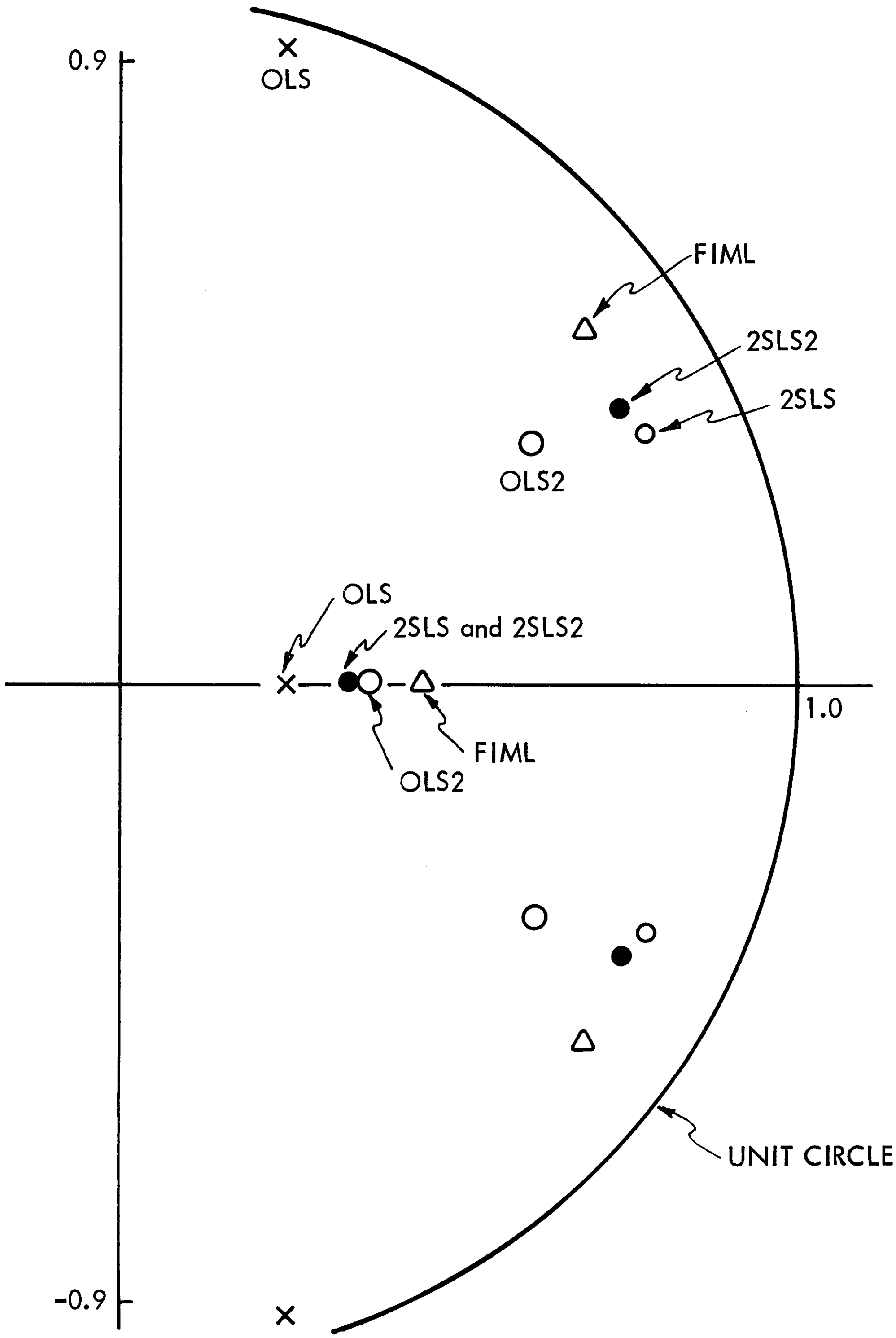


Figure 4.57

Eigenvalues position for "NEW" Model for Different Estimation Procedures and Different Structures

4.6 Important Remarks

In this chapter we have shown that in general the "new" structure has a very low sensitivity to different estimation procedures and different structures. This property should be stressed since it allows to assume that the forecasting properties of the "new" structure are going to be similar no matter which estimation procedure was used to obtain the original econometric model.

A more detailed study of the experiments has shown that the accuracy of the "new" model is slightly increased when the original model has more statistical accuracy, even if the simultation properties of the last one is poor.

Also, a possible interpretation of the insensitivity of the new model in term of the eigenvalues position on the "z" plane has been given.

Up to this point we have tested the sensitivity of the new model to different estimation procedures and different structures and the results have been quite satisfactory. So now, we would like to turn our search to study the effects of changing the elements of the cost matrices Q(t) and R(t). Eventhough, a full study of the effects of changing the coefficients of Q(t) and R(t) was not made, some experiments were made in this context, namely, the weights corresponding to the variables consumption(C) and profits (P) were increased in independent runs by 100% and 200%. The results shown insignificant changes in the performance of the different variables. This experiment was made for the 2SLS model and the increase of weighs on profits show a slightly higher change in the performance of the entire model with respect to the changes motivated by the increased of weights in consumption. It seems premature at this stage to conclude that by observing the change in performance of the model, it could be possible to figure out which variables are not well explained by the model.

Chapter 5

FORECASTING PROPERTIES OF THE "NEW" MODEL

5.1 INTRODUCTION

In Chapter Four we have discussed the sensitivity of the "new" model, to different estimation procedures and model structures, for the period for which the model was estimated (i.e., during the period of fit.) In this chapter, we shall study the forecasting properties of the "new" model. In other words, the behavior of the new structure beyond the period of fit. This shall be carried out by means of several experiments to be described in the next sections. The objective of these experiments is to point out two main properties of the "new" model, namely:

- o Capability to incorporate subjective forecasts into the model.
- o Insensitivity to estimation procedures and model structures.

The main problems, that usually arise in forecasting with standard econometric models, are concerned with the poor performance of the models out of the period of fit and the sensitivity of the forecasts to the estimation procedures; see for example Pindyck (1975) { }. Furthermore, forecasters very often complain about the incapability of the econometric models to include information about the future behavior of the economy, i.e., subjective forecasts are very difficult or almost impossible to incorporate into standard econometric models.

In this context, we shall consider the "new" model developed in Chapter 2, and its properties related to the improvement of forecast accuracy with respect to standard econometric models.

In the following sections, a description of the experiments is given firstly. Next, results for selected experiments are given with some interpretations. In the last section a comparative study of the results is presented, and some important remarks are included as well.

5.2 Description of the Experiments

Before we start describing the experiments we would like to introduce some terminology commonly used by economists to differenciate forecasts methods. Most of the definitions to be presented have been taken from Klein's book; "An Econometric Model of the United States" 1929 - 1952, Chapter V (1955) { }.

A forecast could be defined as a quantitative estimate, or set of estimates about the likelihood of future events based on past and current information. This "past and current information" is embodied in the form of a model. By extrapolating the model out beyond the period over which it was estimated, we can make forecast about future events.

It is useful to distinguish between two types of forecasting, "Ex Post" forecast and "Ex Ante" forecast. Both forecasts predict values of dependent variables (endogenous) beyong the time period in which the model was estimated. However, in an "Ex Post" forecast the forecast period is such that observations on both endogenous variables and exogenous variables are known with certainty. Thus, "Ex-Post" forecast can be checked against existing data, and provide a means of evaluating the forecasting properties of a model. On the other hand an "Ex Ante" forecast predicts values of the endogenous variables beyond the estimation period, using exogenous variables which may or may not be known with certainty. The distinction between "Ex Post" and "Ex Ante" forecasting can be seen in Figure 5.1 (This figure was taken from Pindyck (1975) (pg. 157) { }.

A distinction may also be made between "conditional" and "unconditional" forecasts. In an "unconditional" forecast, values for all the exogenous variables are known with certainty. In a "conditional" forecast, values for one or more exogenous variables are not known with certainty, so that guesses for them must be used to produce the forecast of the endogenous variables.

In our experiments we are concerned with "Ex Post" forecasts since we want to check the performance of the models. However, because the particular structure of the "new" model, we need to know in advance not only every exogenous variable but also the desired trends for each endogenous variable and the different weights of the cost matrices in the objective function. In a forecasting environment, we have interpreted the inclusion of the desired trends for each endogenous variable as the inclusion of the foreseeable future into the model, and the weights for each variable as the degree of confidence that we have in each individual desired trend. In other words, at a given period of

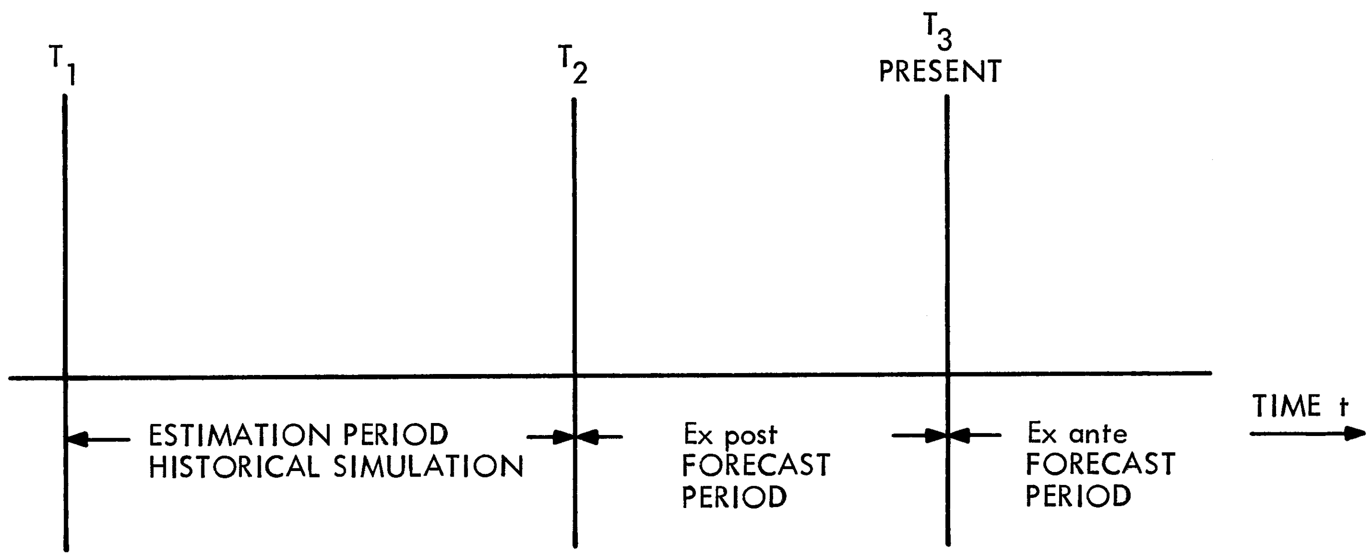

T_1
T_2
T_3
PRESENT
ESTIMATION PERIOD
HISTORICAL SIMULATION
Ex post
FORECAST
PERIOD
Ex ante
FORECAST
PERIOD
TIME t

Figure 5.1

time, forecasters know, by means of different sources as economic expert opinions, political opinions, polls, etc., to certain extent the future path of selected endogenous variables, so it looks as a natural idea to include them into the model by means of the desired trends. On the other hand, the degree of confidence on these "Subjective Forecasts" would be reflected on the weights of the cost matrices in the objective function.

Taking the previous ideas into account, a set of values for the desired trends of the endogenous variables was chosen in a very gross manner for the period 1941-1952 for which the forecast experiments would be run.

Private investment was chosen to remain constant for this period at one billion of constant dollars. The national income was assumed to increase at a constant rate of three billion of constant dollars per year, and finally the private wage bill (W1) or the demand for labor was assumed to increase at a rate of two billion of constant dollars per year. The trends corresponding to the remaining endogenous variables were obtained from the definition equations of the model as to obtain a consistent set of data. The values for the desired trends for the endogenous variables for the period 1941-1952 are shown in Table 5.1.

It should be pointed out at this stage, that since the obtention of the new structure requires the solution of the optimal tracking problem for the entire period i.e., from 1920-1952. The historical values used in Chapter Four were assigned to the desired trends for the period 1920-1940, and the values discussed in the previous paragraph to the period 1941-1952. This should be interpreted as if the "new" structure use the period from 1920 - to 1940 to learn about the dynamics of the system. Therefore, the "new" structure will use, the information of the historical period (i.e. 1920-1940) plus the subjective forecast incorporated into the new model through the solution of the optimal control problem, to produce the forecast for the period 1941-1952.

Due to limitation on the computer program the weights for the forecasting period remained the same as for the historical period, i.e., the normalized weights described in Chapter Four were used for the entire period 1920-1952.

The historical values for the exogenous variables (control and purely exogenous) for the period 1920-1940 were the same values used to run the experiments of Chapter Four. The historical values for the period 1941-1952 (the forecasting period) were obtained from the Klein-Goldberger Model (1955) { }, adjusted for 1932 dollar value.

The forecast experiment was run for each model structure described in Chapter 2 (i.e., OLS, 2LSS, FIML, OLS2, 2SLS2) and numerical results for selected runs are shown in the next sections.

5.3 Presentation of Results

In the next pages numerical results for selected runs of the forecast experiment are presented. The runs for the structures corresponding to OLS2 and 2SLS2 are not presented in detail because their similarity with the runs corresponding to OLS and 2SLS (for a summary of the quadratic errors of the different structures the reader is referred to Table 5.56 of

YEAR	C	I	W1	Y	P	K_{-1}
1941	74.20	1.0	45.0	82.0	27.86	204.5
1942	62.81	1.0	47.0	85.0	17.99	205.5
1943	61.14	1.0	49.0	88.0	11.88	206.5
1944	61.71	1.0	51.0	91.0	10.63	207.5
1945	70.73	1.0	53.0	94.0	15.91	208.5
1946	89.54	1.0	55.0	97.0	27.82	209.5
1947	93.57	1.0	57.0	100.0	32.50	210.5
1948	96.27	1.0	59.0	103.0	33.62	211.5
1949	97.05	1.0	61.0	106.0	33.38	212.5
1950	103.94	1.0	63.0	109.0	33.86	213.5
1951	106.07	1.0	65.0	112.0	32.48	214.5
1952	105.08	1.0	67.0	115.0	31.94	215.5

TABLE 5.1

DESIRED TRENDS FOR THE ENDOGENOUS VARIABLES FOR THE PERIOD 1941-1952 of section 5.4)

In interpreting the numerical results we must be aware that the forecasting period correspond to a very difficult period to predict (i.e. the Second World War) and several authors prefer to skip this period because its difficult. However, we have chosen not to skip this period because we are not too much interested in the accuracy of the forecast but in comparing the forecasting properties of the "new" model against the performance of standard econometric models. In this context, the period corresponding to the Second World War presents a challenging test to the forecasting properties of the new model.

5.3.1 Forecasting With the OLS Structure

For this experiment the standard econometric model ("old" model) was obtained by applying the ordinary least squares estimation procedure to Klein's structure.

The results are shown numerically and graphically in Tables 5.2 to 5.19 and in Figures 5.1 to 5.18. In each diagram time runs along the vertical axis, the desired path is denoted by letter "D", historical values by letter "H" the "old" model simulated path by "O" and the new model path by "N".

The first thing we note in the diagrams is the striking difference between the forecasts given by the "old" model and the "new" model.

We observe that the big oscilation produced by the "old" model is mainly produced by the suddenly increase of the policy variables during the period corresponding to the Second World War. At the same time we note that the "new" model dampens this big oscilation, but still keeps some dynamics so as to explain for the big jump on the policy variables.

Some variables, as national income (Y) and investment (I) are tracked very well by the "new" model, even for the war period.

We observe that some of the characteristics of the "new" model, observed during the historical simulation (1920-1940) in Chapter Four, are retained when solving the "new" model for the period (1920-1952), namely, the "new" model gives upward biased values for most of the variables. This property was discussed in Chapter Four, and was attributed to the ordinary least squares estimation procedure. (i.e., OLS gives biased estimates because it is not a simultaneous equation estimation procedure).

Another property that we observe in the "new" model is that once the war period is over, its simulated path approaches the historical path much faster than the simulated path by the "old" model. This could be explained by the fact that the new structure (closed-loop structure) under the presence of disturbances regains its nominal path much faster than an open loop structure as the "old" model.

Many of the differences encountered in variables as consumption (C), and capital stock (K) could be possible due to the fact that profits are not well explained in the original model. In Chapter Four we observed big values for the feedback gains corresponding to this variable. Besides, for this experiment the desired path for profits during the war period was set far away from the historical path. These facts motivate the "new" model to depart significantly from the historical values for profits. Therefore, consumption (C) and capital stock (K), that depend heavely in profits exhibit A wrong behavior, specially for the period in which profits are far away from the historical values (1941-1945).

In fact, later runs with desired paths adjusted as to explain a closer approach of the desired path for profits to the historical path, and with higher weight in the coefficient corresponding to profits, have shown a significant improvement in the performance of profits (P) and consumption (C), however, the performance of national income (Y) for the same run decreased significantly. This will be discussed in more detail in Section 5.4.

C(T) : CONSUMPTION IN PERIOD T

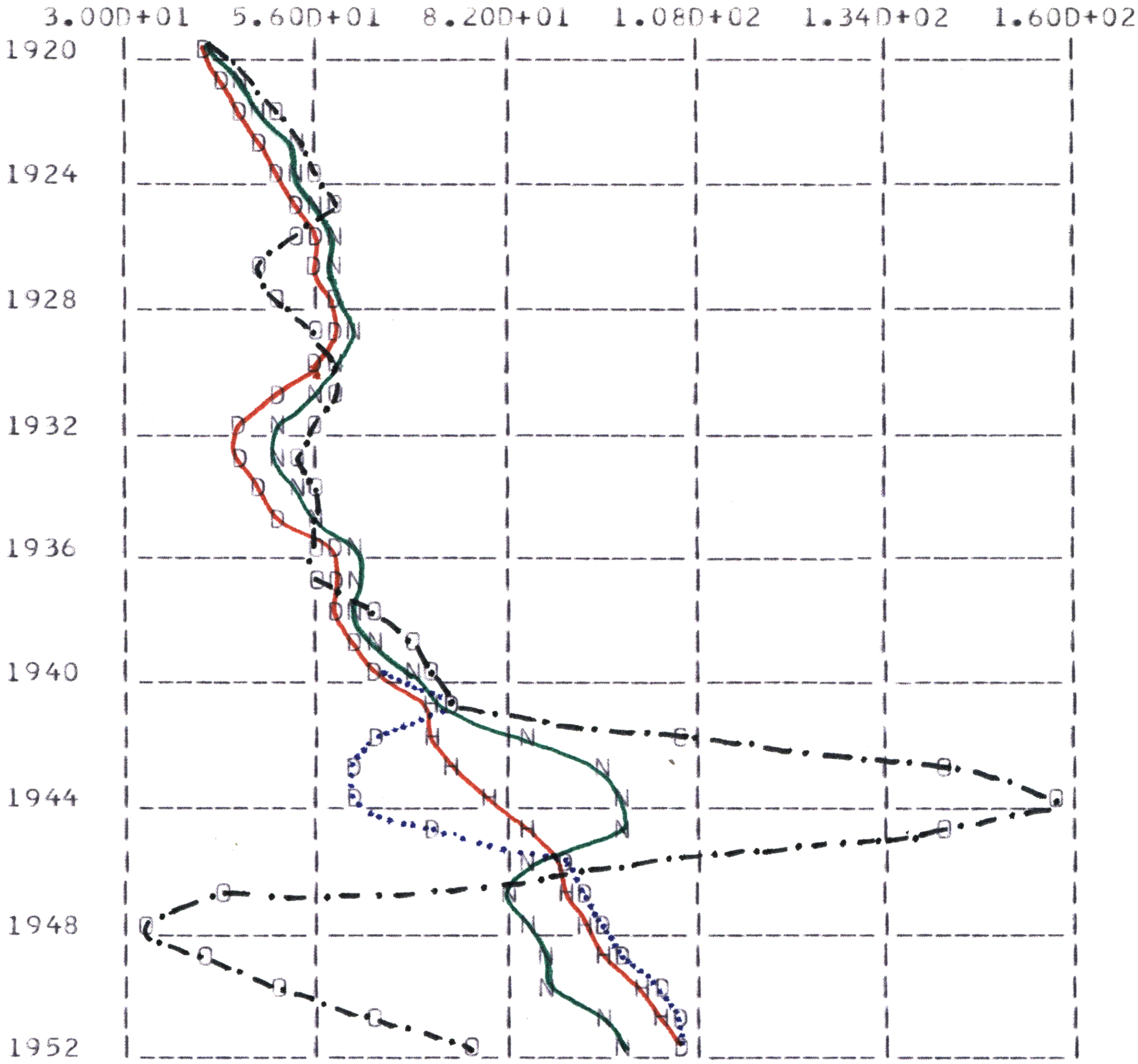


Figure 5.2

C(T) : Consumption in Period T

Forecasting Experiment for OLS Structure

C(T) : CONSUMPTION IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
39.8000D+00	39.8000D+00	39.8000D+00	39.8000D+00	0.0	0.0
41.9000D+00	46.8649D+00	46.0654D+00	41.9000D+00	-49.6492D-01	-41.6539D-01
45.0000D+00	50.3231D+00	49.3480D+00	45.0000D+00	-53.2314D-01	-43.4802D-01
49.2000D+00	53.5089D+00	52.6783D+00	49.2000D+00	-43.0890D-01	-34.7827D-01
50.6000D+00	57.2819D+00	54.3485D+00	50.6000D+00	-66.8190D-01	-37.4849D-01
52.6000D+00	57.5059D+00	56.4898D+00	52.6000D+00	-49.0592D-01	-38.8976D-01
55.1000D+00	52.2898D+00	58.2234D+00	55.1000D+00	28.1020D-01	-31.2337D-01
56.2000D+00	47.7399D+00	58.9474D+00	56.2000D+00	84.6008D-01	-27.4742D-01
57.3000D+00	49.6560D+00	59.8145D+00	57.3000D+00	76.4403D-01	-25.1454D-01
57.8000D+00	56.2135D+00	61.4927D+00	57.8000D+00	15.8652D-01	-36.9273D-01
55.0000D+00	59.0718D+00	59.0413D+00	55.0000D+00	-40.7179D-01	-40.4125D-01
50.9000D+00	59.1084D+00	54.9570D+00	50.9000D+00	-82.0839D-01	-40.5696D-01
45.6000D+00	56.1557D+00	50.2629D+00	45.6000D+00	-10.5557D+00	-46.6287D-01
46.5000D+00	54.6381D+00	49.8622D+00	46.5000D+00	-81.3810D-01	-33.6216D-01
48.7000D+00	55.8385D+00	52.3322D+00	48.7000D+00	-71.3848D-01	-36.3225D-01
51.3000D+00	57.0179D+00	55.5606D+00	51.3000D+00	-57.1790D-01	-42.6056D-01
57.7000D+00	56.3447D+00	60.7351D+00	57.7000D+00	13.5528D-01	-30.3506D-01
58.7000D+00	56.4633D+00	61.8618D+00	58.7000D+00	22.3670D-01	-31.6178D-01
57.5000D+00	62.5495D+00	61.8717D+00	57.5000D+00	-50.4949D-01	-43.7170D-01
61.6000D+00	67.8219D+00	65.0952D+00	61.6000D+00	-62.2193D-01	-34.9516D-01
65.0000D+00	70.4239D+00	68.9858D+00	65.0000D+00	-54.2389D-01	-39.8576D-01
72.0600D+00	74.2373D+00	73.5730D+00	74.2000D+00	-21.7726D-01	-15.1304D-01
70.4600D+00	10.6193D+01	85.0062D+00	62.8100D+00	-35.7330D+00	-14.5462D+00
73.7700D+00	14.1183D+01	94.3044D+00	61.1400D+00	-67.4133D+00	-20.5344D+00
78.5200D+00	15.7414D+01	98.7217D+00	61.7100D+00	-78.8945D+00	-20.2017D+00
84.6100D+00	14.2512D+01	98.5838D+00	70.7300D+00	-57.9020D+00	-13.9738D+00
90.7200D+00	84.1774D+00	84.9869D+00	89.5400D+00	65.4260D-01	57.3307D-01
90.9000D+00	43.4132D+00	81.6175D+00	93.5700D+00	47.4868D+00	92.8251D-01
92.0300D+00	32.0602D+00	83.3752D+00	96.2700D+00	59.9698D+00	86.5478D-01
94.3200D+00	40.7959D+00	86.2456D+00	97.0500D+00	53.5241D+00	80.7441D-01
10.0500D+01	51.4906D+00	88.4417D+00	10.3940D+01	49.0094D+00	12.0583D+00
10.1700D+01	63.5749D+00	93.7795D+00	10.6070D+01	38.1251D+00	79.2046D-01
10.4510D+01	76.5924D+00	98.4675D+00	10.5080D+01	27.9176D+00	60.4251D-01

QUADRATIC ERROR OLD MODEL: 2952.3382D+01

Table 5.2

QUADRATIC ERROR NEW MODEL: 2021.1105D+00

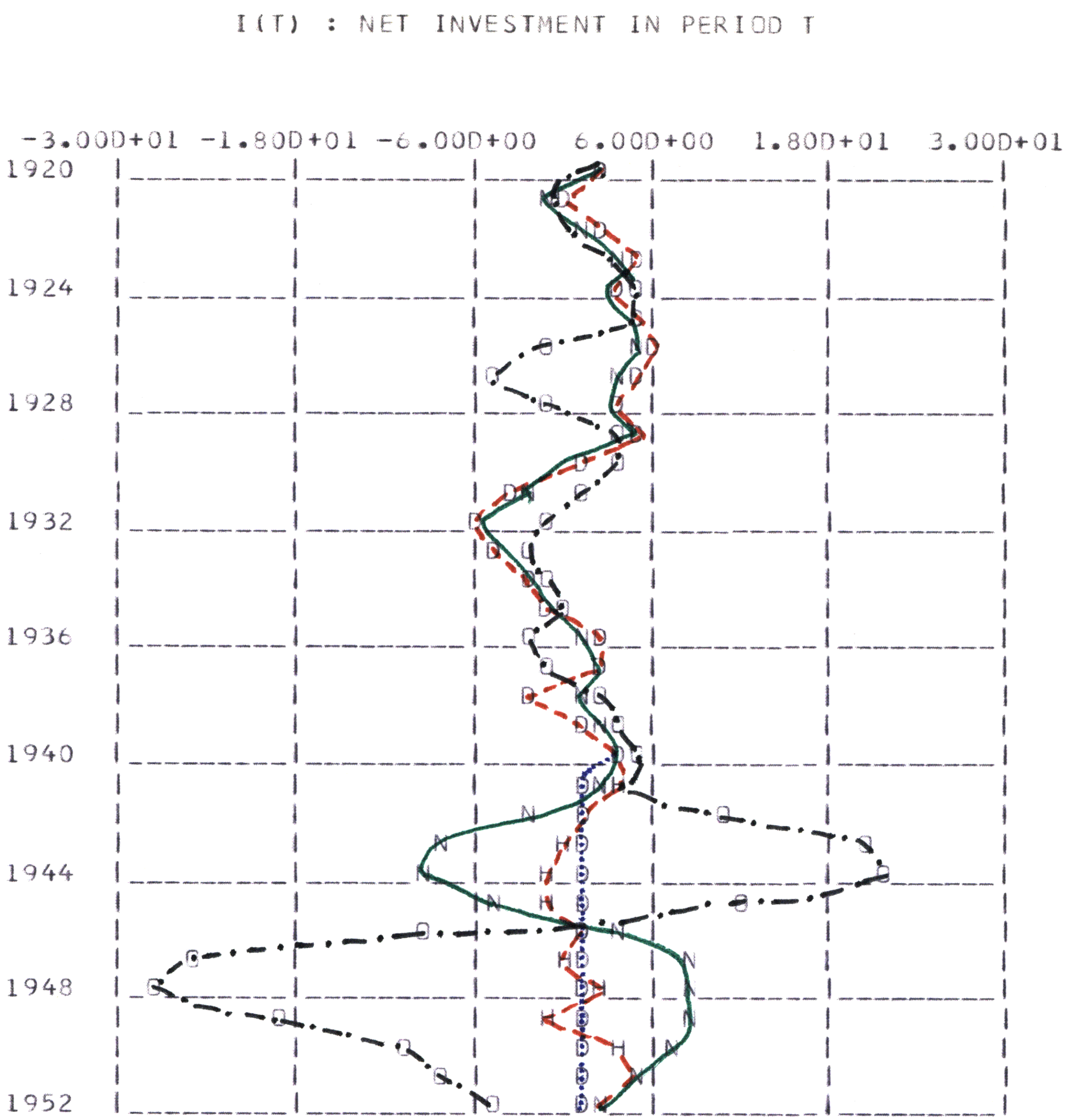


Figure 5.3

I(T) : Investment in Period T

Forecasting Experiment for OLS Structure

I(T) : NET INVESTMENT IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
27.0000D-01	27.0000D-01	27.0000D-01	27.0000D-01	0.0	0.0
-20.0000D-02	-68.3347D-02	-79.1293D-02	-20.0000D-02	48.3347D-02	59.1293D-02
19.0000D-01	13.9981D-01	13.2171D-01	19.0000D-01	50.0192D-02	57.8294D-02
52.0000D-01	36.9924D-01	36.8533D-01	52.0000D-01	15.0076D-01	15.1467D-01
30.0000D-01	53.4894D-01	40.2841D-01	30.0000D-01	-23.4894D-01	-10.2841D-01
51.0000D-01	43.2855D-01	44.7704D-01	51.0000D-01	77.1452D-02	62.2962D-02
56.0000D-01	-72.0529D-02	42.9767D-01	56.0000D-01	63.2053D-01	13.0233D-01
42.0000D-01	-42.2865D-01	35.7660D-01	42.0000D-01	84.2865D-01	62.3397D-02
30.0000D-01	-16.6337D-01	41.3052D-01	30.0000D-01	46.6337D-01	-11.3052D-01
51.0000D-01	33.2678D-01	50.4825D-01	51.0000D-01	17.7322D-01	51.7521D-03
10.0000D-01	33.0776D-01	16.0024D-01	10.0000D-01	-23.0776D-01	-60.0238D-02
-34.0000D-01	12.4112D-01	-26.7004D-01	-34.0000D-01	-46.4112D-01	-72.9963D-02
-62.0000D-01	-14.5471D-01	-57.9674D-01	-62.0000D-01	-47.4529D-01	-40.3262D-02
-51.0000D-01	-18.1058D-01	-48.2649D-01	-51.0000D-01	-32.8942D-01	-27.3515D-02
-30.0000D-01	-77.2482D-02	-25.8632D-01	-30.0000D-01	-22.2752D-01	-41.3681D-02
-13.0000D-01	-50.9104D-02	-84.5980D-02	-13.0000D-01	-79.0896D-02	-45.4020D-02
21.0000D-01	-21.5375D-01	13.2413D-01	21.0000D-01	42.5375D-01	77.5873D-02
20.0000D-01	-15.9393D-01	20.3446D-01	20.0000D-01	35.9393D-01	-34.4556D-03
-19.0000D-01	19.6571D-01	79.8639D-02	-19.0000D-01	-38.6571D-01	-26.9864D-01
13.0000D-01	41.9446D-01	18.7057D-01	13.0000D-01	-28.9446D-01	-57.0573D-02
33.0000D-01	42.1300D-01	36.2736D-01	33.0000D-01	-91.2996D-02	-32.7364D-02
40.2000D-01	27.5284D-01	27.8978D-01	10.0000D-01	12.6716D-01	12.3022D-01
14.3000D-01	10.5072D+00	-20.4753D-01	10.0000D-01	-90.7721D-01	34.7753D-01
-45.0000D-02	19.9151D+00	-79.8668D-01	10.0000D-01	-20.3651D+00	75.3668D-01
-73.0000D-02	21.3064D+00	-97.0841D-01	10.0000D-01	-22.0364D+00	89.7841D-01
-71.0000D-02	12.0807D+00	-51.3424D-01	10.0000D-01	-12.7907D+00	44.2424D-01
40.5000D-01	-95.8864D-01	32.4986D-01	10.0000D-01	13.6386D+00	80.0142D-02
-28.0000D-02	-25.7055D+00	86.2573D-01	10.0000D-01	25.4255D+00	-89.0573D-01
24.9000D-01	-27.3650D+00	87.8972D-01	10.0000D-01	29.8550D+00	-62.9972D-01
-16.5000D-01	-19.0447D+00	78.2484D-01	10.0000D-01	17.3947D+00	-94.7484D-01
35.8000D-01	-11.3328D+00	69.1425D-01	10.0000D-01	14.9128D+00	-33.3425D-01
50.8000D-01	-85.3402D-01	45.7561D-01	10.0000D-01	13.6140D+00	50.4393D-02
15.0000D-01	-43.6112D-01	27.8937D-01	10.0000D-01	58.6112D-01	-12.8937D-01

QUADRATIC ERROR OLD MODEL: 3882.0874D+00

QUADRATIC ERROR NEW MODEL: 4106.5507D-01

Table 5.3

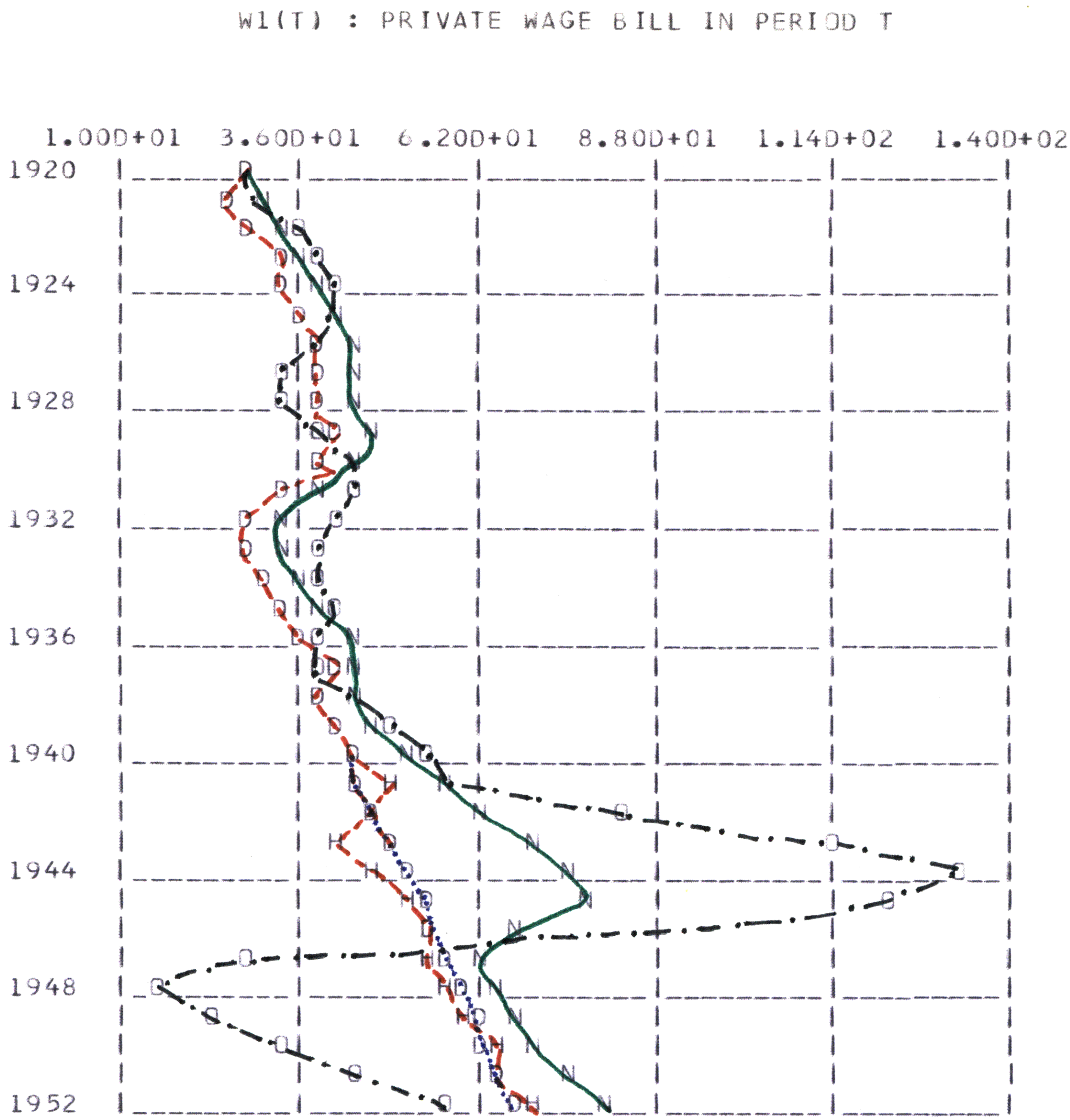


Figure 5.4

W1(T) : Private Wage Bill in Period T

Forecasting Experiment for OLS Structure

W1(T) : PRIVATE WAGE BILL IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
28.8000D+00	28.8000D+00	28.8000D+00	28.8000D+00	0.0	0.0
25.5000D+00	31.7598D+00	31.0261D+00	25.5000D+00	-62.5981D-01	-55.2612D-01
29.3000D+00	34.7743D+00	33.8260D+00	29.3000D+00	-54.7426D-01	-45.2596D-01
34.1000D+00	37.8462D+00	36.9713D+00	34.1000D+00	-37.4619D-01	-28.7126D-01
33.9000D+00	41.4097D+00	38.5418D+00	33.9000D+00	-75.0968D-01	-46.4177D-01
35.4000D+00	41.9960D+00	40.8801D+00	35.4000D+00	-65.9596D-01	-54.8013D-01
37.4000D+00	37.4694D+00	42.9181D+00	37.4000D+00	-69.3900D-03	-55.1809D-01
37.9000D+00	32.8672D+00	43.5871D+00	37.9000D+00	50.3277D-01	-56.8706D-01
39.2000D+00	33.9806D+00	44.0120D+00	39.2000D+00	52.1944D-01	-48.1202D-01
41.3000D+00	39.8253D+00	45.2831D+00	41.3000D+00	14.7470D-01	-39.8310D-01
37.9000D+00	43.3581D+00	43.5599D+00	37.9000D+00	-54.5815D-01	-56.5990D-01
34.5000D+00	43.4790D+00	39.4966D+00	34.5000D+00	-89.7901D-01	-49.9655D-01
29.0000D+00	40.4932D+00	34.6725D+00	29.0000D+00	-11.4932D+00	-56.7247D-01
28.5000D+00	38.3020D+00	33.3876D+00	28.5000D+00	-98.0202D-01	-48.8762D-01
30.6000D+00	39.0992D+00	35.4142D+00	30.6000D+00	-84.9915D-01	-48.1421D-01
33.2000D+00	40.4099D+00	38.7771D+00	33.2000D+00	-72.0990D-01	-55.7706D-01
36.8000D+00	39.1313D+00	43.1027D+00	36.8000D+00	-23.3133D-01	-63.0274D-01
41.0000D+00	39.6176D+00	44.7466D+00	41.0000D+00	13.8241D-01	-37.4655D-01
38.2000D+00	44.7299D+00	44.2991D+00	38.2000D+00	-65.2992D-01	-60.9913D-01
41.6000D+00	50.2824D+00	47.6373D+00	41.6000D+00	-86.8241D-01	-60.3726D-01
45.0000D+00	53.2009D+00	51.5313D+00	45.0000D+00	-82.0087D-01	-65.3134D-01
49.0600D+00	57.3390D+00	56.0895D+00	45.0000D+00	-82.7898D-01	-70.2952D-01
46.0800D+00	82.4239D+00	62.2621D+00	47.0000D+00	-36.3439D+00	-16.1821D+00
42.3900D+00	11.4918D+01	69.9918D+00	49.0000D+00	-72.5278D+00	-27.6018D+00
46.9800D+00	13.1749D+01	74.4961D+00	51.0000D+00	-84.7695D+00	-27.5161D+00
52.5200D+00	12.0824D+01	76.8852D+00	53.0000D+00	-68.3042D+00	-24.3652D+00
54.1500D+00	67.9072D+00	66.0777D+00	55.0000D+00	-13.7572D+00	-11.9277D+00
54.0400D+00	27.3027D+00	62.6722D+00	57.0000D+00	26.7373D+00	-86.3225D-01
56.5200D+00	14.6998D+00	64.5340D+00	59.0000D+00	41.8202D+00	-80.1399D-01
60.3000D+00	21.7738D+00	66.9611D+00	61.0000D+00	38.5262D+00	-66.6109D-01
63.9000D+00	32.4723D+00	69.2059D+00	63.0000D+00	31.4277D+00	-53.0587D-01
65.3900D+00	44.7185D+00	74.5123D+00	65.0000D+00	21.1715D+00	-86.2230D-01
69.1100D+00	57.9234D+00	79.6170D+00	67.0000D+00	11.1866D+00	-10.5070D+00

QUADRATIC ERROR OLD MODEL: 2509.2722D+01

QUADRATIC ERROR NEW MODEL: 3512.2745D+00

Table 5.4

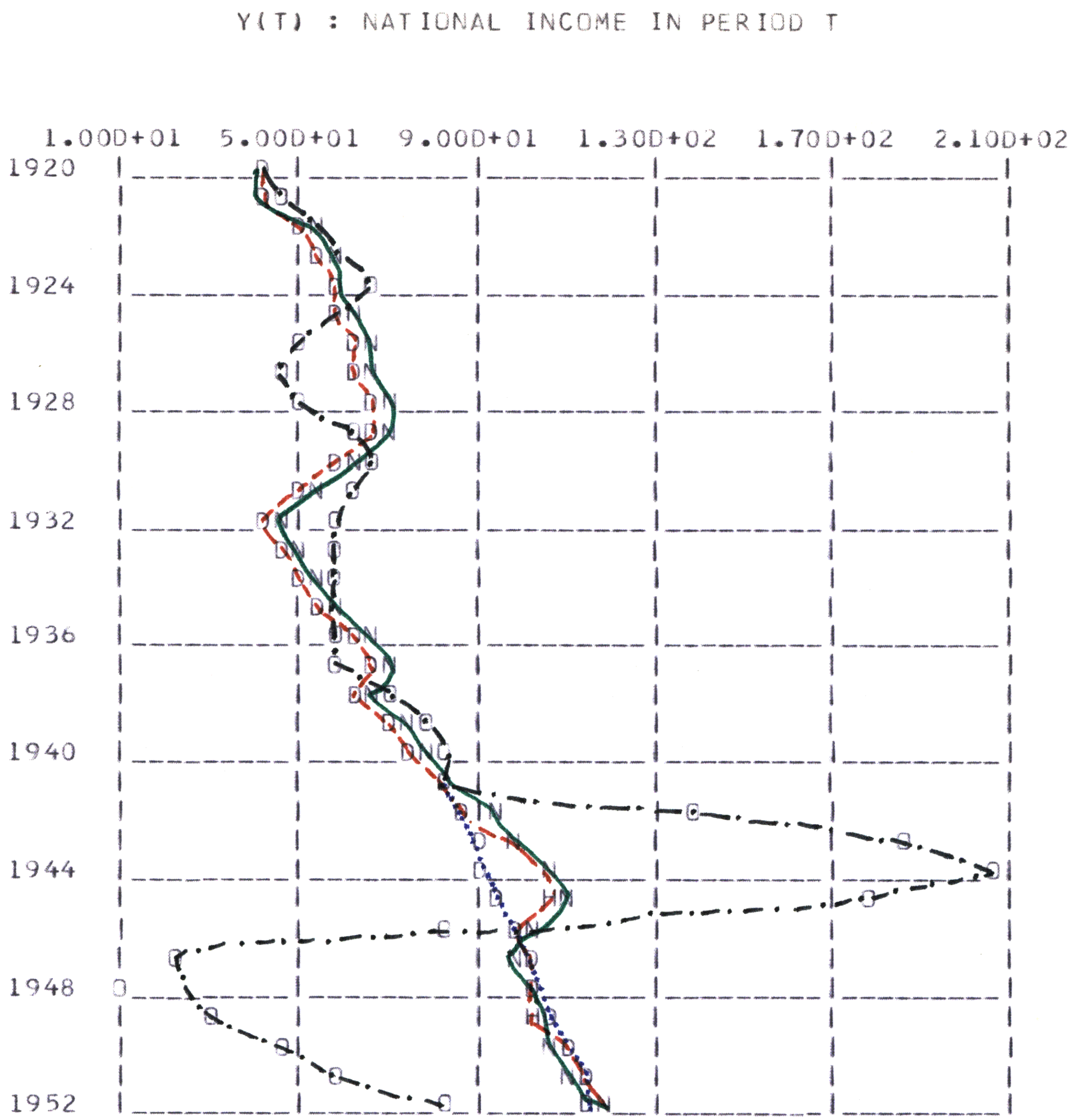


Figure 5.5

Y(T) : National Income in Period T

Forecasting Experiment for OLS Structure

Y(T) : NATIONAL INCOME IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
43.7000D+00	43.7000D+00	43.7000D+00	43.7000D+00	0.0	0.0
40.6000D+00	45.0816D+00	43.9069D+00	40.6000D+00	-44.8158D-01	-33.0689D-01
49.1000D+00	53.9229D+00	52.6996D+00	49.1000D+00	-48.2295D-01	-35.9962D-01
55.4000D+00	58.2081D+00	57.1304D+00	55.4000D+00	-28.0814D-01	-17.3037D-01
56.4000D+00	65.4308D+00	59.6575D+00	56.4000D+00	-90.3084D-01	-32.5747D-01
58.7000D+00	62.8345D+00	63.2910D+00	58.7000D+00	-41.3446D-01	-45.9099D-01
60.3000D+00	51.1693D+00	65.1084D+00	60.3000D+00	91.3073D-01	-48.0837D-01
61.3000D+00	44.4113D+00	65.8119D+00	61.3000D+00	16.8887D+00	-45.1195D-01
64.0000D+00	51.6926D+00	68.6071D+00	64.0000D+00	12.3074D+00	-46.0715D-01
67.0000D+00	63.6403D+00	71.4849D+00	67.0000D+00	33.5974D-01	-44.8488D-01
57.7000D+00	64.0795D+00	62.9913D+00	57.7000D+00	-63.7955D-01	-52.9129D-01
50.7000D+00	63.5495D+00	55.8369D+00	50.7000D+00	-12.8495D+00	-51.3687D-01
41.3000D+00	56.6010D+00	46.8995D+00	41.3000D+00	-15.3010D+00	-55.9945D-01
45.3000D+00	56.7275D+00	49.8235D+00	45.3000D+00	-11.4275D+00	-45.2353D-01
48.9000D+00	58.2660D+00	53.1566D+00	48.9000D+00	-93.6600D-01	-42.5664D-01
53.3000D+00	59.8038D+00	58.9432D+00	53.3000D+00	-65.0880D-01	-56.4316D-01
61.8000D+00	56.1910D+00	67.1766D+00	61.8000D+00	56.0904D-01	-53.7660D-01
65.0000D+00	59.1694D+00	68.2547D+00	65.0000D+00	58.3063D-01	-32.5473D-01
61.2000D+00	70.1152D+00	66.7062D+00	61.2000D+00	-89.1520D-01	-55.0618D-01
68.4000D+00	77.5164D+00	73.9102D+00	68.4000D+00	-91.1639D-01	-55.1023D-01
74.1000D+00	80.4369D+00	79.4377D+00	74.1000D+00	-63.3688D-01	-53.3773D-01
82.8800D+00	83.7901D+00	83.6086D+00	82.0000D+00	-91.0100D-02	-72.8616D-02
93.0800D+00	13.7890D+01	92.0251D+00	85.0000D+00	-44.8102D+00	10.5490D-01
99.1800D+00	18.6958D+01	99.1508D+00	88.0000D+00	-87.7785D+00	29.1841D-03
10.6080D+01	20.7011D+01	10.5181D+01	91.0000D+00	-10.0931D+01	89.9117D-02
10.6170D+01	17.6863D+01	11.0800D+01	94.0000D+00	-70.6927D+00	-46.2961D-01
10.1230D+01	81.0488D+00	10.1218D+01	97.0000D+00	20.1812D+00	12.1867D-03
96.0500D+00	23.1377D+00	99.0099D+00	10.0000D+01	72.9123D+00	-29.5992D-01
10.0250D+01	10.4252D+00	10.0244D+01	10.3000D+01	89.8248D+00	61.7310D-04
10.0620D+01	29.7012D+00	10.4287D+01	10.6000D+01	70.9188D+00	-36.6735D-01
10.8870D+01	44.9478D+00	10.6680D+01	10.9000D+01	63.9222D+00	21.8982D-01
11.1710D+01	59.9709D+00	11.1173D+01	11.2000D+01	51.7391D+00	53.7060D-02
11.4930D+01	81.1513D+00	11.6951D+01	11.5000D+01	33.7787D+00	-20.2088D-01

QUADRATIC ERROR OLD MODEL: 5327.3837D+01

QUADRATIC ERROR NEW MODEL: 4834.9688D-01

Table 5.5

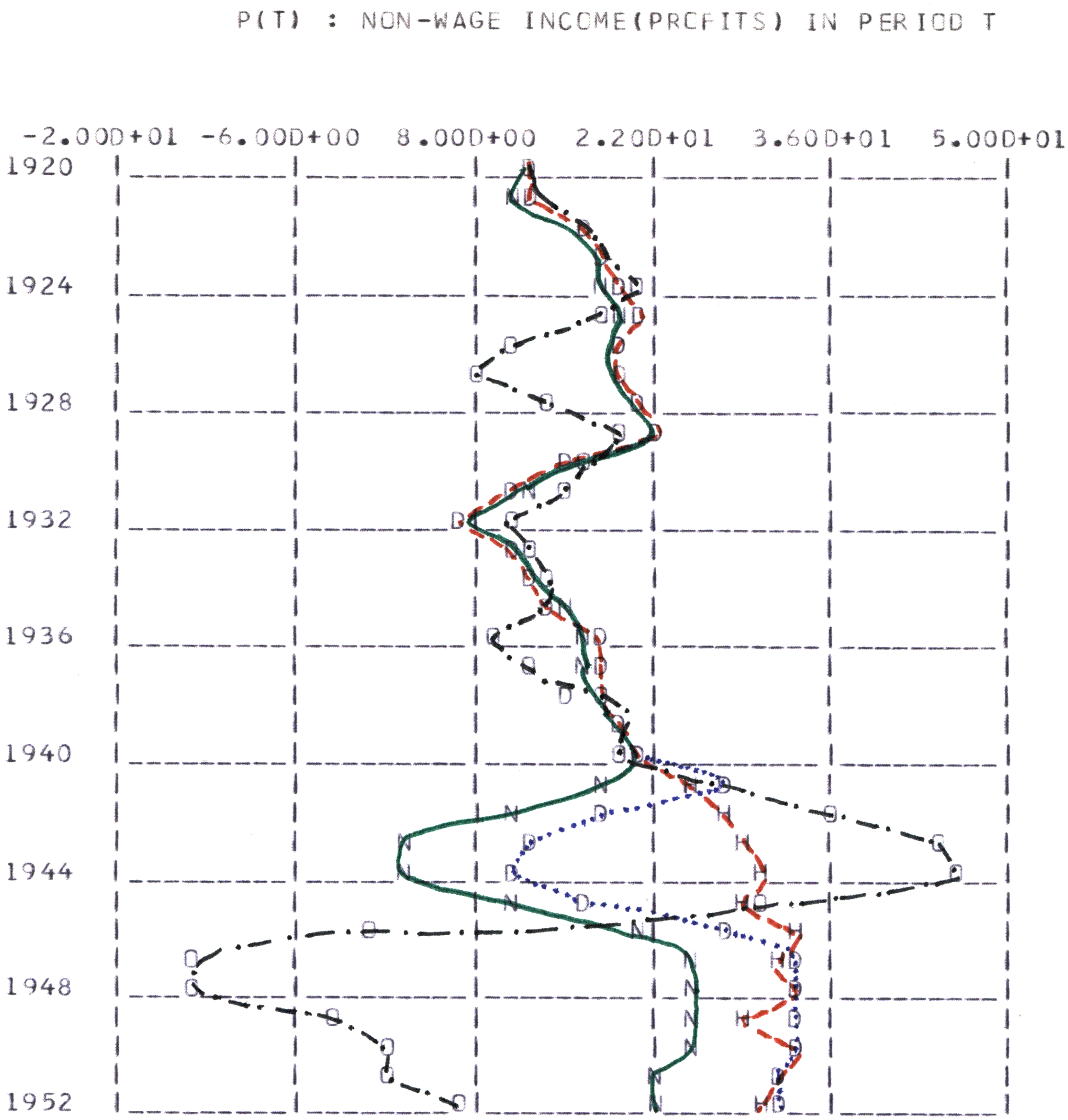


Figure 5.6

P(T) : Non-Wage Income(Profits) in Period T

Forecasting Experiment for OLS Structure

P(T) : NON-WAGE INCOME(PROFITS) IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
12.7000D+00	12.7000D+00	12.7000D+00	12.7000D+00	0.0	0.0
12.4000D+00	10.6218D+00	10.3967D+00	12.4000D+00	17.7823D-01	20.0329D-01
16.9000D+00	16.2487D+00	16.2170D+00	16.9000D+00	65.1308D-02	68.3032D-02
18.4000D+00	17.4620D+00	17.4116D+00	18.4000D+00	93.8049D-02	98.8386D-02
19.4000D+00	20.9212D+00	18.1563D+00	19.4000D+00	-15.2116D-01	12.4366D-01
20.1000D+00	17.6385D+00	19.5135D+00	20.1000D+00	24.6149D-01	58.6523D-02
19.6000D+00	10.3999D+00	19.2406D+00	19.6000D+00	92.0012D-01	35.9364D-02
19.8000D+00	79.4404D-01	18.9284D+00	19.8000D+00	11.8560D+00	87.1598D-02
21.1000D+00	14.0120D+00	21.1337D+00	21.1000D+00	70.8796D-01	-33.6718D-03
21.7000D+00	19.8150D+00	22.4785D+00	21.7000D+00	18.8504D-01	-77.8498D-02
15.6000D+00	16.5214D+00	15.5326D+00	15.6000D+00	-92.1401D-02	67.4340D-03
11.4000D+00	15.2705D+00	11.8254D+00	11.4000D+00	-38.7050D-01	-42.5387D-02
70.0000D-01	10.8078D+00	72.5832D-01	70.0000D-01	-38.0782D-01	-25.8325D-02
11.2000D+00	12.8255D+00	11.1013D+00	11.2000D+00	-16.2550D-01	98.6885D-03
12.3000D+00	13.1668D+00	11.9785D+00	12.3000D+00	-86.6848D-02	32.1479D-02
14.0000D+00	13.2989D+00	14.3951D+00	14.0000D+00	70.1096D-02	-39.5060D-02
17.6000D+00	96.5963D-01	17.0444D+00	17.6000D+00	79.4037D-01	55.5598D-02
17.3000D+00	12.8518D+00	16.9944D+00	17.3000D+00	44.4823D-01	30.5602D-02
15.3000D+00	17.6853D+00	14.9267D+00	15.3000D+00	-23.8528D-01	37.3259D-02
19.0000D+00	19.4340D+00	18.7834D+00	19.0000D+00	-43.3978D-02	21.6563D-02
21.1000D+00	19.2360D+00	20.2042D+00	21.1000D+00	18.6399D-01	89.5772D-02
24.6800D+00	17.3111D+00	18.3169D+00	27.8600D+00	73.6888D-01	63.6315D-01
26.9900D+00	35.4564D+00	10.1923D+00	17.9900D+00	-84.6635D-01	16.7977D+00
29.5700D+00	44.9206D+00	29.7387D-01	11.8800D+00	-15.3506D+00	26.5961D+00
29.7300D+00	45.8914D+00	25.3493D-01	10.6300D+00	-16.1614D+00	27.1951D+00
28.5600D+00	30.9485D+00	10.1136D+00	15.9100D+00	-23.8850D-01	18.4464D+00
32.9000D+00	-10.3848D-01	21.1347D+00	27.8200D+00	33.9385D+00	11.7653D+00
31.5100D+00	-14.6649D+00	25.4477D+00	32.5000D+00	46.1749D+00	60.6225D-01
33.3500D+00	-14.6546D+00	24.8053D+00	33.6200D+00	48.0046D+00	85.4474D-01
28.7000D+00	-36.9264D-01	25.2883D+00	33.3800D+00	32.3926D+00	34.1169D-01
32.8300D+00	33.5516D-02	24.8782D+00	33.8600D+00	32.4945D+00	79.5185D-01
31.3000D+00	73.2429D-02	21.8986D+00	32.4800D+00	30.5676D+00	94.0137D-01
29.7600D+00	71.6786D-01	21.3098D+00	31.9400D+00	22.5921D+00	84.5021D-01

QUADRATIC ERROR OLD MODEL: 1018.5102D+01

QUADRATIC ERROR NEW MODEL: 2603.4528D+00

Table 5.6

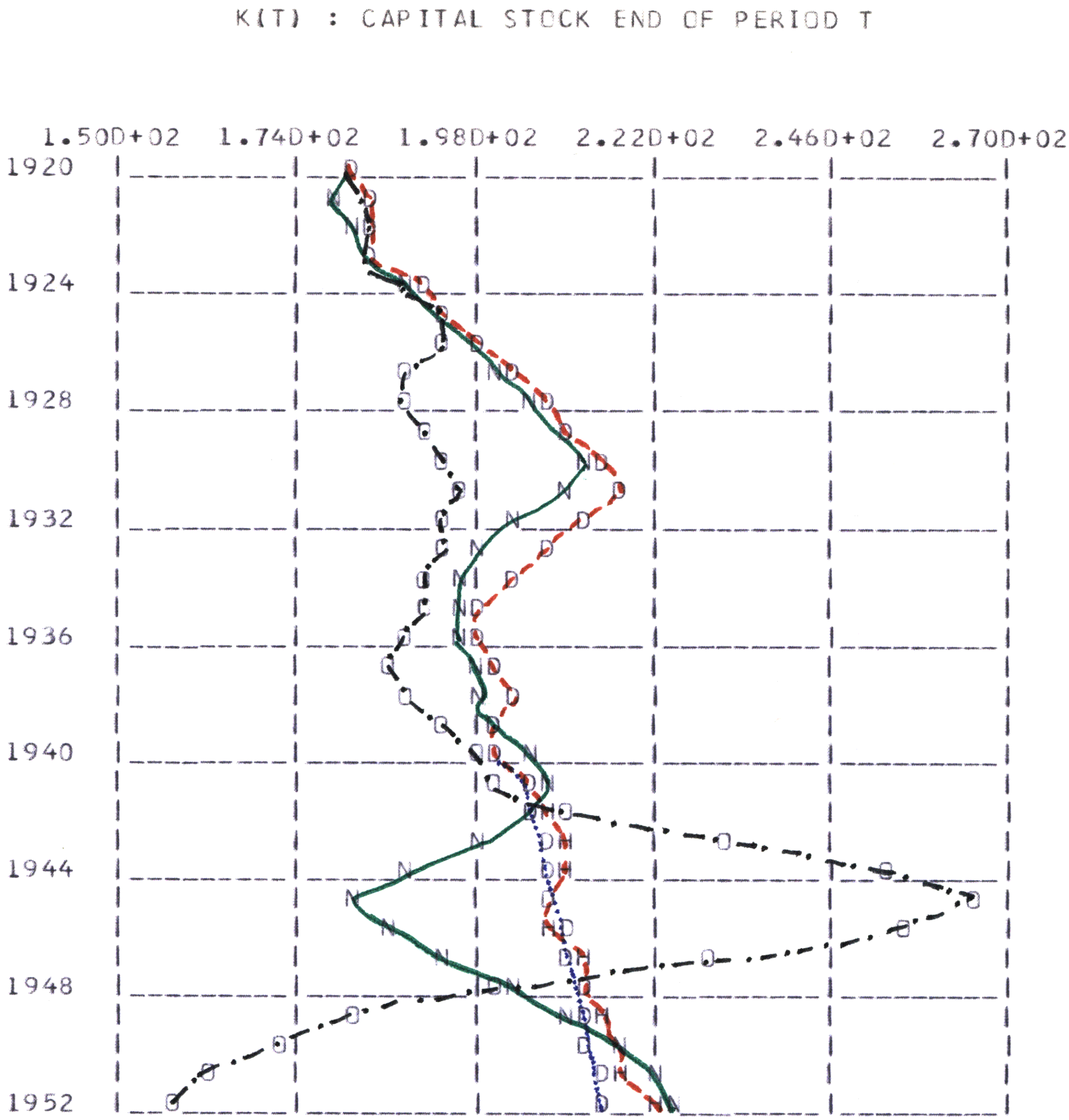


Figure 5.7

K(T) : Capital Stock End of Period T

Forecasting Experiment for OLS Structure

K(T) : CAPITAL STOCK END OF PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
18.0100D+01	18.0100D+01	18.0100D+01	18.0100D+01	0.0	0.0
18.2800D+01	17.9417D+01	17.9309D+01	18.2800D+01	33.8335D-01	34.9129D-01
18.2600D+01	18.0816D+01	18.0630D+01	18.2600D+01	17.8354D-01	19.6959D-01
18.4500D+01	18.4516D+01	18.4316D+01	18.4500D+01	-15.7024D-03	18.4256D-02
18.9700D+01	18.9865D+01	18.8344D+01	18.9700D+01	-16.4645D-02	13.5584D-01
19.2700D+01	19.4193D+01	19.2821D+01	19.2700D+01	-14.9319D-01	-12.1195D-02
19.7800D+01	19.3473D+01	19.7119D+01	19.7800D+01	43.2734D-01	68.1139D-02
20.3400D+01	18.9244D+01	20.0695D+01	20.3400D+01	14.1560D+00	27.0454D-01
20.7600D+01	18.7581D+01	20.4826D+01	20.7600D+01	20.0194D+00	27.7401D-01
21.0600D+01	19.0907D+01	20.9874D+01	21.0600D+01	19.6926D+00	72.5765D-02
21.5700D+01	19.4215D+01	21.1474D+01	21.5700D+01	21.4848D+00	42.2553D-01
21.6700D+01	19.5456D+01	20.8804D+01	21.6700D+01	21.2437D+00	78.9556D-01
21.3300D+01	19.4002D+01	20.3008D+01	21.3300D+01	19.2984D+00	10.2923D+00
20.7100D+01	19.2191D+01	19.8181D+01	20.7100D+01	14.9090D+00	89.1879D-01
20.2000D+01	19.1419D+01	19.5595D+01	20.2000D+01	10.5815D+00	64.0511D-01
19.9000D+01	19.0909D+01	19.4749D+01	19.9000D+01	80.9058D-01	42.5109D-01
19.7700D+01	18.8756D+01	19.6073D+01	19.7700D+01	89.4433D-01	16.2696D-01
19.9800D+01	18.7162D+01	19.8107D+01	19.9800D+01	12.6383D+00	16.9250D-01
20.1800D+01	18.9127D+01	19.8906D+01	20.1800D+01	12.6725D+00	28.9386D-01
19.9900D+01	19.3322D+01	20.0777D+01	19.9900D+01	65.7809D-01	-87.6708D-02
20.1200D+01	19.7535D+01	20.4404D+01	20.1200D+01	36.6509D-01	-32.0407D-01
20.4500D+01	20.0288D+01	20.7194D+01	20.4500D+01	42.1225D-01	-26.9385D-01
20.8520D+01	21.0795D+01	20.5146D+01	20.5500D+01	-22.7496D-01	33.7368D-01
20.9950D+01	23.0710D+01	19.7160D+01	20.6500D+01	-20.7601D+00	12.7904D+00
20.9500D+01	25.2017D+01	18.7451D+01	20.7500D+01	-42.5166D+00	22.0488D+00
20.8770D+01	26.4097D+01	18.2317D+01	20.8500D+01	-55.3272D+00	26.4530D+00
20.8060D+01	25.4509D+01	18.5567D+01	20.9500D+01	-46.4486D+00	22.4931D+00
21.2110D+01	22.8803D+01	19.4193D+01	21.0500D+01	-16.6931D+00	17.9174D+00
21.1830D+01	20.1438D+01	20.2982D+01	21.1500D+01	10.3919D+00	88.4770D-01
21.4320D+01	18.2393D+01	21.0807D+01	21.2500D+01	31.9266D+00	35.1286D-01
21.2670D+01	17.1061D+01	21.7721D+01	21.3500D+01	41.6094D+00	-50.5139D-01
21.6250D+01	16.2527D+01	22.2297D+01	21.4500D+01	53.7234D+00	-60.4700D-01
22.1330D+01	15.8165D+01	22.5086D+01	21.5500D+01	63.1646D+00	-37.5636D-01

QUADRATIC ERROR OLD MODEL: 2066.0030D+01

QUADRATIC ERROR NEW MODEL: 2745.5764D+00

Table 5.7

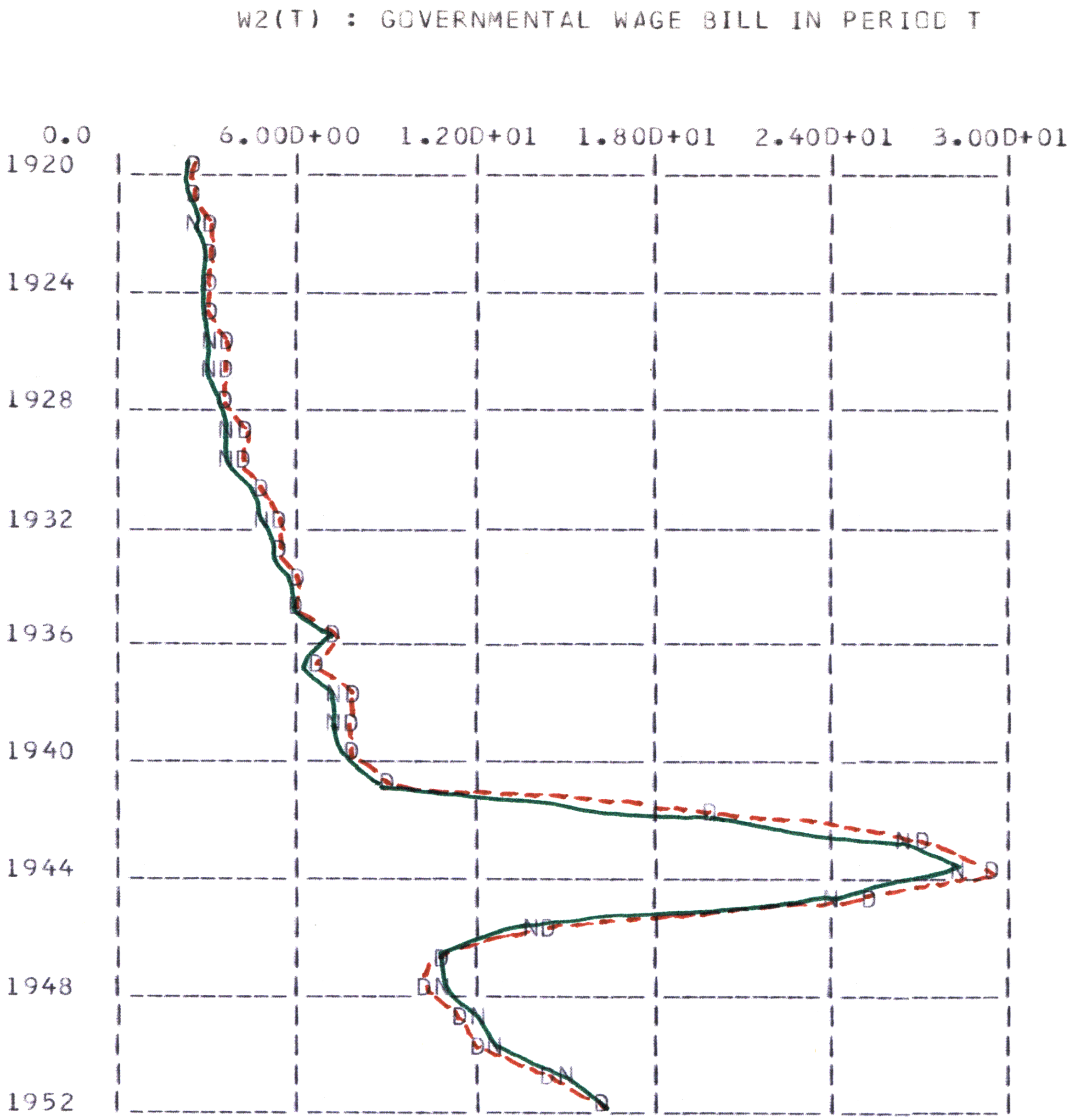


Figure 5.8

W2(T) : Governmental Wage Bill in Period T

Forecasting Experiment for OLS Structure

W2(T) : GOVERNMENTAL WAGE BILL IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
22.0000D-01	22.0000D-01	22.0000D-01	22.0000D-01	0.0	0.0
27.0000D-01	27.0000D-01	24.8406D-01	27.0000D-01	0.0	21.5936D-02
29.0000D-01	29.0000D-01	26.5670D-01	29.0000D-01	0.0	24.3301D-02
29.0000D-01	29.0000D-01	27.4750D-01	29.0000D-01	0.0	15.2503D-02
31.0000D-01	31.0000D-01	29.5936D-01	31.0000D-01	0.0	14.0637D-02
32.0000D-01	32.0000D-01	28.9738D-01	32.0000D-01	0.0	30.2617D-02
33.0000D-01	33.0000D-01	29.4965D-01	33.0000D-01	0.0	35.0352D-02
36.0000D-01	36.0000D-01	32.9649D-01	36.0000D-01	0.0	30.3511D-02
37.0000D-01	37.0000D-01	34.6145D-01	37.0000D-01	0.0	23.8545D-02
40.0000D-01	40.0000D-01	37.2328D-01	40.0000D-01	0.0	27.6722D-02
42.0000D-01	42.0000D-01	38.9882D-01	42.0000D-01	0.0	30.1179D-02
48.0000D-01	48.0000D-01	45.1493D-01	48.0000D-01	0.0	28.5072D-02
53.0000D-01	53.0000D-01	49.6866D-01	53.0000D-01	0.0	33.1339D-02
56.0000D-01	56.0000D-01	53.3460D-01	56.0000D-01	0.0	26.5400D-02
60.0000D-01	60.0000D-01	57.6391D-01	60.0000D-01	0.0	23.6089D-02
61.0000D-01	61.0000D-01	57.7104D-01	61.0000D-01	0.0	32.8959D-02
74.0000D-01	74.0000D-01	70.2946D-01	74.0000D-01	0.0	37.0540D-02
67.0000D-01	67.0000D-01	65.1378D-01	67.0000D-01	0.0	18.6217D-02
77.0000D-01	77.0000D-01	74.8030D-01	77.0000D-01	0.0	21.9696D-02
78.0000D-01	78.0000D-01	74.8954D-01	78.0000D-01	0.0	31.0465D-02
80.0000D-01	80.0000D-01	77.0217D-01	80.0000D-01	0.0	29.7832D-02
91.4000D-01	91.4000D-01	92.0225D-01	91.4000D-01	0.0	-62.2477D-03
20.0100D+00	20.0100D+00	19.5708D+00	20.0100D+00	0.0	43.9248D-02
27.1200D+00	27.1200D+00	26.1851D+00	27.1200D+00	0.0	93.4872D-02
29.3700D+00	29.3700D+00	28.1498D+00	29.3700D+00	0.0	12.2018D-01
25.0900D+00	25.0900D+00	23.8008D+00	25.0900D+00	0.0	12.8918D-01
14.1800D+00	14.1800D+00	14.0055D+00	14.1800D+00	0.0	17.4525D-02
10.5000D+00	10.5000D+00	10.8899D+00	10.5000D+00	0.0	-38.9927D-02
10.3800D+00	10.3800D+00	10.9046D+00	10.3800D+00	0.0	-52.4580D-02
11.6200D+00	11.6200D+00	12.0379D+00	11.6200D+00	0.0	-41.7946D-02
12.1400D+00	12.1400D+00	12.5962D+00	12.1400D+00	0.0	-45.6155D-02
14.5200D+00	14.5200D+00	14.7620D+00	14.5200D+00	0.0	-24.2006D-02
16.0600D+00	16.0600D+00	16.0241D+00	16.0600D+00	0.0	35.8995D-03

QUADRATIC ERROR OLD MODEL: 0.0

Table 5.8

QUADRATIC ERROR NEW MODEL: 6632.1860D-03

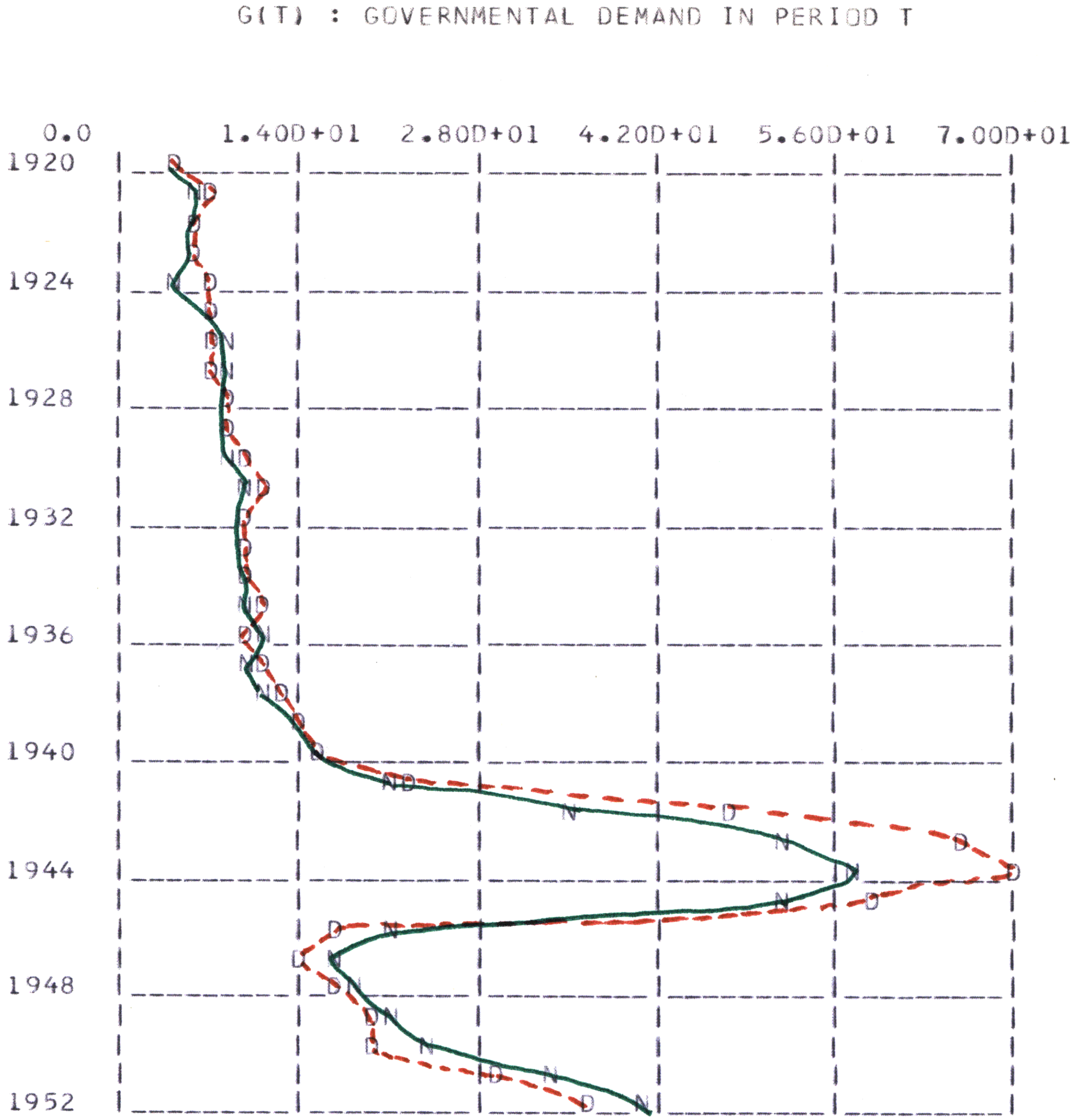


Figure 5.9

G(T) : Governmental Demand for Period T

Forecasting Experiment for OLS Structure

G(T) : GOVERNMENTAL DEMAND IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
46.0000D-01	46.0000D-01	46.0000D-01	46.0000D-01	0.0	0.0
66.0000D-01	66.0000D-01	56.2208D-01	66.0000D-01	0.0	97.7917D-02
61.0000D-01	61.0000D-01	53.0676D-01	61.0000D-01	0.0	79.3242D-02
57.0000D-01	57.0000D-01	49.3380D-01	57.0000D-01	0.0	76.6199D-02
66.0000D-01	66.0000D-01	46.7205D-01	66.0000D-01	0.0	19.2795D-01
65.0000D-01	65.0000D-01	65.3305D-01	65.0000D-01	0.0	-33.0499D-03
66.0000D-01	66.0000D-01	78.7267D-01	66.0000D-01	0.0	-12.7267D-01
76.0000D-01	76.0000D-01	84.9833D-01	76.0000D-01	0.0	-89.8334D-02
79.0000D-01	79.0000D-01	78.1924D-01	79.0000D-01	0.0	80.7579D-03
81.0000D-01	81.0000D-01	78.8933D-01	81.0000D-01	0.0	21.0674D-02
94.0000D-01	94.0000D-01	89.4830D-01	94.0000D-01	0.0	45.1698D-02
10.7000D+00	10.7000D+00	10.0432D+00	10.7000D+00	0.0	65.6823D-02
10.2000D+00	10.2000D+00	96.6094D-01	10.2000D+00	0.0	53.9057D-02
93.0000D-01	93.0000D-01	91.1328D-01	93.0000D-01	0.0	18.6722D-02
10.0000D+00	10.0000D+00	92.6160D-01	10.0000D+00	0.0	73.8399D-02
10.5000D+00	10.5000D+00	10.1841D+00	10.5000D+00	0.0	31.5857D-02
10.3000D+00	10.3000D+00	11.6895D+00	10.3000D+00	0.0	-13.8954D-01
11.0000D+00	11.0000D+00	10.2588D+00	11.0000D+00	0.0	74.1203D-02
13.0000D+00	13.0000D+00	10.8305D+00	13.0000D+00	0.0	21.6950D-01
14.4000D+00	14.4000D+00	14.3820D+00	14.4000D+00	0.0	17.9925D-03
15.4000D+00	15.4000D+00	14.9078D+00	15.4000D+00	0.0	49.2240D-02
22.1700D+00	22.1700D+00	20.7534D+00	22.1700D+00	0.0	14.1661D-01
47.4600D+00	47.4600D+00	35.5854D+00	47.4600D+00	0.0	11.8746D+00
65.8300D+00	65.8300D+00	52.4587D+00	65.8300D+00	0.0	13.3713D+00
69.9700D+00	69.9700D+00	57.1566D+00	69.9700D+00	0.0	12.8134D+00
58.1800D+00	58.1800D+00	51.7075D+00	58.1800D+00	0.0	64.7253D-01
17.0800D+00	17.0800D+00	21.1288D+00	17.0800D+00	0.0	-40.4878D-01
14.2000D+00	14.2000D+00	16.5979D+00	14.2000D+00	0.0	-23.9786D-01
16.7500D+00	16.7500D+00	18.4343D+00	16.7500D+00	0.0	-16.8430D-01
20.1700D+00	20.1700D+00	21.6449D+00	20.1700D+00	0.0	-14.7485D-01
19.9400D+00	19.9400D+00	24.4059D+00	19.9400D+00	0.0	-44.6592D-01
29.1400D+00	29.1400D+00	34.1916D+00	29.1400D+00	0.0	-50.5163D-01
36.0300D+00	36.0300D+00	40.3431D+00	36.0300D+00	0.0	-43.1315D-01

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 6365.0442D-01

Table 5.9

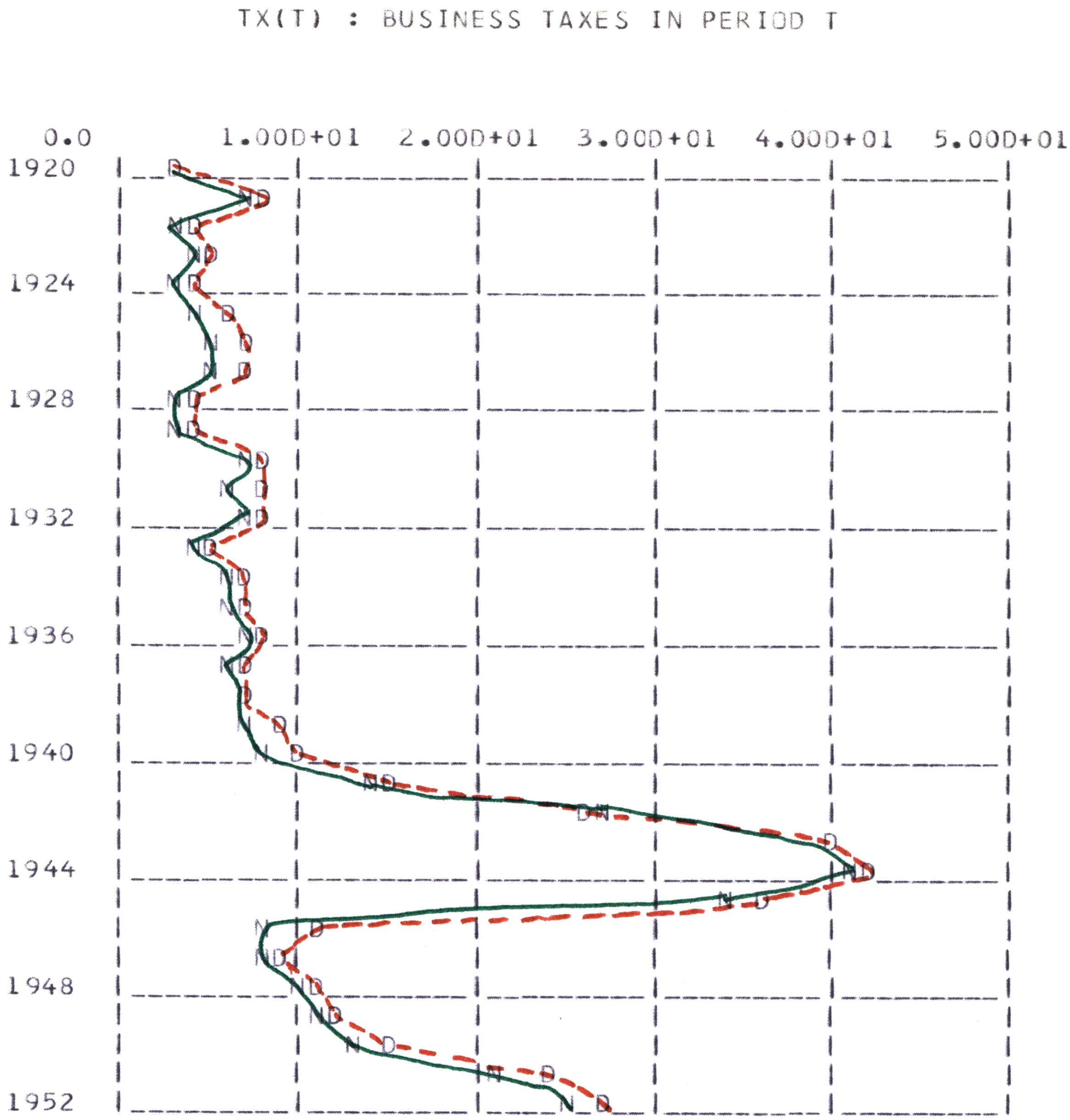


Figure 5.10

TX(T) : Business Taxes in Period T

Forecasting Experiment for OLS Structure

TX(T) : BUSINESS TAXES IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
34.0000D-01	34.0000D-01	34.0000D-01	34.0000D-01	0.0	0.0
77.0000D-01	77.0000D-01	69.8929D-01	77.0000D-01	0.0	71.0711D-02
39.0000D-01	39.0000D-01	32.7686D-01	39.0000D-01	0.0	62.3143D-02
47.0000D-01	47.0000D-01	41.6703D-01	47.0000D-01	0.0	53.2967D-02
38.0000D-01	38.0000D-01	33.9148D-01	38.0000D-01	0.0	40.8517D-02
55.0000D-01	55.0000D-01	42.0886D-01	55.0000D-01	0.0	12.9114D-01
70.0000D-01	70.0000D-01	52.8534D-01	70.0000D-01	0.0	17.1466D-01
67.0000D-01	67.0000D-01	52.1041D-01	67.0000D-01	0.0	14.8959D-01
42.0000D-01	42.0000D-01	31.5715D-01	42.0000D-01	0.0	10.4285D-01
40.0000D-01	40.0000D-01	29.4543D-01	40.0000D-01	0.0	10.5457D-01
77.0000D-01	77.0000D-01	65.9850D-01	77.0000D-01	0.0	11.0150D-01
75.0000D-01	75.0000D-01	64.9323D-01	75.0000D-01	0.0	10.0677D-01
83.0000D-01	83.0000D-01	72.2763D-01	83.0000D-01	0.0	10.7237D-01
54.0000D-01	54.0000D-01	43.2542D-01	54.0000D-01	0.0	10.7458D-01
68.0000D-01	68.0000D-01	58.5088D-01	68.0000D-01	0.0	94.9115D-02
72.0000D-01	72.0000D-01	59.5556D-01	72.0000D-01	0.0	12.4444D-01
83.0000D-01	83.0000D-01	65.7213D-01	83.0000D-01	0.0	17.2787D-01
67.0000D-01	67.0000D-01	59.0030D-01	67.0000D-01	0.0	79.9696D-02
74.0000D-01	74.0000D-01	67.9465D-01	74.0000D-01	0.0	60.5348D-02
89.0000D-01	89.0000D-01	74.3751D-01	89.0000D-01	0.0	14.6249D-01
96.0000D-01	96.0000D-01	80.8315D-01	96.0000D-01	0.0	15.1685D-01
15.3700D+00	15.3700D+00	13.5076D+00	15.3700D+00	0.0	18.6241D-01
26.2700D+00	26.2700D+00	26.5190D+00	26.2700D+00	0.0	-24.9009D-02
39.9700D+00	39.9700D+00	39.6257D+00	39.9700D+00	0.0	34.4326D-02
41.6800D+00	41.6800D+00	40.9891D+00	41.6800D+00	0.0	69.0933D-02
35.9100D+00	35.9100D+00	34.3575D+00	35.9100D+00	0.0	15.5252D-01
10.6200D+00	10.6200D+00	81.4775D-01	10.6200D+00	0.0	24.7225D-01
87.7000D-01	87.7000D-01	78.3116D-01	87.7000D-01	0.0	93.8844D-02
11.0200D+00	11.0200D+00	10.3554D+00	11.0200D+00	0.0	66.4580D-02
12.2200D+00	12.2200D+00	11.4279D+00	12.2200D+00	0.0	79.2077D-02
15.1500D+00	15.1500D+00	13.0817D+00	15.1500D+00	0.0	20.6835D-01
24.2100D+00	24.2100D+00	21.3738D+00	24.2100D+00	0.0	28.3616D-01
27.1100D+00	27.1100D+00	24.6491D+00	27.1100D+00	0.0	24.6087D-01

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 5875.9356D-02

Table 5.10

5.3.2 Forecasting With the 2SLS Structure

For this run, the standard econometric model ("old" model) was obtained by using the two stage least squares procedure to Klein's original structure.

The results are shown numerically and graphically in Tables 5.20 to 5.37 and in figures 5.19 to 5.36. The convention for symbols in the different figures is the same used in the previous section.

The behavior of the "new" model for this run is similar to the behavior of the "new" model for OLS, described in the last section, therefore, most of the comments made for OLS are valid for 2SLS.

A general improvement on the performance over the previous run, is observed in most of the variables. This, as concluded in the sensitivity experiments, is due to the substantial improvement in the statistics of the "old" model obtained with 2SLS over the "old" model obtained with OLS.

There are no significant biases in this run, investment (I) and national income (Y) are the variables that run closest to theri historical values.

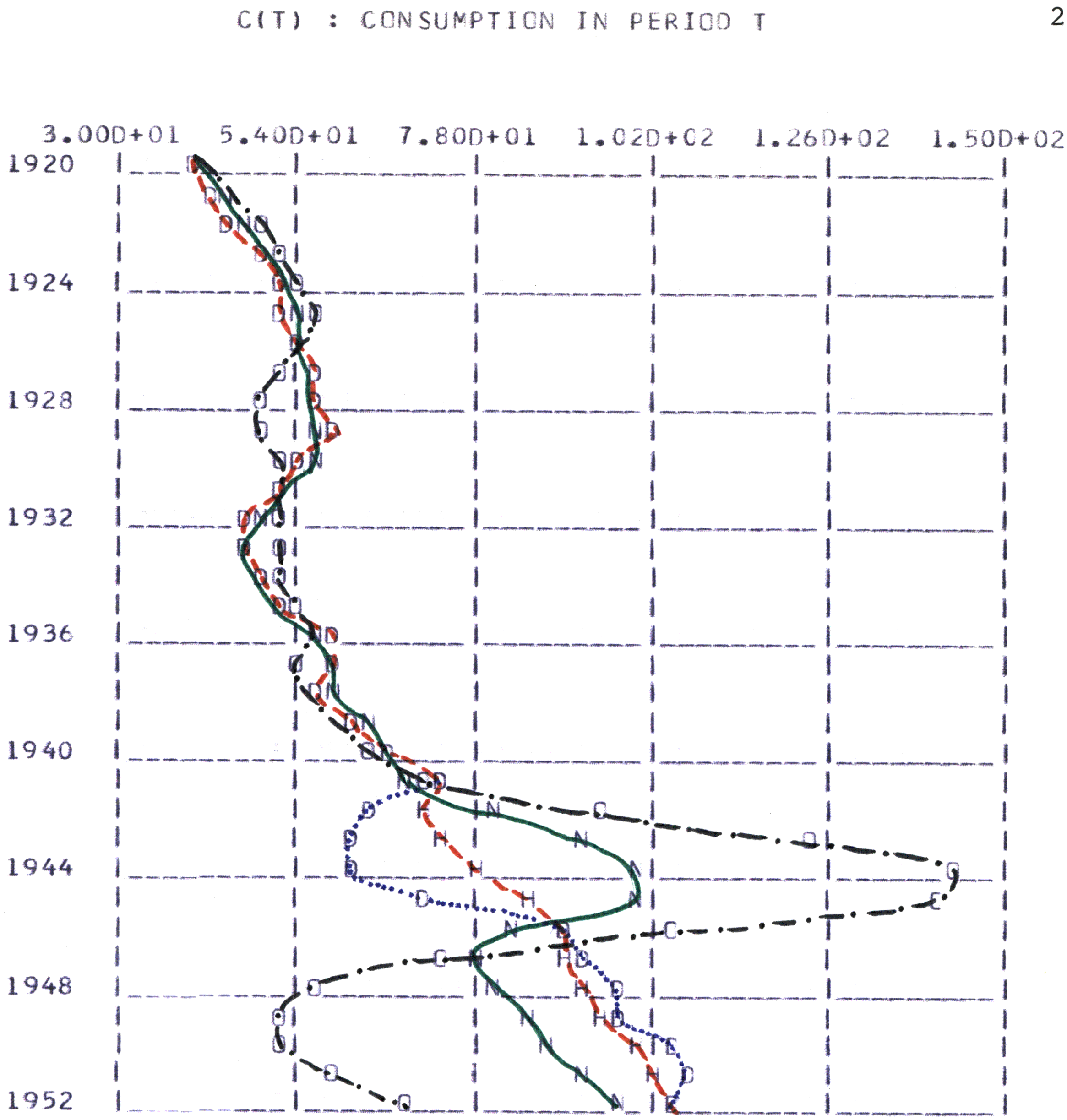


Figure 5.11

C(T) : Consumption in Period T

Forecasting Experiment for 2SLS Structure

C(T) : CONSUMPTION IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
39.8000D+00	39.8000D+00	39.8000D+00	39.8000D+00	0.0	0.0
41.9000D+00	45.1683D+00	44.0227D+00	41.9000D+00	-32.6830D-01	-21.2275D-01
45.0000D+00	48.0097D+00	45.7098D+00	45.0000D+00	-30.0974D-01	-70.9762D-02
49.2000D+00	51.3217D+00	48.4819D+00	49.2000D+00	-21.2171D-01	71.8140D-02
50.6000D+00	54.1722D+00	50.5250D+00	50.6000D+00	-35.7217D-01	74.9726D-03
52.6000D+00	55.7724D+00	52.9022D+00	52.6000D+00	-31.7240D-01	-30.2156D-02
55.1000D+00	54.4600D+00	54.7026D+00	55.1000D+00	63.9984D-02	39.7408D-02
56.2000D+00	51.3467D+00	55.5645D+00	56.2000D+00	48.5334D-01	63.5466D-02
57.3000D+00	48.7785D+00	56.1329D+00	57.3000D+00	85.2147D-01	11.6705D-01
57.8000D+00	49.1829D+00	56.9705D+00	57.8000D+00	86.1709D-01	82.9532D-02
55.0000D+00	51.2587D+00	55.6940D+00	55.0000D+00	37.4125D-01	-69.3978D-02
50.9000D+00	52.5129D+00	51.9545D+00	50.9000D+00	-16.1286D-01	-10.5451D-01
45.6000D+00	52.6986D+00	48.1875D+00	45.6000D+00	-70.9863D-01	-25.8750D-01
46.5000D+00	51.6414D+00	46.5154D+00	46.5000D+00	-51.4144D-01	-15.4364D-03
48.7000D+00	52.5481D+00	48.7547D+00	48.7000D+00	-38.4810D-01	-54.6961D-03
51.3000D+00	53.8586D+00	52.2998D+00	51.3000D+00	-25.5857D-01	-99.9762D-02
57.7000D+00	55.3827D+00	57.0964D+00	57.7000D+00	23.1729D-01	60.3570D-02
58.7000D+00	54.7221D+00	57.9295D+00	58.7000D+00	39.7791D-01	77.0497D-02
57.5000D+00	57.7525D+00	59.4093D+00	57.5000D+00	-25.2485D-02	-19.0933D-01
61.6000D+00	61.4081D+00	62.4574D+00	61.6000D+00	19.1886D-02	-85.7404D-02
65.0000D+00	64.4303D+00	65.6528D+00	65.0000D+00	56.9656D-02	-65.2761D-02
72.0600D+00	69.9836D+00	69.0604D+00	74.2000D+00	20.7637D-01	29.9963D-01
70.4600D+00	94.3266D+00	81.4804D+00	62.8100D+00	-23.8666D+00	-11.0204D+00
73.7700D+00	12.4383D+01	93.2327D+00	61.1400D+00	-50.6129D+00	-19.4627D+00
78.5200D+00	14.3504D+01	99.2601D+00	61.7100D+00	-64.9843D+00	-20.7401D+00
84.6100D+00	14.1094D+01	99.1278D+00	70.7300D+00	-56.4839D+00	-14.5178D+00
90.7200D+00	10.4538D+01	83.8314D+00	89.5400D+00	-13.8180D+00	68.8857D-01
90.9000D+00	72.0228D+00	77.8268D+00	93.5700D+00	18.8772D+00	13.0732D+00
92.0300D+00	55.7080D+00	80.3881D+00	96.2700D+00	36.3220D+00	11.6419D+00
94.3200D+00	50.6976D+00	84.2129D+00	97.0500D+00	43.6224D+00	10.1071D+00
10.0500D+01	50.8165D+00	86.8540D+00	10.3940D+01	49.6835D+00	13.6460D+00
10.1700D+01	58.2118D+00	92.5528D+00	10.6070D+01	43.4882D+00	91.4719D-01
10.4510D+01	68.0907D+00	96.9981D+00	10.5080D+01	36.4193D+00	75.1193D-01

QUADRATIC ERROR OLD MODEL: 2035.8789D+01

QUADRATIC ERROR NEW MODEL: 1955.8112D+00

Table 5.11

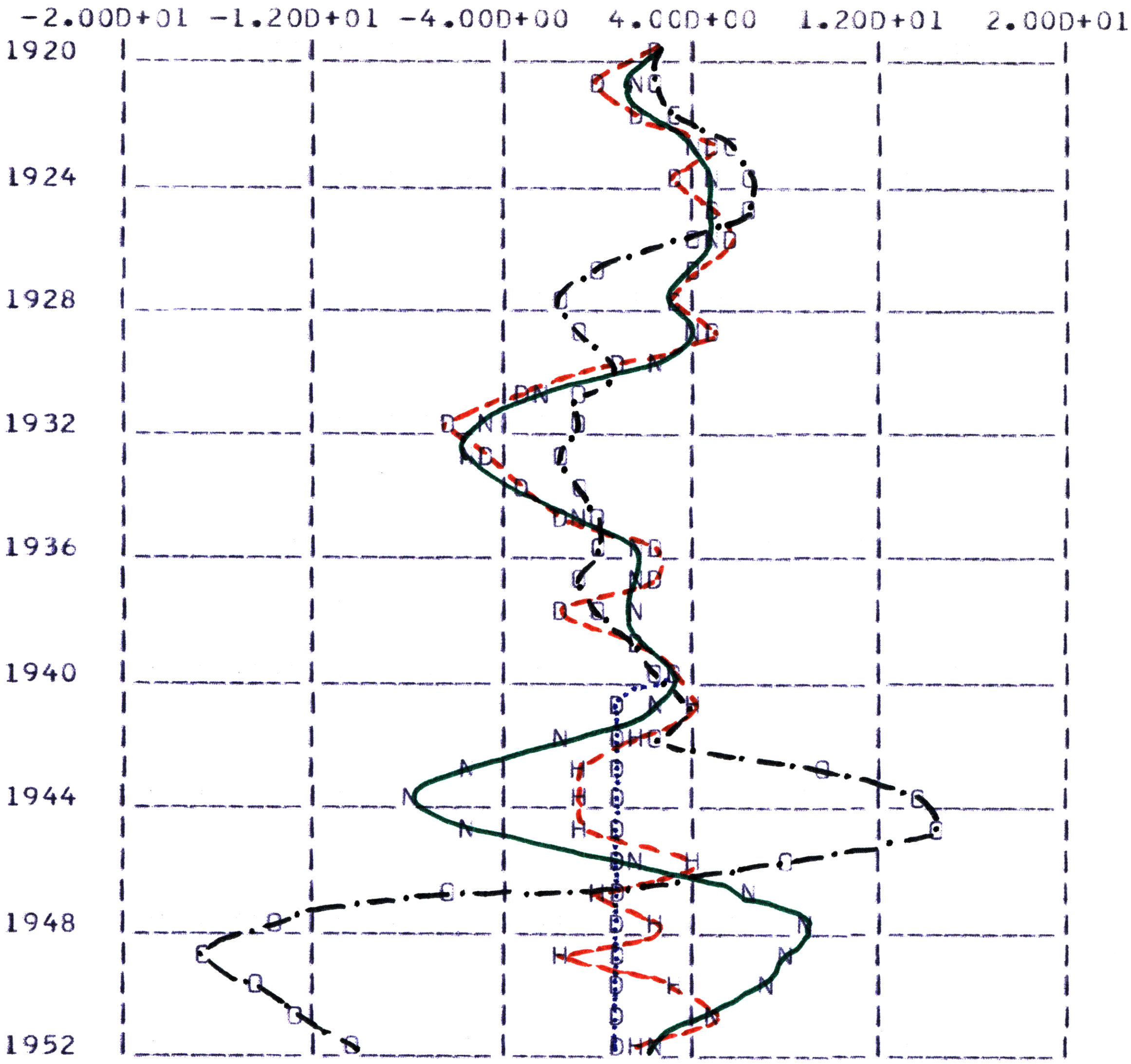


Figure 5.12

I(T) : Net Investment in Period T

Forecasting Experiment for 2SLS Structure

I(T) : NET INVESTMENT IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
27.0000D-01	27.0000D-01	27.0000D-01	27.0000D-01	0.0	0.0
-20.0000D-02	20.2472D-01	18.8078D-01	-20.0000D-02	-22.2472D-01	-20.8078D-01
19.0000D-01	31.5039D-01	15.6433D-01	19.0000D-01	-12.5039D-01	33.5667D-02
52.0000D-01	58.2604D-01	43.5545D-01	52.0000D-01	-62.6044D-02	84.4552D-02
30.0000D-01	62.2305D-01	44.0000D-01	30.0000D-01	-32.2305D-01	-14.0000D-01
51.0000D-01	65.1385D-01	51.0655D-01	51.0000D-01	-14.1385D-01	-65.4562D-04
56.0000D-01	40.6937D-01	48.2615D-01	56.0000D-01	15.3063D-01	77.3855D-02
42.0000D-01	31.4569D-02	36.2635D-01	42.0000D-01	38.8543D-01	57.3648D-02
30.0000D-01	-16.2897D-01	32.4127D-01	30.0000D-01	46.2897D-01	-24.1267D-02
51.0000D-01	-62.5638D-02	41.4925D-01	51.0000D-01	57.2564D-01	95.0752D-02
10.0000D-01	48.8109D-02	26.1843D-01	10.0000D-01	51.1891D-02	-16.1843D-01
-34.0000D-01	-65.0636D-02	-21.6401D-01	-34.0000D-01	-27.4936D-01	-12.3599D-01
-62.0000D-01	-80.8075D-02	-47.8366D-01	-62.0000D-01	-53.9193D-01	-14.1634D-01
-51.0000D-01	-17.4502D-01	-57.5828D-01	-51.0000D-01	-33.5498D-01	65.8283D-02
-30.0000D-01	-71.6899D-02	-29.3651D-01	-30.0000D-01	-22.8310D-01	-63.4857D-03
-13.0000D-01	-32.0662D-02	-95.2586D-02	-13.0000D-01	-97.9338D-02	-34.7414D-02
21.0000D-01	-15.1933D-02	12.5014D-01	21.0000D-01	22.5193D-01	84.9861D-02
20.0000D-01	-10.6898D-01	17.5882D-01	20.0000D-01	30.6898D-01	24.1179D-02
-19.0000D-01	17.7299D-02	13.6664D-01	-19.0000D-01	-20.7730D-01	-32.6664D-01
13.0000D-01	18.4687D-01	18.8671D-01	13.0000D-01	-54.6874D-02	-58.6709D-02
33.0000D-01	25.1381D-01	32.8119D-01	33.0000D-01	78.6186D-02	18.8109D-03
40.2000D-01	25.2922D-01	24.3028D-01	10.0000D-01	14.9078D-01	15.8972D-01
14.3000D-01	27.6787D-01	-14.4905D-01	10.0000D-01	-13.3787D-01	28.7905D-01
-45.0000D-02	98.5253D-01	-55.1327D-01	10.0000D-01	-10.3025D+00	50.6327D-01
-73.0000D-02	13.9850D+00	-82.3737D-01	10.0000D-01	-14.7150D+00	75.0737D-01
-71.0000D-02	14.3505D+00	-52.9876D-01	10.0000D-01	-15.0605D+00	45.8876D-01
40.5000D-01	76.1545D-01	15.9844D-01	10.0000D-01	-35.6545D-01	24.5156D-01
-28.0000D-02	-61.4500D-01	63.7203D-01	10.0000D-01	58.6500D-01	-66.5203D-01
24.9000D-01	-13.9446D+00	86.2098D-01	10.0000D-01	16.4346D+00	-61.3098D-01
-16.5000D-01	-16.4293D+00	78.7372D-01	10.0000D-01	14.7793D+00	-95.2372D-01
35.8000D-01	-14.1711D+00	72.3424D-01	10.0000D-01	17.7511D+00	-36.5424D-01
50.8000D-01	-12.5602D+00	51.0302D-01	10.0000D-01	17.6402D+00	-23.0162D-03
15.0000D-01	-10.1562D+00	23.8060D-01	10.0000D-01	11.6562D+00	-88.0599D-02

QUADRATIC ERROR OLD MODEL: 2016.2675D+00

QUADRATIC ERROR NEW MODEL: 3340.6210D-01

Table 5.12

W1(T) : PRIVATE WAGE BILL IN PERIOD T

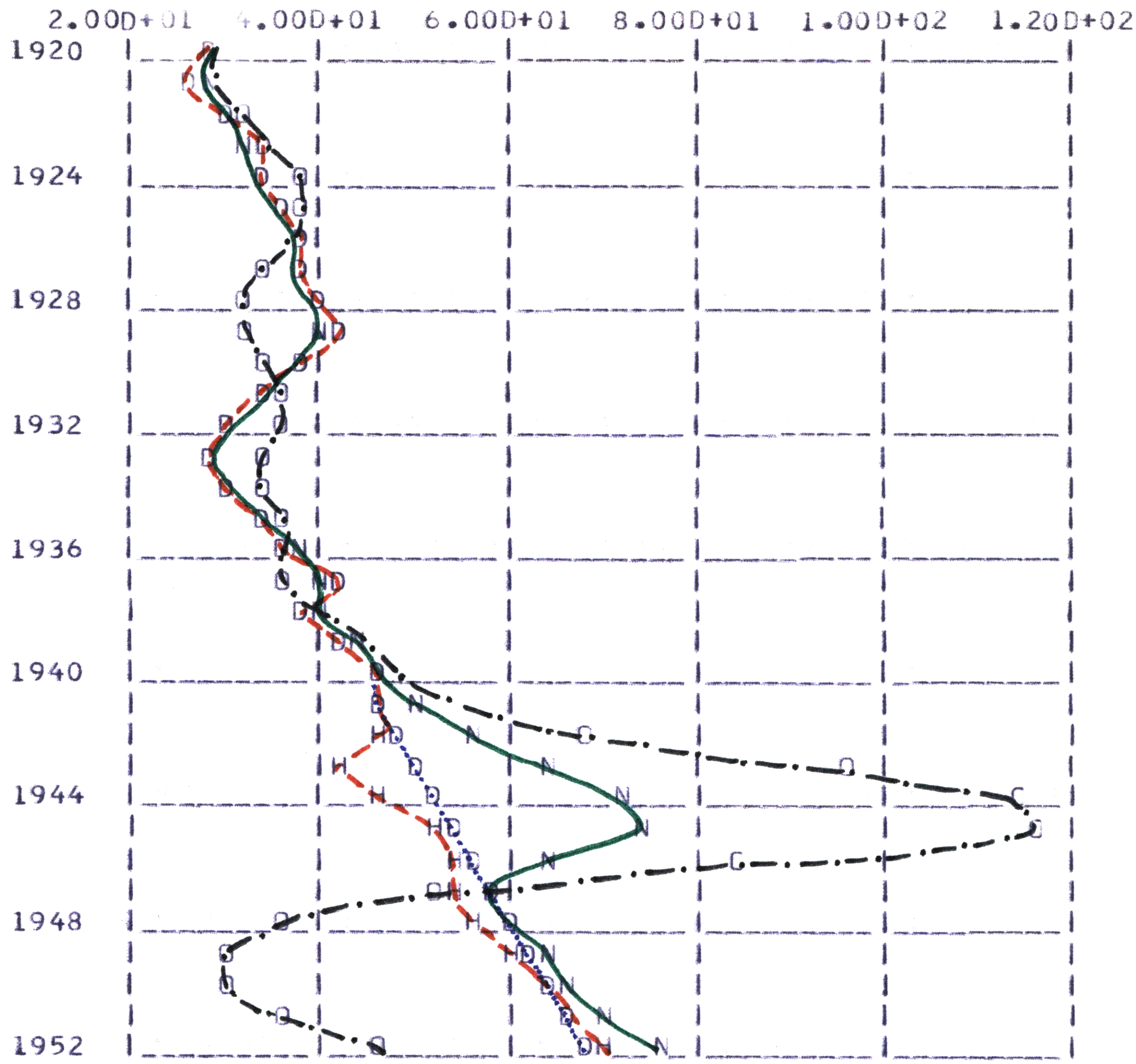


Figure 5.13

W1(T) : Private Wage Bill in Period T

Forecasting Experiment for 2SLS Structure

W1(T) : PRIVATE WAGE BILL IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
28.8000D+00	28.8000D+00	28.8000D+00	28.8000D+00	0.0	0.0
25.5000D+00	28.9987D+00	27.8392D+00	25.5000D+00	-34.9870D-01	-23.3920D-01
29.3000D+00	31.5713D+00	29.3870D+00	29.3000D+00	-22.7125D-01	-87.0069D-03
34.1000D+00	34.5533D+00	31.6214D+00	34.1000D+00	-45.3268D-02	24.7863D-01
33.9000D+00	37.2913D+00	33.6797D+00	33.9000D+00	-33.9133D-01	22.0332D-02
35.4000D+00	38.8235D+00	36.1077D+00	35.4000D+00	-34.2355D-01	-70.7706D-02
37.4000D+00	37.7511D+00	38.0686D+00	37.4000D+00	-35.1133D-02	-66.8642D-02
37.9000D+00	34.7247D+00	38.9308D+00	37.9000D+00	31.7532D-01	-10.3080D-01
39.2000D+00	32.0131D+00	39.3081D+00	39.2000D+00	71.8688D-01	-10.8090D-02
41.3000D+00	31.9034D+00	39.4793D+00	41.3000D+00	93.9665D-01	18.2072D-01
37.9000D+00	34.0087D+00	38.3589D+00	37.9000D+00	38.9126D-01	-45.8903D-02
34.5000D+00	35.2492D+00	34.7144D+00	34.5000D+00	-74.9222D-02	-21.4366D-02
29.0000D+00	35.1430D+00	30.8744D+00	29.0000D+00	-61.4298D-01	-18.7442D-01
28.5000D+00	33.8181D+00	28.7908D+00	28.5000D+00	-53.1813D-01	-29.0835D-02
30.6000D+00	34.2837D+00	30.4589D+00	30.6000D+00	-36.8369D-01	14.1085D-02
33.2000D+00	35.6752D+00	34.2067D+00	33.2000D+00	-24.7522D-01	-10.0667D-01
36.8000D+00	36.2714D+00	37.9603D+00	36.8000D+00	52.8580D-02	-11.6033D-01
41.0000D+00	36.3735D+00	39.2702D+00	41.0000D+00	46.2653D-01	17.2982D-01
38.2000D+00	38.6097D+00	40.3454D+00	38.2000D+00	-40.9671D-02	-21.4541D-01
41.6000D+00	42.3722D+00	43.5934D+00	41.6000D+00	-77.2240D-02	-19.9345D-01
45.0000D+00	45.5157D+00	46.6352D+00	45.0000D+00	-51.5739D-02	-16.3516D-01
49.0600D+00	50.9819D+00	49.3080D+00	45.0000D+00	-19.2195D-01	-24.8003D-02
46.0800D+00	68.8752D+00	55.5466D+00	47.0000D+00	-22.7952D+00	-94.6657D-01
42.3900D+00	95.5679D+00	64.9075D+00	49.0000D+00	-53.1779D+00	-22.5175D+00
46.9800D+00	11.4569D+01	71.5292D+00	51.0000D+00	-67.5888D+00	-24.5492D+00
52.5200D+00	11.5380D+01	74.9316D+00	53.0000D+00	-62.8602D+00	-22.4116D+00
54.1500D+00	84.1482D+00	63.6945D+00	55.0000D+00	-29.9982D+00	-95.4451D-01
54.0400D+00	52.7048D+00	57.6769D+00	57.0000D+00	13.3517D-01	-36.3688D-01
56.5200D+00	36.0015D+00	59.7907D+00	59.0000D+00	20.5185D+00	-32.7070D-01
60.3000D+00	30.1341D+00	63.1217D+00	61.0000D+00	30.1659D+00	-28.2166D-01
63.9000D+00	29.9725D+00	65.5536D+00	63.0000D+00	33.9275D+00	-16.5363D-01
65.8900D+00	36.7906D+00	70.7123D+00	65.0000D+00	29.0994D+00	-48.2234D-01
69.1100D+00	46.8947D+00	75.4213D+00	67.0000D+00	22.2153D+00	-63.1135D-01

QUADRATIC ERROR OLD MODEL: 1690.9998D+01

QUADRATIC ERROR NEW MODEL: 1927.9531D+00

Table 5.13

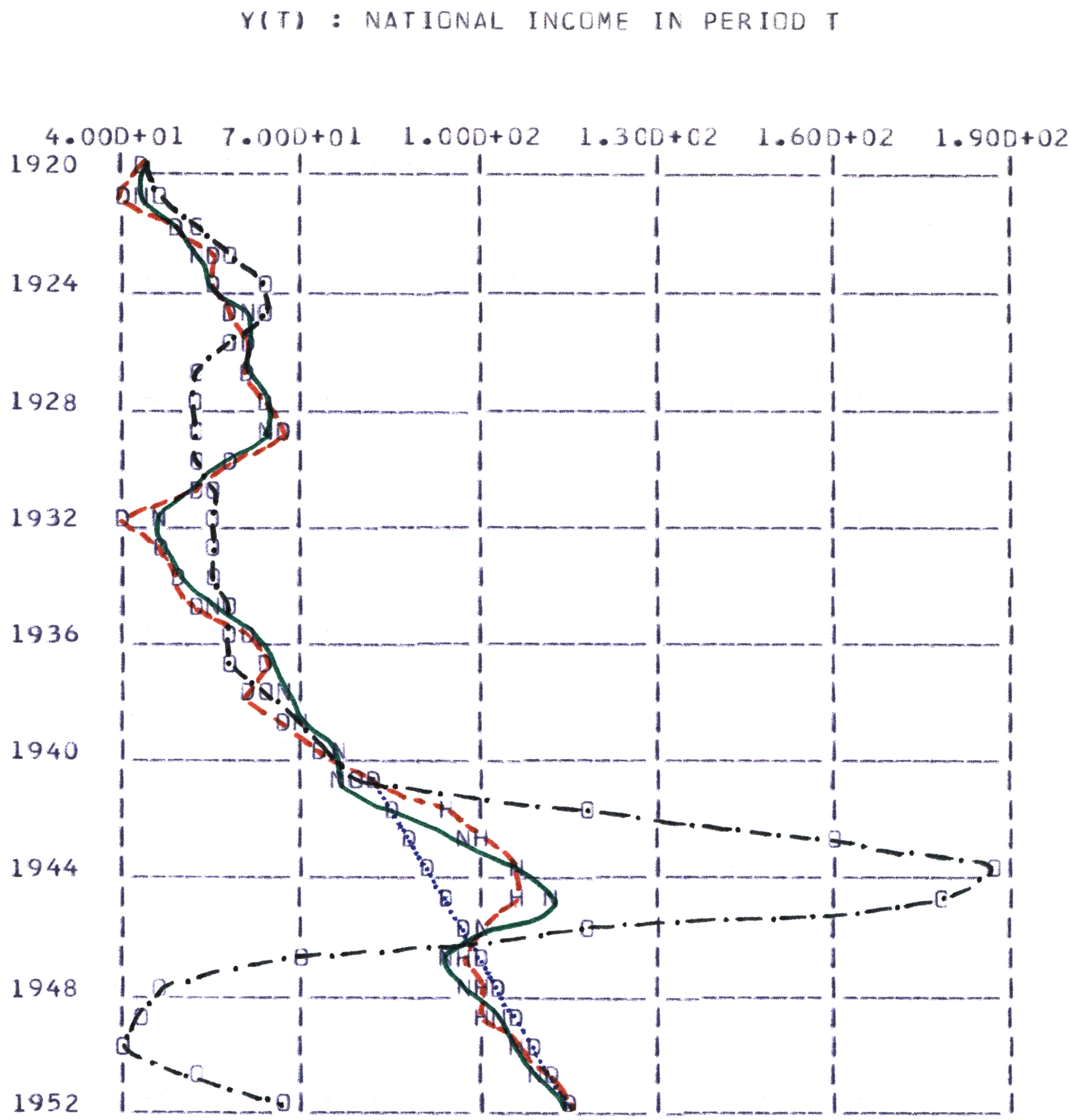


Figure 5.14

Y(T) : National Income in Period T

Forecasting Experiment for 2SLS Structure

Y(T) : NATIONAL INCOME IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
43.7000D+00	43.7000D+00	43.7000D+00	43.7000D+00	0.0	0.0
40.6000D+00	46.0930D+00	42.7395D+00	40.6000D+00	-54.9302D-01	-21.3946D-01
49.1000D+00	53.3601D+00	48.9047D+00	49.1000D+00	-42.6013D-01	19.5255D-02
55.4000D+00	58.1478D+00	52.2623D+00	55.4000D+00	-27.4776D-01	31.3767D-01
56.4000D+00	63.1952D+00	56.4253D+00	56.4000D+00	-67.9522D-01	-25.3370D-03
58.7000D+00	63.2862D+00	59.7415D+00	58.7000D+00	-45.8625D-01	-10.4151D-01
60.3000D+00	58.1294D+00	61.2157D+00	60.3000D+00	21.7062D-01	-91.5706D-02
61.3000D+00	52.5612D+00	62.4833D+00	61.3000D+00	87.3877D-01	-11.8328D-01
64.0000D+00	50.8496D+00	65.1696D+00	64.0000D+00	13.1504D+00	-11.6965D-01
67.0000D+00	52.6573D+00	65.1722D+00	67.0000D+00	14.3427D+00	18.2780D-01
57.7000D+00	53.4469D+00	58.2704D+00	57.7000D+00	42.5315D-01	-57.0383D-02
50.7000D+00	55.0622D+00	51.1554D+00	50.7000D+00	-43.6222D-01	-45.5355D-02
41.3000D+00	53.7906D+00	44.7676D+00	41.3000D+00	-12.4906D+00	-34.6763D-01
45.3000D+00	53.7964D+00	45.6285D+00	45.3000D+00	-84.9642D-01	-32.8495D-02
48.9000D+00	55.0312D+00	49.5848D+00	48.9000D+00	-61.3120D-01	-68.4828D-02
53.3000D+00	56.8379D+00	56.1608D+00	53.3000D+00	-35.3791D-01	-28.6075D-01
61.8000D+00	57.2308D+00	62.3937D+00	61.8000D+00	45.6923D-01	-59.3651D-02
65.0000D+00	57.9531D+00	62.9844D+00	65.0000D+00	70.4689D-01	20.1562D-01
61.2000D+00	63.5298D+00	65.6077D+00	61.2000D+00	-23.2978D-01	-44.0770D-01
68.4000D+00	68.7550D+00	71.4430D+00	68.4000D+00	-35.4988D-02	-30.4299D-01
74.1000D+00	72.7442D+00	74.8292D+00	74.1000D+00	13.5584D-01	-72.9225D-02
82.8800D+00	79.3128D+00	74.8066D+00	82.0000D+00	35.6715D-01	80.7342D-01
93.0800D+00	11.8284D+01	85.4513D+00	85.0000D+00	-25.2044D+00	76.2873D-01
99.1800D+00	16.0095D+01	95.7834D+00	88.0000D+00	-60.9155D+00	33.9662D-01
10.6080D+01	18.5779D+01	10.5531D+01	91.0000D+00	-79.6992D+00	54.9128D-02
10.6170D+01	17.7714D+01	11.2541D+01	94.0000D+00	-71.5444D+00	-63.7124D-01
10.1230D+01	11.8613D+01	98.7498D+00	97.0000D+00	-17.3835D+00	24.8015D-01
96.0500D+00	71.3078D+00	94.4955D+00	10.0000D+01	24.7422D+00	15.5451D-01
10.0250D+01	47.4934D+00	97.5070D+00	10.3000D+01	52.7566D+00	27.4297D-01
10.0620D+01	42.2183D+00	10.2991D+01	10.6000D+01	58.4017D+00	-23.7077D-01
10.8870D+01	41.4354D+00	10.4981D+01	10.9000D+01	67.4346D+00	38.8906D-01
11.1710D+01	50.5817D+00	10.9733D+01	11.2000D+01	61.1283D+00	19.7725D-01
11.4930D+01	66.8546D+00	11.4265D+01	11.5000D+01	48.0754D+00	66.4774D-02

QUADRATIC ERROR OLD MODEL: 3450.9134D+01

QUADRATIC ERROR NEW MODEL: 2944.4288D-01

Table 5.14

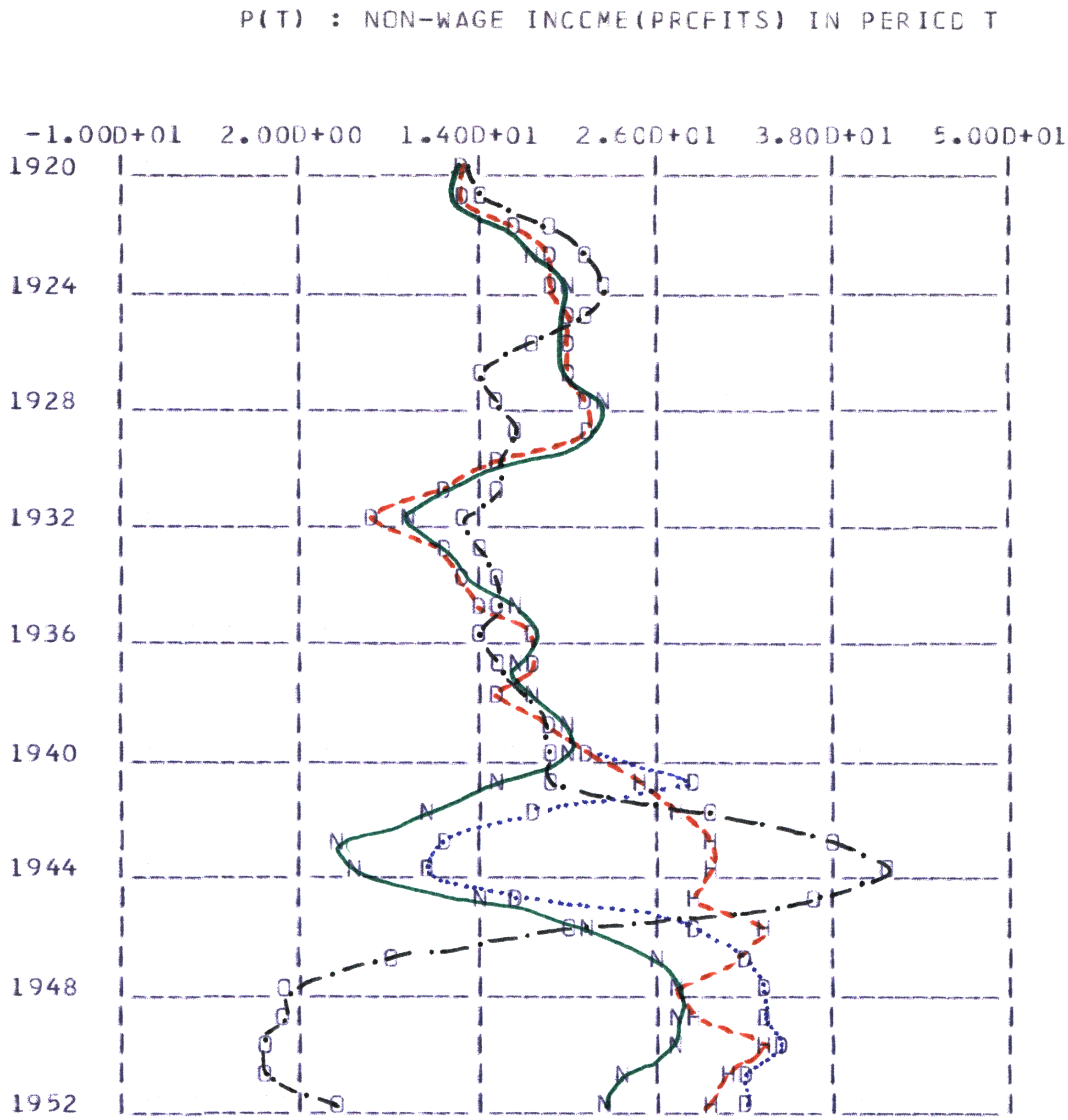


Figure 5.15

P(T) : Non-Wage Income(Profits) in Period T

Forecasting Experiment for 2SLS Structure

P(T) : NON-WAGE INCOME(PROFITS) IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
12.7000D+00	12.7000D+00	12.7000D+00	12.7000D+00	0.0	0.0
12.4000D+00	14.3943D+00	12.2723D+00	12.4000D+00	-19.9432D-01	12.7750D-02
16.9000D+00	18.8889D+00	16.6297D+00	16.9000D+00	-19.8888D-01	27.0261D-02
18.4000D+00	20.6945D+00	17.5681D+00	18.4000D+00	-22.9449D-01	83.1886D-02
19.4000D+00	22.8039D+00	19.5919D+00	19.4000D+00	-34.0388D-01	-19.1884D-02
20.1000D+00	21.2627D+00	20.4983D+00	20.1000D+00	-11.6270D-01	-39.8296D-02
19.6000D+00	17.0783D+00	19.9289D+00	19.6000D+00	25.2175D-01	-32.8870D-02
19.8000D+00	14.2365D+00	20.0462D+00	19.8000D+00	55.6345D-01	-24.6199D-02
21.1000D+00	15.1364D+00	22.2287D+00	21.1000D+00	59.6355D-01	-11.2875D-01
21.7000D+00	16.7539D+00	21.6066D+00	21.7000D+00	49.4603D-01	93.4471D-03
15.6000D+00	15.2381D+00	15.6890D+00	15.6000D+00	36.1886D-02	-89.0397D-03
11.4000D+00	15.0130D+00	11.6219D+00	11.4000D+00	-36.1300D-01	-22.1862D-02
70.0000D-01	13.3476D+00	87.7623D-01	70.0000D-01	-63.4758D-01	-17.7623D-01
11.2000D+00	14.3783D+00	11.2805D+00	11.2000D+00	-31.7828D-01	-80.4712D-03
12.3000D+00	14.7475D+00	13.1627D+00	12.3000D+00	-24.4750D-01	-86.2701D-02
14.0000D+00	15.0627D+00	16.0300D+00	14.0000D+00	-10.6269D-01	-20.2996D-01
17.6000D+00	13.5594D+00	17.1007D+00	17.6000D+00	40.4065D-01	49.9291D-02
17.3000D+00	14.8796D+00	16.8793D+00	17.3000D+00	24.2035D-01	42.0693D-02
15.3000D+00	17.2201D+00	17.7271D+00	15.3000D+00	-19.2011D-01	-24.2707D-01
19.0000D+00	18.5827D+00	20.2216D+00	19.0000D+00	41.7252D-02	-12.2158D-01
21.1000D+00	19.2284D+00	20.2340D+00	21.1000D+00	18.7158D-01	86.6016D-02
24.6800D+00	19.1909D+00	15.7501D+00	27.8600D+00	54.8910D-01	89.2993D-01
26.9900D+00	29.3993D+00	10.0146D+00	17.9900D+00	-24.0926D-01	16.9754D+00
29.5700D+00	37.4075D+00	45.4521D-01	11.8800D+00	-78.3752D-01	25.0248D+00
29.7300D+00	41.8404D+00	59.9848D-01	10.6300D+00	-12.1104D+00	23.7315D+00
28.5600D+00	37.2442D+00	14.0577D+00	15.9100D+00	-86.8419D-01	14.5023D+00
32.9000D+00	20.2853D+00	20.9337D+00	27.8200D+00	12.6147D+00	11.9663D+00
31.5100D+00	81.0299D-01	25.6877D+00	32.5000D+00	23.4070D+00	58.2232D-01
33.3500D+00	11.1190D-01	26.6140D+00	33.6200D+00	32.2381D+00	67.3602D-01
28.7000D+00	46.4182D-02	27.7287D+00	33.3800D+00	28.2358D+00	97.1317D-02
32.8300D+00	-67.7136D-02	26.6609D+00	33.8600D+00	33.5071D+00	61.6915D-01
31.3000D+00	-72.8943D-02	24.1000D+00	32.4800D+00	32.0289D+00	72.0003D-01
29.7600D+00	38.9989D-01	22.6210D+00	31.9400D+00	25.8601D+00	71.3899D-01

QUADRATIC ERROR OLD MODEL: 5904.0640D+00

QUADRATIC ERROR NEW MODEL: 2150.9964D+00

Table 5.15

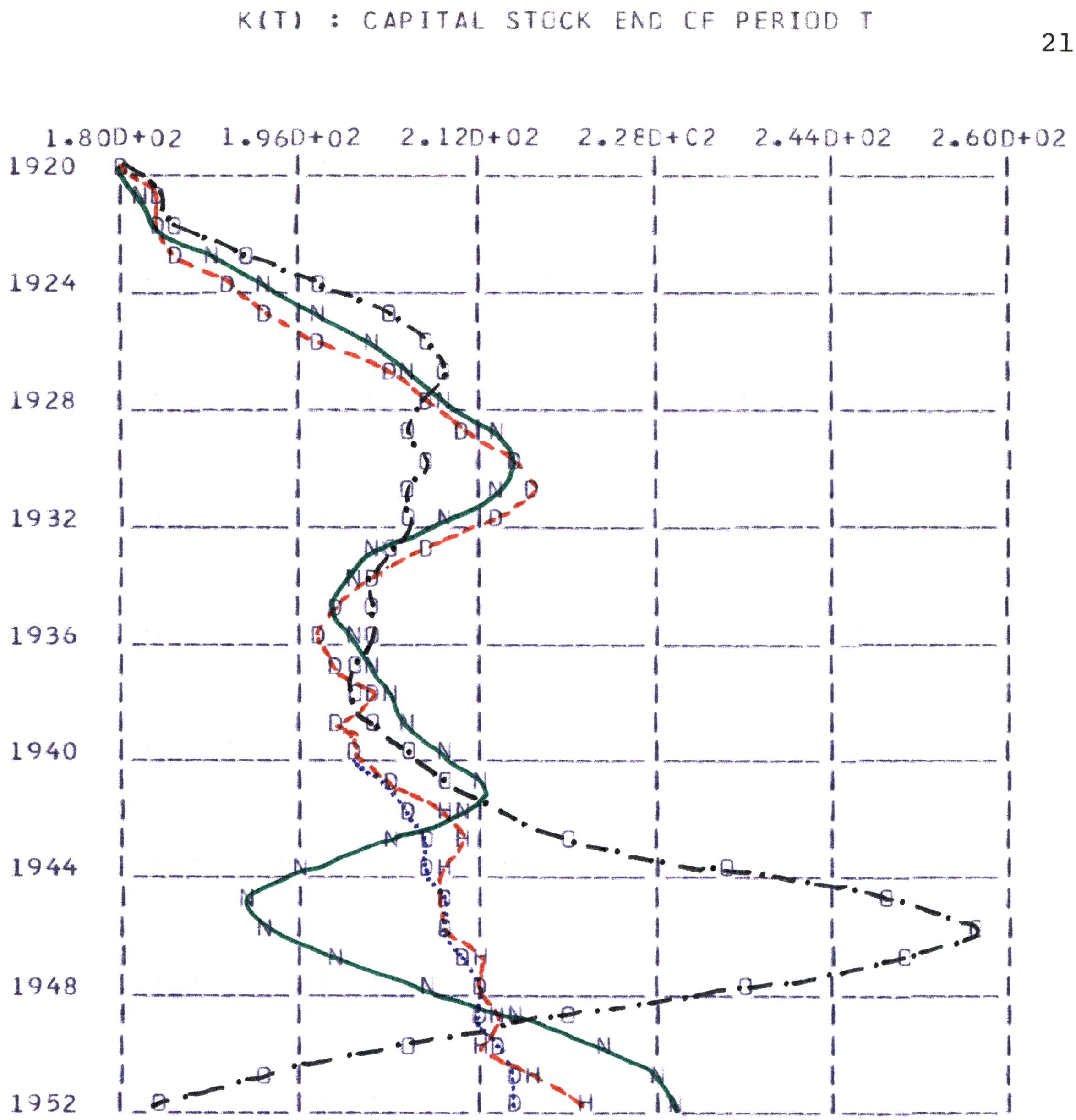


Figure 5.16

K(T) : Capital Stock End of Period T

Forecasting Experiment for 2SLS Structure

K(T) : CAPITAL STOCK END OF PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
18.0100D+01	18.0100D+01	18.0100D+01	18.0100D+01	0.0	0.0
18.2800D+01	18.2125D+01	18.1981D+01	18.2800D+01	67.5280D-02	81.9220D-02
18.2600D+01	18.5275D+01	18.3545D+01	18.2600D+01	-26.7511D-01	-94.5112D-02
18.4500D+01	19.1101D+01	18.7901D+01	18.4500D+01	-66.0116D-01	-34.0056D-01
18.9700D+01	19.7324D+01	19.2301D+01	18.9700D+01	-76.2421D-01	-26.0056D-01
19.2700D+01	20.3838D+01	19.7407D+01	19.2700D+01	-11.1381D+00	-47.0711D-01
19.7800D+01	20.7907D+01	20.2233D+01	19.7800D+01	-10.1074D+00	-44.3325D-01
20.3400D+01	20.8222D+01	20.5860D+01	20.3400D+01	-48.2199D-01	-24.5961D-01
20.7600D+01	20.6593D+01	20.9101D+01	20.7600D+01	10.0697D-01	-15.0087D-01
21.0600D+01	20.5967D+01	21.3250D+01	21.0600D+01	46.3261D-01	-26.5012D-01
21.5700D+01	20.6455D+01	21.5869D+01	21.5700D+01	92.4450D-01	-16.8552D-02
21.6700D+01	20.5805D+01	21.3705D+01	21.6700D+01	10.8951D+00	29.9545D-01
21.3300D+01	20.4997D+01	20.8921D+01	21.3300D+01	83.0321D-01	43.7911D-01
20.7100D+01	20.3252D+01	20.3163D+01	20.7100D+01	38.4824D-01	39.3739D-01
20.2000D+01	20.2535D+01	20.0226D+01	20.2000D+01	-53.4864D-02	17.7391D-01
19.9000D+01	20.2214D+01	19.9274D+01	19.9000D+01	-32.1420D-01	-27.3506D-02
19.7700D+01	20.2062D+01	20.0524D+01	19.7700D+01	-43.6227D-01	-28.2364D-01
19.9800D+01	20.0993D+01	20.2282D+01	19.9800D+01	-11.9329D-01	-24.8247D-01
20.1800D+01	20.1171D+01	20.3649D+01	20.1800D+01	62.9412D-02	-18.4911D-01
19.9900D+01	20.3017D+01	20.5536D+01	19.9900D+01	-31.1746D-01	-56.3582D-01
20.1200D+01	20.5531D+01	20.8817D+01	20.1200D+01	-43.3128D-01	-76.1701D-01
20.4500D+01	20.8060D+01	21.1247D+01	20.4500D+01	-35.6050D-01	-67.4729D-01
20.8520D+01	21.0828D+01	20.9798D+01	20.5500D+01	-23.0836D-01	-12.7823D-01
20.9950D+01	22.0681D+01	20.4285D+01	20.6500D+01	-10.7309D+00	56.6503D-01
20.9500D+01	23.4666D+01	19.6048D+01	20.7500D+01	-25.1659D+00	13.4524D+00
20.8770D+01	24.9016D+01	19.0749D+01	20.8500D+01	-40.2464D+00	18.0212D+00
20.8060D+01	25.6632D+01	19.2347D+01	20.9500D+01	-48.5718D+00	15.7127D+00
21.2110D+01	25.0487D+01	19.8719D+01	21.0500D+01	-38.3768D+00	13.3907D+00
21.1830D+01	23.6542D+01	20.7340D+01	21.1500D+01	-24.7122D+00	44.8972D-01
21.4320D+01	22.0113D+01	21.5214D+01	21.2500D+01	-57.9289D-01	-89.3995D-02
21.2670D+01	20.5942D+01	22.2448D+01	21.3500D+01	67.2824D-01	-97.7824D-01
21.6250D+01	19.3382D+01	22.7551D+01	21.4500D+01	22.8684D+00	-11.3013D+00
22.1330D+01	18.3225D+01	22.9932D+01	21.5500D+01	38.1046D+00	-86.0185D-01

QUADRATIC ERROR OLD MODEL: 9611.8103D+00

QUADRATIC ERROR NEW MODEL: 1560.7291D+00

Table 5.16

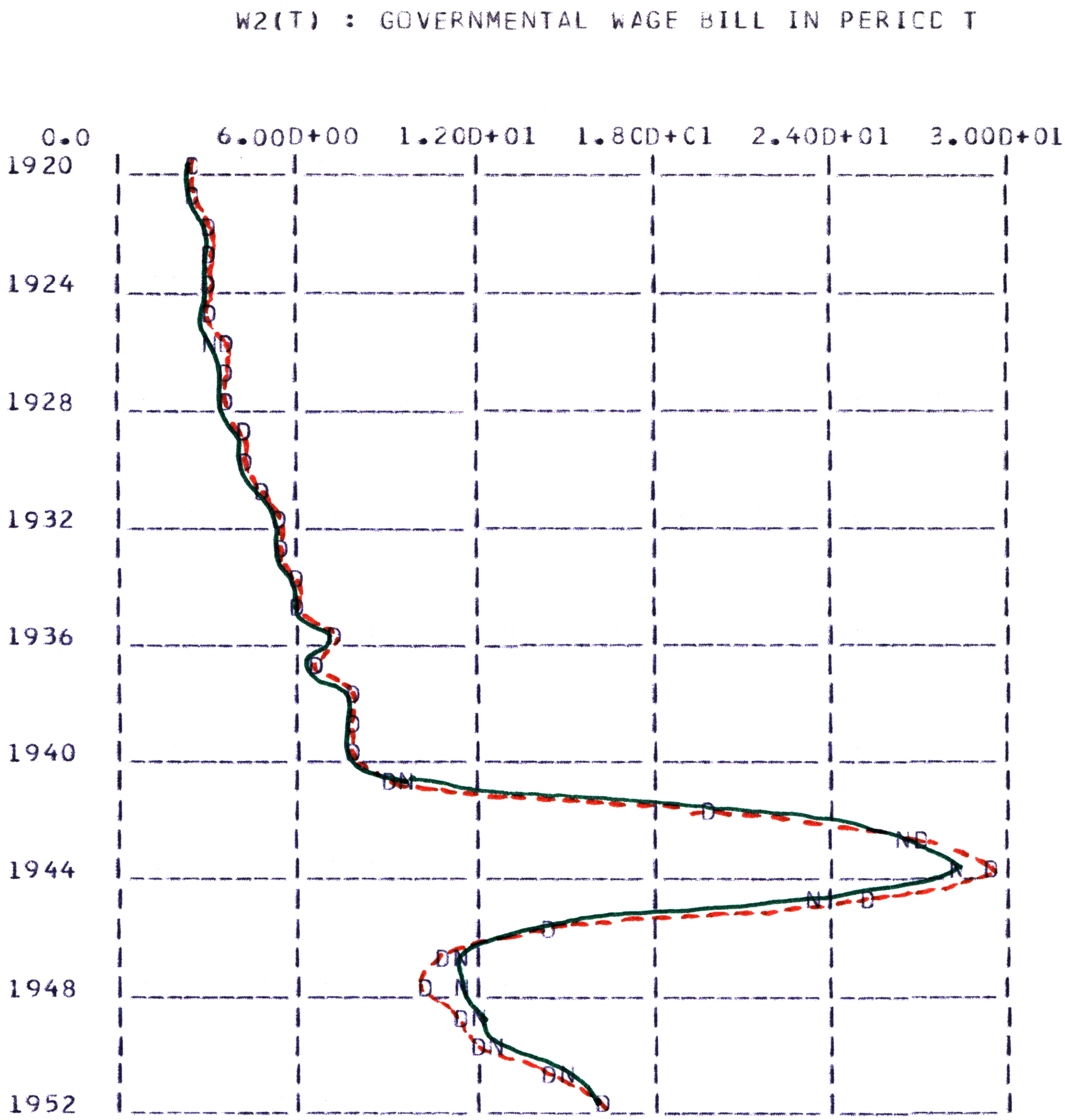


Figure 5.17

W2(T) : Governmental Wage Bill in Period T

Forecasting Experiment for 2SLS Structure

W2(T) : GOVERNMENTAL WAGE BILL IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
22.0000D-01	22.0000D-01	22.0000D-01	22.0000D-01	0.0	0.0
27.0000D-01	27.0000D-01	26.2800D-01	27.0000D-01	0.0	71.9978D-03
29.0000D-01	29.0000D-01	28.8800D-01	29.0000D-01	0.0	12.0011D-03
29.0000D-01	29.0000D-01	30.7284D-01	29.0000D-01	0.0	-17.2845D-02
31.0000D-01	31.0000D-01	31.5379D-01	31.0000D-01	0.0	-53.7851D-03
32.0000D-01	32.0000D-01	31.3550D-01	32.0000D-01	0.0	64.4951D-03
33.0000D-01	33.0000D-01	32.1819D-01	33.0000D-01	0.0	81.8059D-03
36.0000D-01	36.0000D-01	35.0628D-01	36.0000D-01	0.0	93.7211D-03
37.0000D-01	37.0000D-01	36.3281D-01	37.0000D-01	0.0	67.1898D-03
40.0000D-01	40.0000D-01	40.8637D-01	40.0000D-01	0.0	-86.3706D-03
42.0000D-01	42.0000D-01	42.2244D-01	42.0000D-01	0.0	-22.4407D-03
48.0000D-01	48.0000D-01	48.1913D-01	48.0000D-01	0.0	-19.1275D-03
53.0000D-01	53.0000D-01	51.1698D-01	53.0000D-01	0.0	18.3022D-02
56.0000D-01	56.0000D-01	55.5719D-01	56.0000D-01	0.0	42.8116D-03
60.0000D-01	60.0000D-01	59.6321D-01	60.0000D-01	0.0	36.7887D-03
61.0000D-01	61.0000D-01	59.2413D-01	61.0000D-01	0.0	17.5874D-02
74.0000D-01	74.0000D-01	73.3261D-01	74.0000D-01	0.0	67.3900D-03
67.0000D-01	67.0000D-01	68.3490D-01	67.0000D-01	0.0	-13.4896D-02
77.0000D-01	77.0000D-01	75.3522D-01	77.0000D-01	0.0	16.4784D-02
78.0000D-01	78.0000D-01	76.2796D-01	78.0000D-01	0.0	17.2041D-02
80.0000D-01	80.0000D-01	79.6008D-01	80.0000D-01	0.0	39.9151D-03
91.4000D-01	91.4000D-01	97.4850D-01	91.4000D-01	0.0	-60.8499D-02
20.0100D+00	20.0100D+00	19.8901D+00	20.0100D+00	0.0	11.9869D-02
27.1200D+00	27.1200D+00	26.3306D+00	27.1200D+00	0.0	78.9352D-02
29.3700D+00	29.3700D+00	28.0032D+00	29.3700D+00	0.0	13.6684D-01
25.0900D+00	25.0900D+00	23.5520D+00	25.0900D+00	0.0	15.3802D-01
14.1800D+00	14.1800D+00	14.1216D+00	14.1800D+00	0.0	58.3524D-03
10.5000D+00	10.5000D+00	11.1309D+00	10.5000D+00	0.0	-63.0934D-02
10.3800D+00	10.3800D+00	11.1024D+00	10.3800D+00	0.0	-72.2352D-02
11.6200D+00	11.6200D+00	12.1404D+00	11.6200D+00	0.0	-52.0426D-02
12.1400D+00	12.1400D+00	12.7665D+00	12.1400D+00	0.0	-62.6455D-02
14.5200D+00	14.5200D+00	14.9204D+00	14.5200D+00	0.0	-40.0436D-02
16.0600D+00	16.0600D+00	16.2229D+00	16.0600D+00	0.0	-16.2873D-02

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 7234.2082D-03

Table 5.17

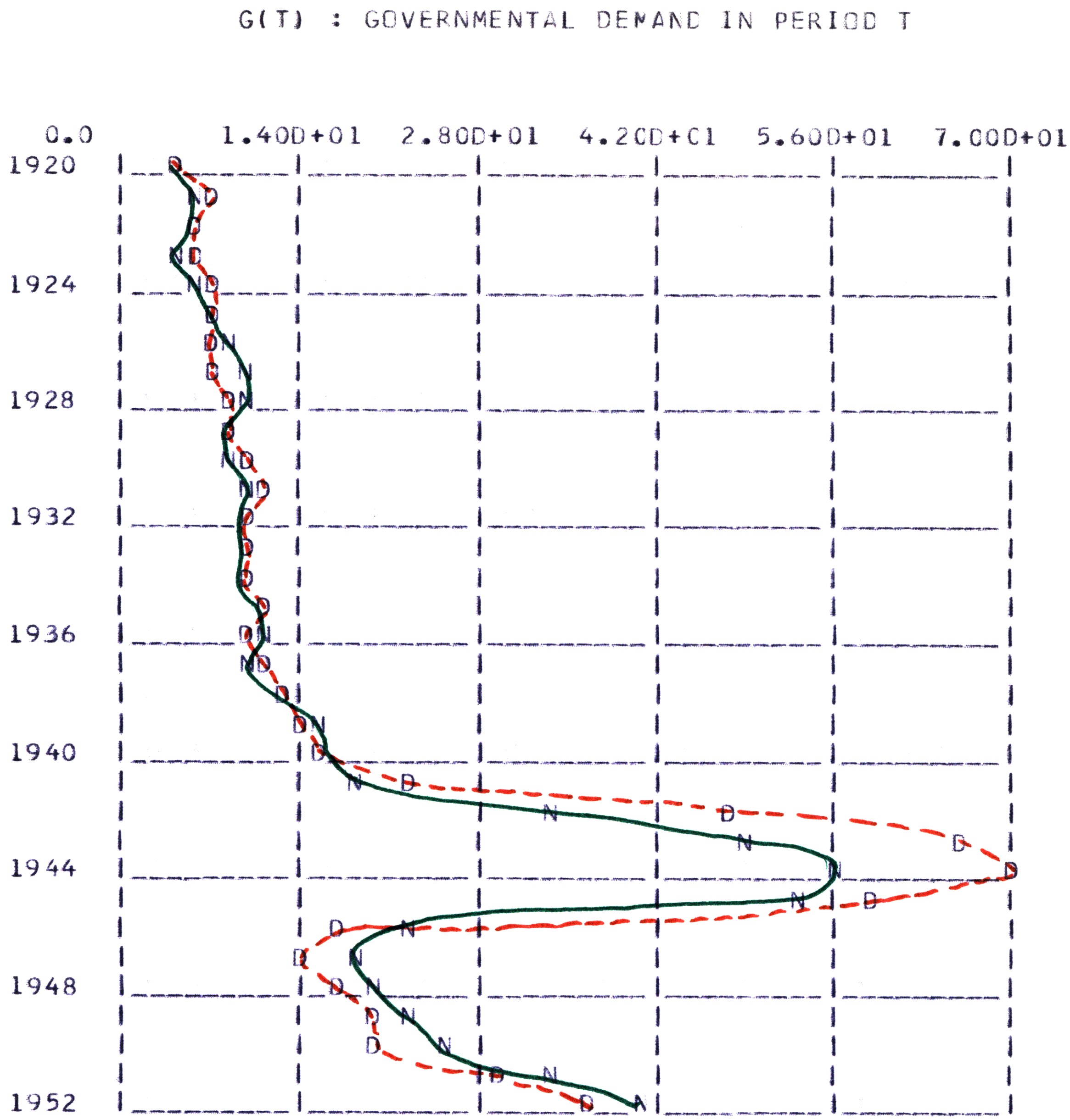


Figure 5.18

G(T) : Governmental Demand in Period T

Forecasting Experiment for 2SLS Structure

G(T) : GOVERNMENTAL DEMAND IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
46.0000D-01	46.0000D-01	46.0000D-01	46.0000D-01	0.0	0.0
66.0000D-01	66.0000D-01	49.4399D-01	66.0000D-01	0.0	16.5601D-01
61.0000D-01	61.0000D-01	58.4333D-01	61.0000D-01	0.0	25.6673D-02
57.0000D-01	57.0000D-01	47.6080D-01	57.0000D-01	0.0	93.9201D-02
66.0000D-01	66.0000D-01	55.9334D-01	66.0000D-01	0.0	10.0666D-01
65.0000D-01	65.0000D-01	68.9704D-01	65.0000D-01	0.0	-39.7040D-02
66.0000D-01	66.0000D-01	80.0873D-01	66.0000D-01	0.0	-14.0873D-01
76.0000D-01	76.0000D-01	92.8924D-01	76.0000D-01	0.0	-16.8924D-01
79.0000D-01	79.0000D-01	95.3084D-01	79.0000D-01	0.0	-16.3084D-01
81.0000D-01	81.0000D-01	81.8549D-01	81.0000D-01	0.0	-85.4914D-03
94.0000D-01	94.0000D-01	80.3165D-01	94.0000D-01	0.0	13.6835D-01
10.7000D+00	10.7000D+00	91.5593D-01	10.7000D+00	0.0	15.4407D-01
10.2000D+00	10.2000D+00	95.4735D-01	10.2000D+00	0.0	65.2651D-02
93.0000D-01	93.0000D-01	99.3462D-01	93.0000D-01	0.0	-63.4625D-02
10.0000D+00	10.0000D+00	10.2738D+00	10.0000D+00	0.0	-27.3848D-02
10.5000D+00	10.5000D+00	11.4203D+00	10.5000D+00	0.0	-92.0303D-02
10.3000D+00	10.3000D+00	11.7908D+00	10.3000D+00	0.0	-14.9084D-01
11.0000D+00	11.0000D+00	10.1925D+00	11.0000D+00	0.0	80.7480D-02
13.0000D+00	13.0000D+00	12.0178D+00	13.0000D+00	0.0	98.2232D-02
14.4000D+00	14.4000D+00	15.2599D+00	14.4000D+00	0.0	-85.9890D-02
15.4000D+00	15.4000D+00	15.1979D+00	15.4000D+00	0.0	20.2107D-02
22.1700D+00	22.1700D+00	18.8366D+00	22.1700D+00	0.0	33.3337D-01
47.4600D+00	47.4600D+00	33.5870D+00	47.4600D+00	0.0	13.8730D+00
65.8300D+00	65.8300D+00	49.3253D+00	65.8300D+00	0.0	16.5047D+00
69.9700D+00	69.9700D+00	56.1798D+00	69.9700D+00	0.0	13.7902D+00
58.1800D+00	58.1800D+00	53.2230D+00	58.1800D+00	0.0	49.5705D-01
17.0800D+00	17.0800D+00	22.0797D+00	17.0800D+00	0.0	-49.9969D-01
14.2000D+00	14.2000D+00	18.5008D+00	14.2000D+00	0.0	-43.0084D-01
16.7500D+00	16.7500D+00	19.3679D+00	16.7500D+00	0.0	-26.1792D-01
20.1700D+00	20.1700D+00	22.6925D+00	20.1700D+00	0.0	-25.2247D-01
19.9400D+00	19.9400D+00	24.6056D+00	19.9400D+00	0.0	-46.6564D-01
29.1400D+00	29.1400D+00	34.1644D+00	29.1400D+00	0.0	-50.2438D-01
36.0300D+00	36.0300D+00	40.1728D+00	36.0300D+00	0.0	-41.4277D-01

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 8345.9452D-01

Table 5.18

TX(T) : BUSINESS TAXES IN PERIOD T

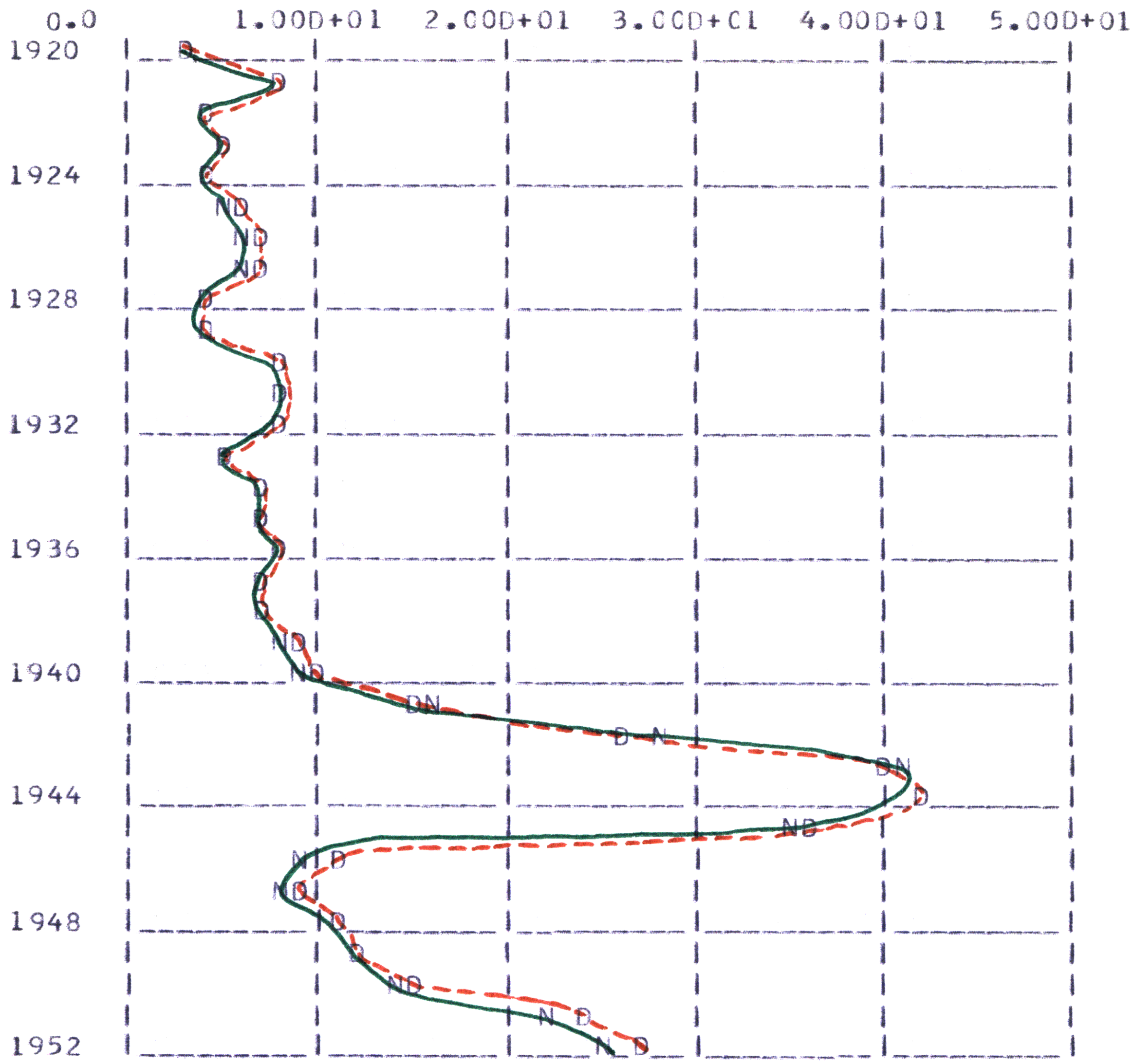


Figure 5.19

TX(T) : Business Taxes in Period T

Forecasting Experiment for 2SLS Structure

TX(T) : BUSINESS TAXES IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
34.0000D-01	34.0000D-01	34.0000D-01	34.0000D-01	0.0	0.0
77.0000D-01	77.0000D-01	81.0805D-01	77.0000D-01	0.0	-40.8054D-02
39.0000D-01	39.0000D-01	42.1268D-01	39.0000D-01	0.0	-31.2677D-02
47.0000D-01	47.0000D-01	53.3577D-01	47.0000D-01	0.0	-63.5774D-02
38.0000D-01	38.0000D-01	40.9303D-01	38.0000D-01	0.0	-29.3029D-02
55.0000D-01	55.0000D-01	51.6424D-01	55.0000D-01	0.0	33.5764D-02
70.0000D-01	70.0000D-01	63.2176D-01	70.0000D-01	0.0	67.8242D-02
67.0000D-01	67.0000D-01	59.9684D-01	67.0000D-01	0.0	70.3156D-02
42.0000D-01	42.0000D-01	37.3541D-01	42.0000D-01	0.0	46.4590D-02
40.0000D-01	40.0000D-01	41.3301D-01	40.0000D-01	0.0	-13.3006D-02
77.0000D-01	77.0000D-01	80.7368D-01	77.0000D-01	0.0	-37.3679D-02
75.0000D-01	75.0000D-01	77.9108D-01	75.0000D-01	0.0	-29.1080D-02
83.0000D-01	83.0000D-01	81.8356D-01	83.0000D-01	0.0	11.6436D-02
54.0000D-01	54.0000D-01	50.6328D-01	54.0000D-01	0.0	33.6717D-02
68.0000D-01	68.0000D-01	65.0720D-01	68.0000D-01	0.0	29.2798D-02
72.0000D-01	72.0000D-01	66.0673D-01	72.0000D-01	0.0	59.3273D-02
83.0000D-01	83.0000D-01	77.4376D-01	83.0000D-01	0.0	55.6245D-02
67.0000D-01	67.0000D-01	68.9646D-01	67.0000D-01	0.0	-19.6462D-02
74.0000D-01	74.0000D-01	71.8605D-01	74.0000D-01	0.0	21.3951D-02
89.0000D-01	89.0000D-01	81.6102D-01	89.0000D-01	0.0	73.8983D-02
96.0000D-01	96.0000D-01	93.0262D-01	96.0000D-01	0.0	29.7381D-02
15.3700D+00	15.3700D+00	15.5207D+00	15.3700D+00	0.0	-15.0700D-02
26.2700D+00	26.2700D+00	28.1671D+00	26.2700D+00	0.0	-18.9710D-01
39.9700D+00	39.9700D+00	41.2614D+00	39.9700D+00	0.0	-12.9138D-01
41.6800D+00	41.6800D+00	41.6717D+00	41.6800D+00	0.0	83.3599D-04
35.9100D+00	35.9100D+00	34.5107D+00	35.9100D+00	0.0	13.9929D-01
10.6200D+00	10.6200D+00	87.5971D-01	10.6200D+00	0.0	18.6029D-01
87.7000D-01	87.7000D-01	82.0419D-01	87.7000D-01	0.0	56.5812D-02
11.0200D+00	11.0200D+00	10.8700D+00	11.0200D+00	0.0	14.9988D-02
12.2200D+00	12.2200D+00	11.7883D+00	12.2200D+00	0.0	43.1657D-02
15.1500D+00	15.1500D+00	13.7129D+00	15.1500D+00	0.0	14.3711D-01
24.2100D+00	24.2100D+00	22.0874D+00	24.2100D+00	0.0	21.2255D-01
27.1100D+00	27.1100D+00	25.2862D+00	27.1100D+00	0.0	18.2379D-01

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 2500.6147D-02

Table 5.19

5.3.3 Forecasting With the FIML Structure

For this run, the standard econometric model ("old" model) was obtained by using the full information maximum likelihood estimation procedure to Klein's original structure.

The results are shown numerically and graphically in Tables 5.38 to 5.55 and in Figures 5.37 to 5.54. The convention for symbols in the different diagrams is the same used in previous runs.

As expected, the behavior of the "new" model is similar to the behavior of previous runs. However, the performance of this "new" model is slightly superior to the performance of the "new" model obtained by 2SLS and OLS in despite of the poor performance of the "old" model obtained with FIML. In fact, the big oscilations produced by the "old" model obtained with FIML, give us the worst performance for "old" models. The phenomenon of obtaining the best performance for "new" models and the worst performance for "old" models by using the structure obtained using FIML could be explained by the fact that full information maximum likelihood being the most powerful statistic method from the point of view of large sample theory has very low performance for small samples.

About the performance of each variable in particular, most of the comments given for OLS and 2SLS can be applied to the FIML structure.

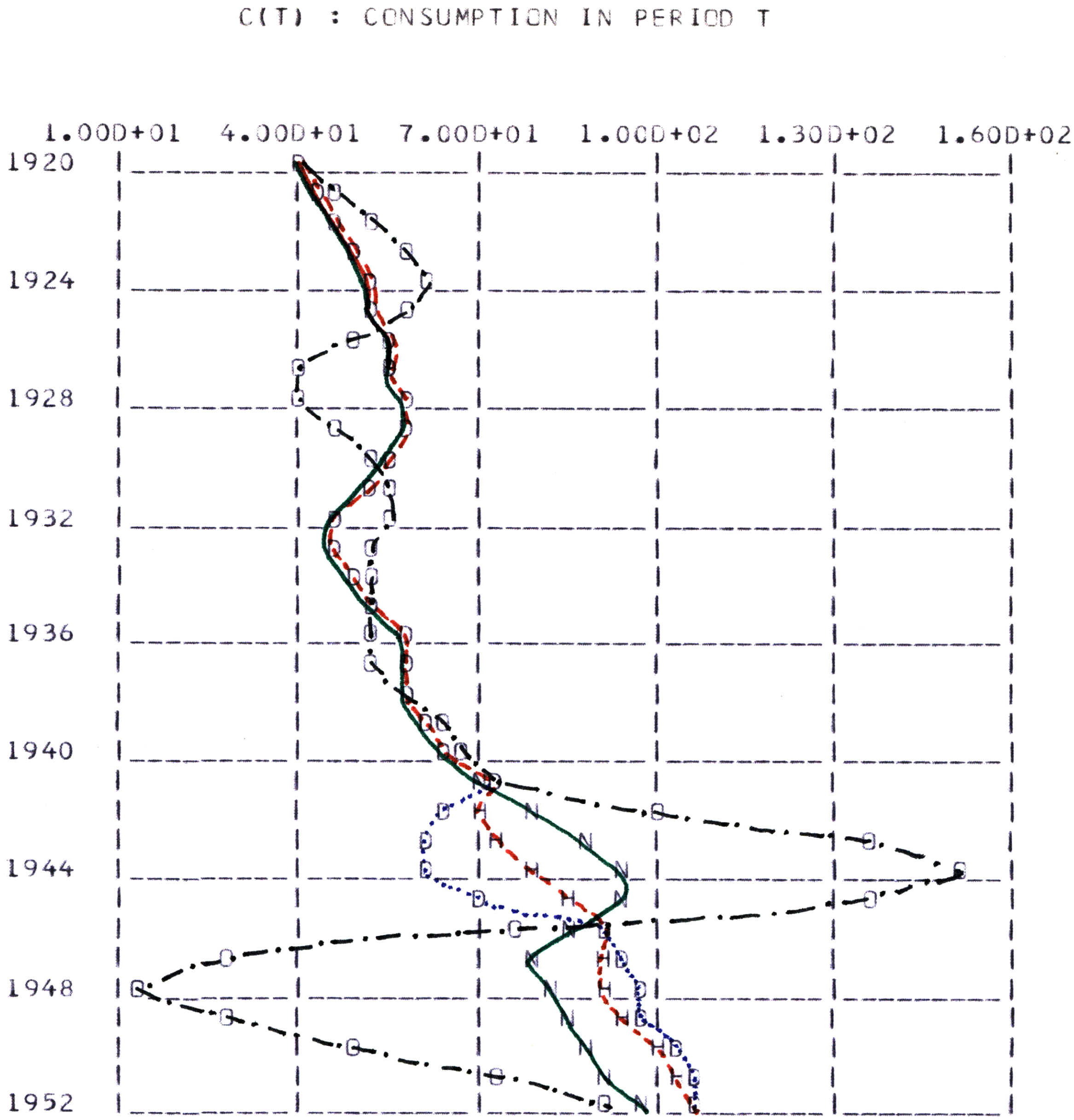


Figure 5.20

C(T) : Consumption in Period T

Forecasting Experiment for FIML Structure

C(T) : CONSUMPTION IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
39.8000D+00	39.8000D+00	39.8000D+00	39.8000D+00	0.0	0.0
41.9000D+00	44.9269D+00	42.6425D+00	41.9000D+00	-30.2687D-01	-74.2503D-02
45.0000D+00	51.6939D+00	46.1643D+00	45.0000D+00	-66.9391D-01	-11.6434D-01
49.2000D+00	57.0552D+00	48.9022D+00	49.2000D+00	-78.5516D-01	29.7847D-02
50.6000D+00	61.0707D+00	50.7283D+00	50.6000D+00	-10.4707D+00	-12.8270D-02
52.6000D+00	58.7950D+00	52.8732D+00	52.6000D+00	-61.9495D-01	-27.3224D-02
55.1000D+00	49.4228D+00	54.5417D+00	55.1000D+00	56.7718D-01	55.8334D-02
56.2000D+00	40.3758D+00	55.3485D+00	56.2000D+00	15.8242D+00	85.1526D-02
57.3000D+00	39.7592D+00	56.5703D+00	57.3000D+00	17.5408D+00	72.9653D-02
57.8000D+00	46.9893D+00	58.0324D+00	57.8000D+00	10.8107D+00	-23.2360D-02
55.0000D+00	52.8552D+00	55.1387D+00	55.0000D+00	21.4484D-01	-13.8658D-02
50.9000D+00	56.2664D+00	51.2123D+00	50.9000D+00	-53.6640D-01	-31.2260D-02
45.6000D+00	54.5418D+00	46.5354D+00	45.6000D+00	-89.4184D-01	-93.5381D-02
46.5000D+00	52.7835D+00	46.4644D+00	46.5000D+00	-62.8347D-01	35.6418D-03
48.7000D+00	52.4614D+00	48.5684D+00	48.7000D+00	-37.6140D-01	13.1609D-02
51.3000D+00	52.7900D+00	52.0430D+00	51.3000D+00	-14.8999D-01	-74.3004D-02
57.7000D+00	51.5738D+00	57.2259D+00	57.7000D+00	61.2619D-01	47.4149D-02
58.7000D+00	51.6603D+00	58.2359D+00	58.7000D+00	70.3971D-01	46.4083D-02
57.5000D+00	57.9482D+00	58.3978D+00	57.5000D+00	-44.8222D-02	-89.7801D-02
61.6000D+00	64.2895D+00	61.7521D+00	61.6000D+00	-26.8947D-01	-15.2113D-02
65.0000D+00	67.9329D+00	65.4936D+00	65.0000D+00	-29.3287D-01	-49.3613D-02
72.0600D+00	71.0397D+00	69.5794D+00	74.2000D+00	10.2034D-01	24.8060D-01
70.4600D+00	10.0716D+01	79.7936D+00	62.8100D+00	-30.2560D+00	-93.3356D-01
73.7700D+00	13.4723D+01	88.3012D+00	61.1400D+00	-60.9525D+00	-14.5312D+00
78.5200D+00	15.2093D+01	93.4425D+00	61.7100D+00	-73.5727D+00	-14.9225D+00
84.6100D+00	13.6365D+01	94.6489D+00	70.7300D+00	-51.7548D+00	-10.0389D+00
90.7200D+00	75.6534D+00	84.0225D+00	89.5400D+00	15.0666D+00	66.9753D-01
90.9000D+00	26.6012D+00	79.7281D+00	93.5700D+00	64.2988D+00	11.1719D+00
92.0300D+00	12.0706D+00	81.0904D+00	96.2700D+00	79.9594D+00	10.9396D+00
94.3200D+00	27.1705D+00	84.1477D+00	97.0500D+00	67.1495D+00	10.1723D+00
10.0500D+01	50.0341D+00	86.5871D+00	10.3940D+01	50.4659D+00	13.9129D+00
10.1700D+01	72.3900D+00	91.5794D+00	10.6070D+01	29.3100D+00	10.1206D+00
10.4510D+01	90.1834D+00	96.2765D+00	10.5080D+01	14.3266D+00	82.3349D-01

QUADRATIC ERROR OLD MODEL: 3284.1413D+01

QUADRATIC ERROR NEW MODEL: 1301.2766D+00

Table 5.20

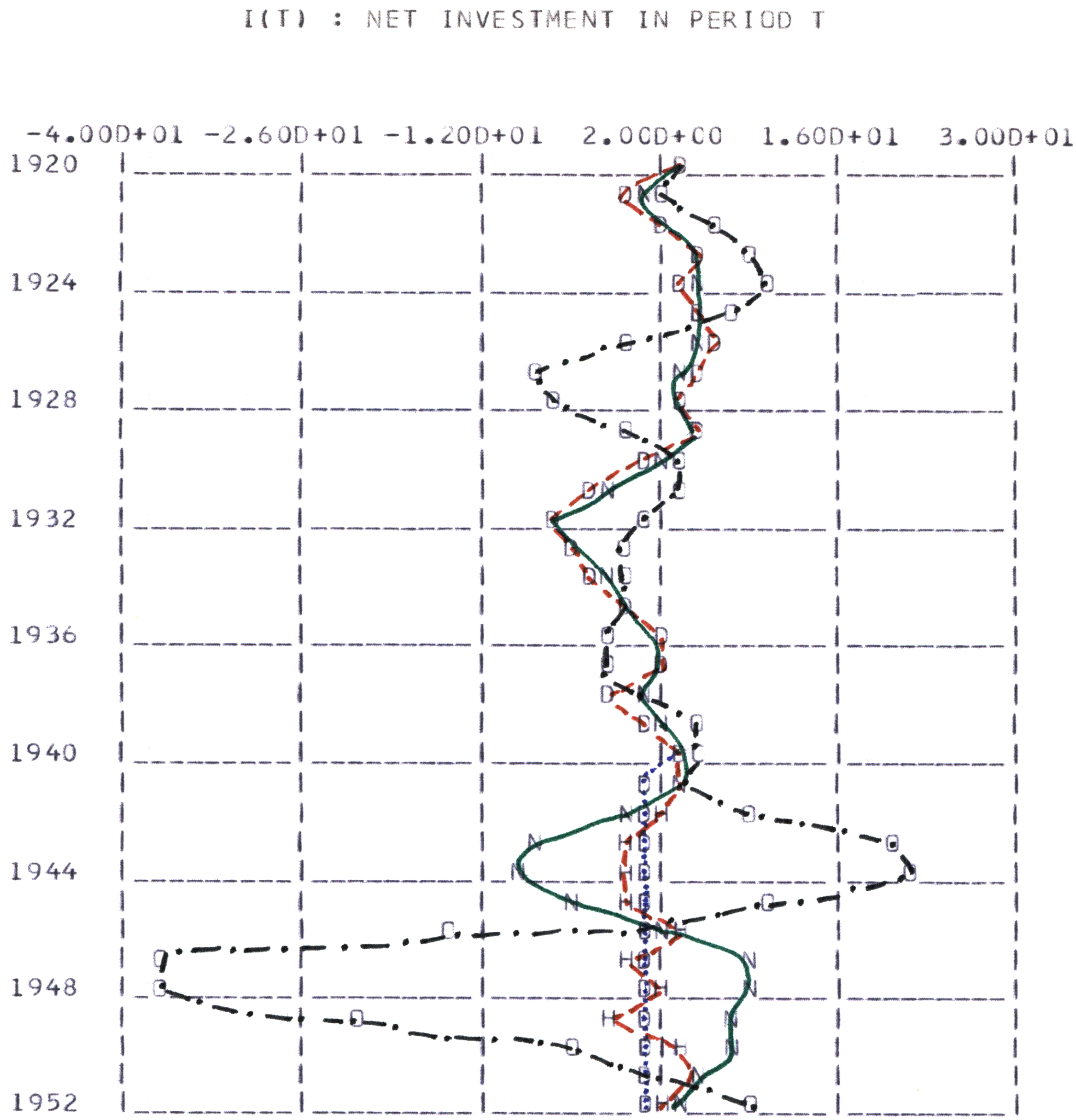


Figure 5.21

I(T) : Net Investment in Period T

Forecasting Experiment for FIML Structure

I(T) : NET INVESTMENT IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
27.0000D-01	27.0000D-01	27.0000D-01	27.0000D-01	0.0	0.0
-20.0000D-02	16.8433D-01	42.2161D-02	-20.0000D-02	-18.8433D-01	-62.2161D-02
19.0000D-01	55.1603D-01	20.5155D-01	19.0000D-01	-36.1603D-01	-15.1555D-02
52.0000D-01	92.4644D-01	45.1155D-01	52.0000D-01	-40.4644D-01	68.8451D-02
30.0000D-01	98.1996D-01	45.4225D-01	30.0000D-01	-68.1996D-01	-15.4225D-01
51.0000D-01	69.7135D-01	48.5527D-01	51.0000D-01	-18.7135D-01	24.4727D-02
56.0000D-01	-96.3264D-02	46.3745D-01	56.0000D-01	65.6326D-01	96.2546D-02
42.0000D-01	-77.6247D-01	36.8677D-01	42.0000D-01	11.9625D+00	51.3235D-02
30.0000D-01	-68.9667D-01	39.1258D-01	30.0000D-01	98.9667D-01	-91.2578D-02
51.0000D-01	-33.0584D-02	47.4305D-01	51.0000D-01	54.3058D-01	35.6945D-02
10.0000D-01	31.7362D-01	17.9992D-01	10.0000D-01	-21.7362D-01	-79.9921D-02
-34.0000D-01	27.3721D-01	-28.6794D-01	-34.0000D-01	-61.3721D-01	-53.2058D-02
-62.0000D-01	58.9480D-02	-57.6687D-01	-62.0000D-01	-67.8948D-01	-43.3127D-02
-51.0000D-01	-11.8604D-01	-52.7985D-01	-51.0000D-01	-39.1396D-01	17.9846D-02
-30.0000D-01	-87.4728D-02	-25.4629D-01	-30.0000D-01	-21.2527D-01	-45.3712D-02
-13.0000D-01	-10.3549D-01	-75.9264D-02	-13.0000D-01	-26.4511D-02	-54.0736D-02
21.0000D-01	-25.6058D-01	14.2970D-01	21.0000D-01	46.6058D-01	67.0304D-02
20.0000D-01	-26.7771D-01	20.1380D-01	20.0000D-01	46.7771D-01	-13.8003D-03
-19.0000D-01	12.2764D-01	84.3349D-02	-19.0000D-01	-31.2764D-01	-27.4335D-01
13.0000D-01	45.8190D-01	16.2053D-01	13.0000D-01	-32.8190D-01	-32.0530D-02
33.0000D-01	51.3746D-01	35.1071D-01	33.0000D-01	-18.3746D-01	-21.0714D-02
40.2000D-01	34.4466D-01	28.5626D-01	10.0000D-01	57.5338D-02	11.6374D-01
14.3000D-01	90.5144D-01	-13.1805D-01	10.0000D-01	-76.2144D-01	27.4805D-01
-45.0000D-02	19.6816D+00	-71.3166D-01	10.0000D-01	-20.1316D+00	66.8166D-01
-73.0000D-02	21.3484D+00	-92.0077D-01	10.0000D-01	-22.0784D+00	84.7077D-01
-71.0000D-02	10.5866D+00	-51.2355D-01	10.0000D-01	-11.2966D+00	44.1355D-01
40.5000D-01	-14.7800D+00	26.6442D-01	10.0000D-01	18.8300D+00	13.8558D-01
-28.0000D-02	-36.5503D+00	83.7722D-01	10.0000D-01	36.2703D+00	-86.5722D-01
24.9000D-01	-37.4561D+00	91.8836D-01	10.0000D-01	39.9461D+00	-66.9836D-01
-16.5000D-01	-22.3664D+00	80.9042D-01	10.0000D-01	20.7164D+00	-97.4042D-01
35.8000D-01	-45.5791D-01	72.9155D-01	10.0000D-01	81.3791D-01	-37.1155D-01
50.3000D-01	49.5340D-01	54.1296D-01	10.0000D-01	12.6599D-02	-33.2958D-02
15.0000D-01	94.6597D-01	33.1016D-01	10.0000D-01	-79.6597D-01	-18.1016D-01

QUADRATIC ERROR OLD MODEL: 5475.9777D+00

QUADRATIC ERROR NEW MODEL: [illegible]

Table 5.21

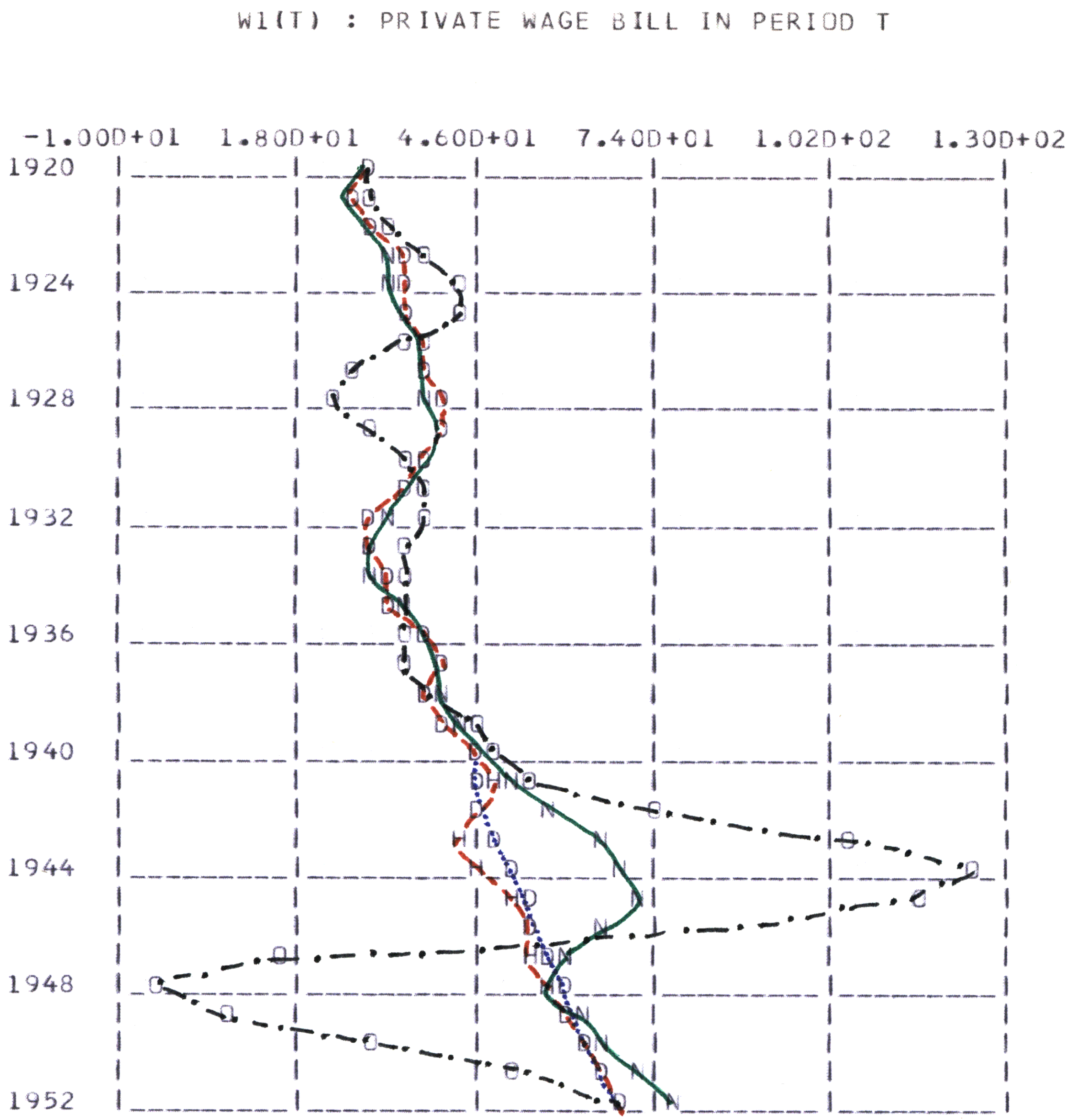


Figure 5.22

Wl(T) : Private Wage Bill in Period T

Forecasting Experiment for FIML Structure

W1(T) : PRIVATE WAGE BILL IN PERIOD T

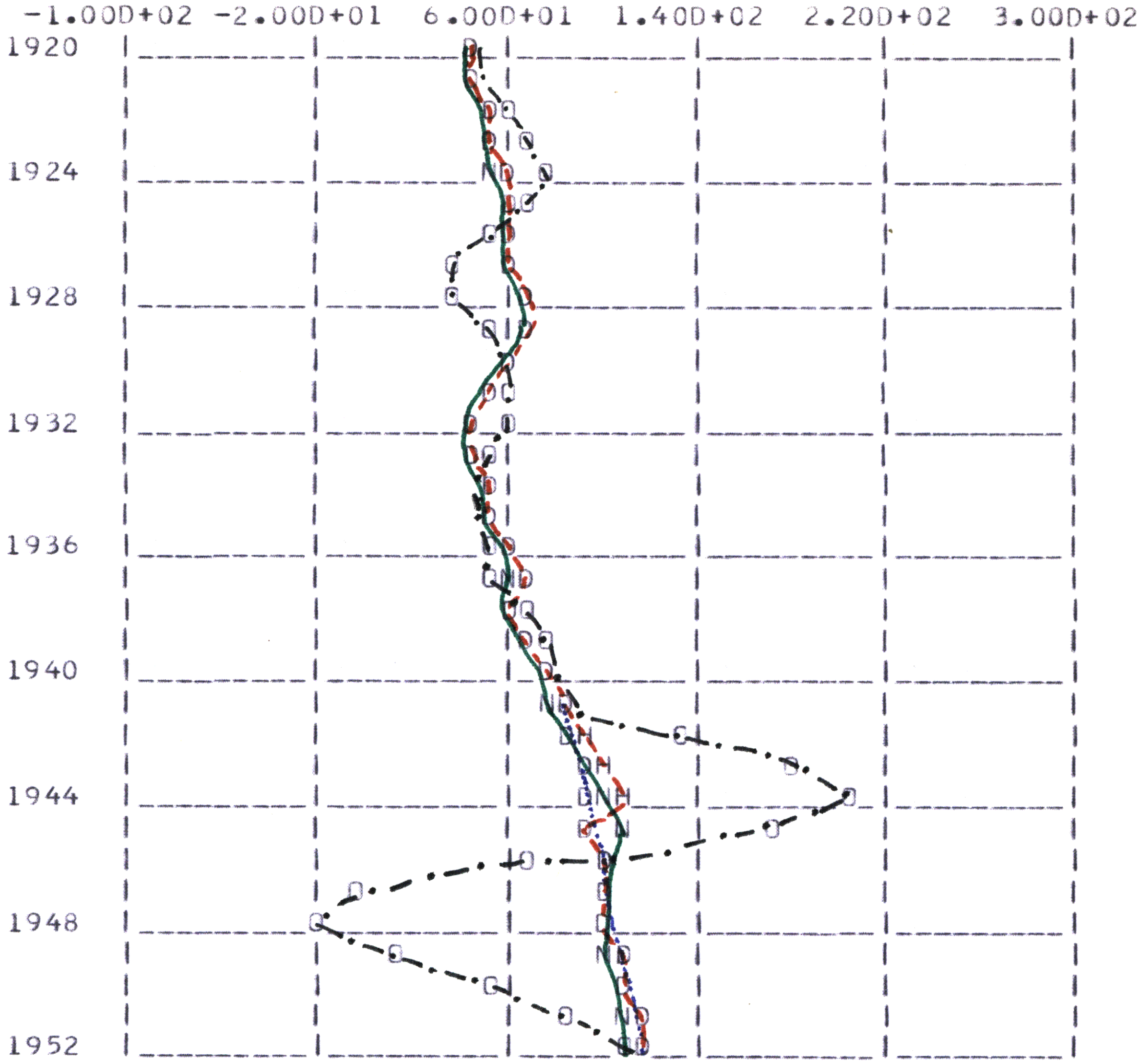
HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
28.8000D+00	28.8000D+00	28.8000D+00	28.8000D+00	0.0	0.0
25.5000D+00	28.2626D+00	26.5846D+00	25.5000D+00	-27.6258D-01	-10.8458D-01
29.3000D+00	33.2797D+00	28.6665D+00	29.3000D+00	-39.7975D-01	63.3496D-02
34.1000D+00	38.7400D+00	31.4175D+00	34.1000D+00	-46.3995D-01	26.8252D-01
33.9000D+00	42.6889D+00	33.1749D+00	33.9000D+00	-87.8886D-01	72.5125D-02
35.4000D+00	41.9989D+00	35.3886D+00	35.4000D+00	-65.9893D-01	11.3701D-03
37.4000D+00	34.6657D+00	37.5483D+00	37.4000D+00	27.3429D-01	-14.8261D-02
37.9000D+00	25.6449D+00	38.4302D+00	37.9000D+00	12.2551D+00	-53.0229D-02
39.2000D+00	22.8509D+00	38.9607D+00	39.2000D+00	16.3491D+00	23.9344D-02
41.3000D+00	28.2032D+00	40.0075D+00	41.3000D+00	13.0968D+00	12.9246D-01
37.9000D+00	35.1108D+00	38.8249D+00	37.9000D+00	27.8916D-01	-92.4854D-02
34.5000D+00	38.8309D+00	35.0990D+00	34.5000D+00	-43.3092D-01	-59.9045D-02
29.0000D+00	37.9733D+00	30.6002D+00	29.0000D+00	-89.7331D-01	-16.0020D-01
28.5000D+00	35.3922D+00	28.8494D+00	28.5000D+00	-68.9224D-01	-34.9370D-02
30.6000D+00	34.7010D+00	30.4793D+00	30.6000D+00	-41.0099D-01	12.0734D-02
33.2000D+00	35.1560D+00	33.8456D+00	33.2000D+00	-19.5597D-01	-64.5635D-02
36.8000D+00	33.8870D+00	38.0934D+00	36.8000D+00	29.1298D-01	-12.9342D-01
41.0000D+00	33.6982D+00	39.9976D+00	41.0000D+00	73.0176D-01	10.0239D-01
38.2000D+00	38.3143D+00	39.9429D+00	38.2000D+00	-11.4259D-02	-17.4288D-01
41.6000D+00	44.8969D+00	42.7492D+00	41.6000D+00	-32.9685D-01	-11.4918D-01
45.0000D+00	49.2166D+00	46.6324D+00	45.0000D+00	-42.1664D-01	-16.3239D-01
49.0600D+00	53.0490D+00	50.9548D+00	45.0000D+00	-39.8899D-01	-18.9478D-01
46.0800D+00	73.1113D+00	56.7999D+00	47.0000D+00	-27.0313D+00	-10.7199D+00
42.3900D+00	10.4326D+01	64.2275D+00	49.0000D+00	-61.9362D+00	-21.8375D+00
46.9800D+00	12.3871D+01	69.4706D+00	51.0000D+00	-76.8907D+00	-22.4906D+00
52.5200D+00	11.5804D+01	72.4626D+00	53.0000D+00	-63.2835D+00	-19.9426D+00
54.1500D+00	65.8507D+00	64.4896D+00	55.0000D+00	-11.7007D+00	-10.3396D+00
54.0400D+00	15.9497D+00	59.5261D+00	57.0000D+00	38.0903D+00	-54.8605D-01
56.5200D+00	-31.3535D-01	61.0613D+00	59.0000D+00	59.6554D+00	-45.4131D-01
60.3000D+00	63.9138D-01	63.5975D+00	61.0000D+00	53.9086D+00	-32.9746D-01
63.9000D+00	28.0884D+00	66.1747D+00	63.0000D+00	35.8116D+00	-22.7473D-01
65.8900D+00	50.8962D+00	71.3257D+00	65.0000D+00	14.9938D+00	-54.3568D-01
69.1100D+00	69.3604D+00	76.6051D+00	67.0000D+00	-25.0357D-02	-74.9512D-01

QUADRATIC ERROR OLD MODEL: 2508.7630D+01

QUADRATIC ERROR NEW MODEL: 1783.6757D+00

Table 5.22

Y(T) : NATIONAL INCOME IN PERIOD T



<u>Figure 5.23</u>

Y(T) : National Income in Period T

<u>Forecasting Experiment for FIML Structure</u>

Y(T) : NATIONAL INCOME IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
43.7000D+00	43.7000D+00	43.7000D+00	43.7000D+00	0.0	0.0
40.6000D+00	45.5112D+00	40.5494D+00	40.6000D+00	-49.1121D-01	50.6275D-03
49.1000D+00	59.4099D+00	48.8341D+00	49.1000D+00	-10.3099D+00	26.5869D-02
55.4000D+00	67.3016D+00	52.4534D+00	55.4000D+00	-11.9016D+00	29.4663D-01
56.4000D+00	73.6907D+00	55.3383D+00	56.4000D+00	-17.2907D+00	10.6173D-01
58.7000D+00	66.7663D+00	58.9231D+00	58.7000D+00	-80.6630D-01	-22.3078D-02
60.3000D+00	48.0596D+00	60.7562D+00	60.3000D+00	12.2404D+00	-45.6207D-02
61.3000D+00	33.5133D+00	61.5566D+00	61.3000D+00	27.7867D+00	-25.6592D-02
64.0000D+00	36.5626D+00	64.6045D+00	64.0000D+00	27.4374D+00	-60.4477D-02
67.0000D+00	50.7587D+00	66.9839D+00	67.0000D+00	16.2413D+00	16.1122D-03
57.7000D+00	57.7288D+00	58.8478D+00	57.7000D+00	-28.7771D-03	-11.4777D-01
50.7000D+00	62.2036D+00	51.7997D+00	50.7000D+00	-11.5036D+00	-10.9966D-01
41.3000D+00	57.0313D+00	43.3010D+00	41.3000D+00	-15.7313D+00	-20.0103D-01
45.3000D+00	55.4974D+00	45.8832D+00	45.3000D+00	-10.1974D+00	-58.3179D-02
48.9000D+00	54.7867D+00	48.9673D+00	48.9000D+00	-58.8667D-01	-67.2626D-03
53.3000D+00	55.0545D+00	55.0292D+00	53.3000D+00	-17.5450D-01	-17.2924D-01
61.8000D+00	51.0132D+00	63.0896D+00	61.8000D+00	10.7868D+00	-12.8959D-01
65.0000D+00	53.2826D+00	63.8168D+00	65.0000D+00	11.7174D+00	11.8317D-01
61.2000D+00	64.7759D+00	63.0879D+00	61.2000D+00	-35.7586D-01	-18.8790D-01
68.4000D+00	74.3714D+00	69.9657D+00	68.4000D+00	-59.7137D-01	-15.6568D-01
74.1000D+00	78.8703D+00	75.2575D+00	74.1000D+00	-47.7033D-01	-11.5751D-01
82.8800D+00	81.2843D+00	79.3849D+00	82.0000D+00	15.9568D-01	34.9512D-01
93.0800D+00	13.0957D+01	87.6091D+00	85.0000D+00	-37.8775D+00	54.7091D-01
99.1800D+00	18.0264D+01	94.6467D+00	88.0000D+00	-81.0842D+00	45.3335D-01
10.6080D+01	20.1731D+01	10.1344D+01	91.0000D+00	-95.6511D+00	47.3603D-01
10.6170D+01	16.9221D+01	10.7731D+01	94.0000D+00	-63.0515D+00	-15.6054D-01
10.1230D+01	67.3334D+00	99.8925D+00	97.0000D+00	33.8966D+00	13.3749D-01
96.0500D+00	-45.1904D-01	96.9346D+00	10.0000D+01	10.0569D+01	-88.4603D-02
10.0250D+01	-19.6555D+00	98.2374D+00	10.3000D+01	11.9905D+01	20.1264D-01
10.0620D+01	12.7541D+00	10.2631D+01	10.6000D+01	87.8659D+00	-20.1143D-01
10.8870D+01	50.2662D+00	10.5736D+01	10.9000D+01	58.6038D+00	31.3434D-01
11.1710D+01	82.2734D+00	11.0711D+01	11.2000D+01	29.4366D+00	99.9207D-02
11.4930D+01	10.8569D+01	11.6210D+01	11.5000D+01	63.6066D-01	-12.8026D-01

QUADRATIC ERROR OLD MODEL: 6225.9731D+01

Table 5.23

QUADRATIC ERROR NEW MODEL: 1415.[illegible]

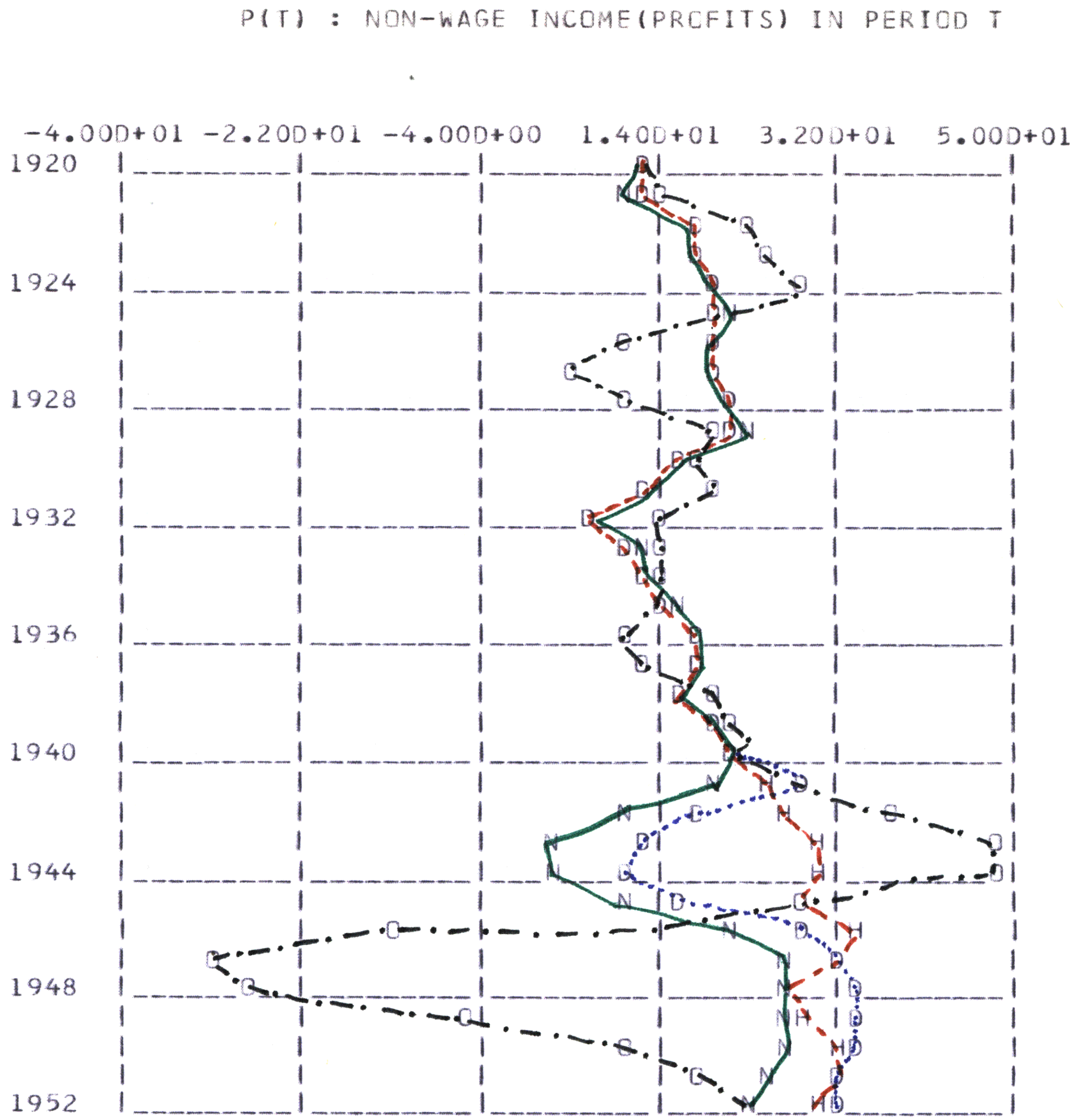


Figure 5.24

P(T) : Non-Wage Income(Profits) in Period T

Forecasting Experiment for FIML Structure

P(T) : NON-WAGE INCOME(PROFITS) IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
12.7000D+00	12.7000D+00	12.7000D+00	12.7000D+00	0.0	0.0
12.4000D+00	14.5486D+00	11.2331D+00	12.4000D+00	-21.4863D-01	11.6691D-01
16.9000D+00	23.2302D+00	17.2500D+00	16.9000D+00	-63.3020D-01	-35.0017D-02
18.4000D+00	25.6616D+00	17.9623D+00	18.4000D+00	-72.6165D-01	43.7695D-02
19.4000D+00	27.9018D+00	18.9126D+00	19.4000D+00	-85.0183D-01	48.7369D-02
20.1000D+00	21.5674D+00	20.3588D+00	20.1000D+00	-14.6738D-01	-25.8798D-02
19.6000D+00	10.0939D+00	19.9890D+00	19.6000D+00	95.0615D-01	-38.8973D-02
19.8000D+00	42.6838D-01	19.5751D+00	19.8000D+00	15.5316D+00	22.4863D-02
21.1000D+00	10.0116D+00	21.9540D+00	21.1000D+00	11.0884D+00	-85.4022D-02
21.7000D+00	18.5555D+00	22.9887D+00	21.7000D+00	31.4449D-01	-12.8873D-01
15.6000D+00	18.4179D+00	15.8633D+00	15.6000D+00	-28.1794D-01	-26.3295D-02
11.4000D+00	18.5727D+00	11.9466D+00	11.4000D+00	-71.7269D-01	-54.6648D-02
70.0000D-01	13.7580D+00	75.1773D-01	70.0000D-01	-67.5801D-01	-51.7727D-02
11.2000D+00	14.5052D+00	11.4833D+00	11.2000D+00	-33.0519D-01	-28.3312D-02
12.3000D+00	14.0857D+00	12.4658D+00	12.3000D+00	-17.8568D-01	-16.5794D-02
14.0000D+00	13.7985D+00	15.1747D+00	14.0000D+00	20.1475D-02	-11.7473D-01
17.6000D+00	97.2622D-01	17.7249D+00	17.6000D+00	78.7378D-01	-12.4933D-02
17.3000D+00	12.8843D+00	17.0258D+00	17.3000D+00	44.1566D-01	27.4228D-02
15.3000D+00	18.7616D+00	15.4373D+00	15.3000D+00	-34.6160D-01	-13.7262D-02
19.0000D+00	21.6745D+00	19.4998D+00	19.0000D+00	-26.7452D-01	-49.9785D-02
21.1000D+00	21.6537D+00	20.6684D+00	21.1000D+00	-55.3691D-02	43.1637D-02
24.6800D+00	19.0953D+00	18.9629D+00	27.8600D+00	55.8466D-01	57.1713D-01
26.9900D+00	37.8362D+00	10.8759D+00	17.9900D+00	-10.8462D+00	16.1141D+00
29.5700D+00	48.8180D+00	38.5503D-01	11.8800D+00	-19.2480D+00	25.7150D+00
29.7300D+00	48.4905D+00	34.0818D-01	10.6300D+00	-18.7605D+00	26.3218D+00
28.5600D+00	28.3279D+00	11.2591D+00	15.9100D+00	23.2056D-02	17.3009D+00
32.9000D+00	-12.6972D+00	21.3816D+00	27.8200D+00	45.5972D+00	11.5184D+00
31.5100D+00	-30.9687D+00	26.4295D+00	32.5000D+00	62.4787D+00	50.8054D-01
33.3500D+00	-26.9001D+00	26.1539D+00	33.6200D+00	60.2501D+00	71.9607D-01
28.7000D+00	-52.5728D-01	26.9044D+00	33.3800D+00	33.9573D+00	17.9565D-01
32.8300D+00	10.0378D+00	26.9342D+00	33.8600D+00	22.7922D+00	58.9584D-01
31.3000D+00	16.8572D+00	24.6154D+00	32.4800D+00	14.4428D+00	66.8456D-01
29.7600D+00	23.1490D+00	23.5605D+00	31.9400D+00	66.1102D-01	61.9947D-01

QUADRATIC ERROR OLD MODEL: 1326.5420D+01

QUADRATIC ERROR NEW MODEL: 2284.3800D+00

Table 5.24

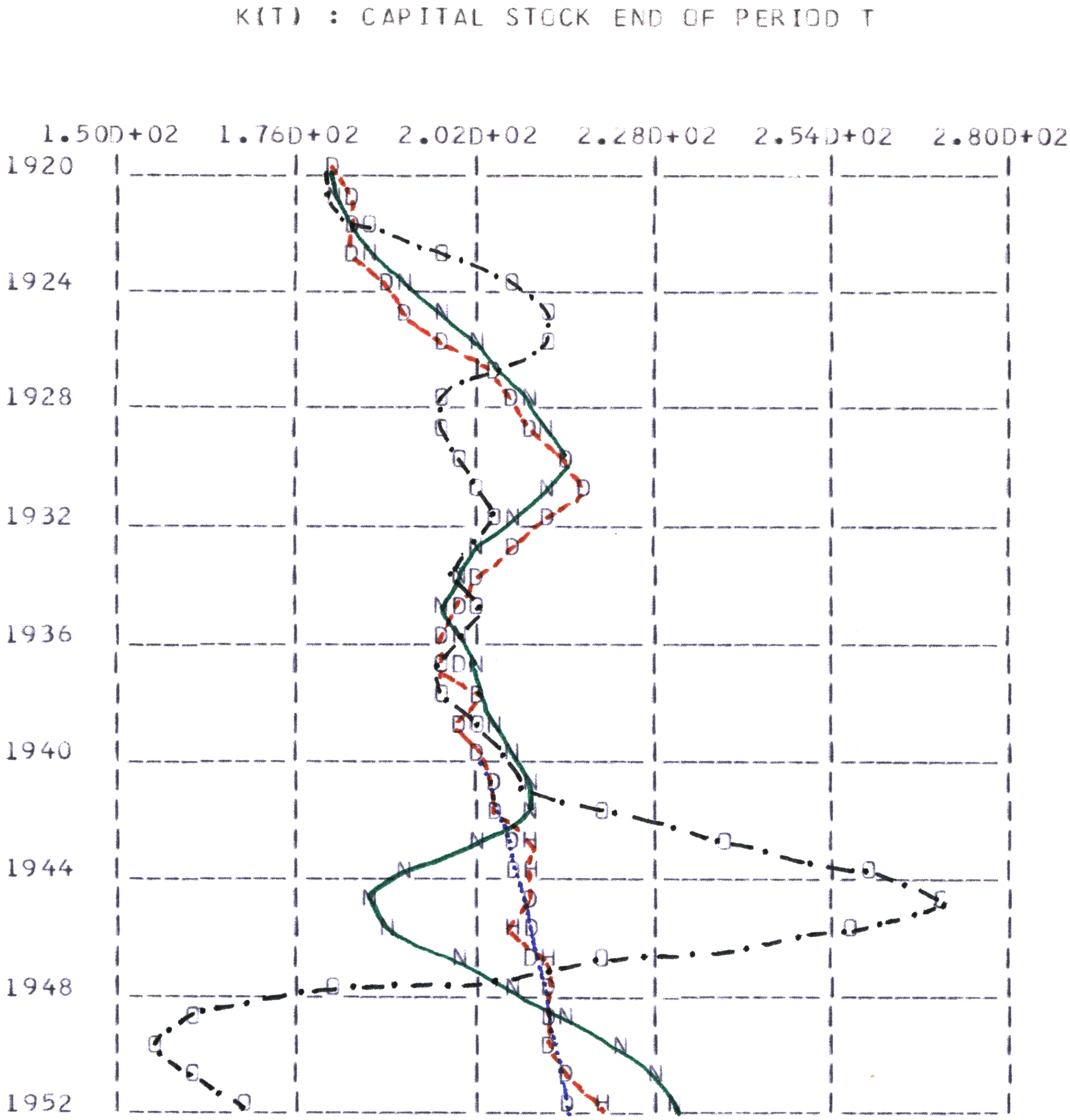


Figure 5.25

K(T) : Capital Stock End of Period T

Forecasting Experiment for FIML Structure

K(T) : CAPITAL STOCK END OF PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
18.0100D+01	18.0100D+01	18.0100D+01	18.0100D+01	0.0	0.0
18.2800D+01	18.1784D+01	18.0522D+01	18.2800D+01	10.1567D-01	22.7784D-01
18.2600D+01	18.7300D+01	18.2574D+01	18.2600D+01	-47.0037D-01	26.2843D-03
18.4500D+01	19.6547D+01	18.7085D+01	18.4500D+01	-12.0468D+00	-25.8526D-01
18.9700D+01	20.6367D+01	19.1628D+01	18.9700D+01	-16.6668D+00	-19.2751D-01
19.2700D+01	21.3338D+01	19.6483D+01	19.2700D+01	-20.6381D+00	-37.8278D-01
19.7800D+01	21.2375D+01	20.1120D+01	19.7800D+01	-14.5749D+00	-33.2024D-01
20.3400D+01	20.4612D+01	20.4807D+01	20.3400D+01	-12.1239D-01	-14.0700D-01
20.7600D+01	19.7716D+01	20.8720D+01	20.7600D+01	98.8429D-01	-11.1958D-01
21.0600D+01	19.7385D+01	21.3463D+01	21.0600D+01	13.2149D+00	-28.6264D-01
21.5700D+01	20.0559D+01	21.5263D+01	21.5700D+01	15.1413D+00	43.7443D-02
21.6700D+01	20.3296D+01	21.2395D+01	21.6700D+01	13.4040D+00	43.0538D-01
21.3300D+01	20.3885D+01	20.6628D+01	21.3300D+01	94.1456D-01	66.7226D-01
20.7100D+01	20.2699D+01	20.1348D+01	20.7100D+01	44.0060D-01	57.5210D-01
20.2000D+01	20.1825D+01	19.8802D+01	20.2000D+01	17.5332D-02	31.9839D-01
19.9000D+01	20.0789D+01	19.8042D+01	19.9000D+01	-17.8918D-01	95.7655D-02
19.7700D+01	19.8229D+01	19.9472D+01	19.7700D+01	-52.8599D-02	-17.7204D-01
19.9800D+01	19.5551D+01	20.1486D+01	19.9800D+01	42.4911D-01	-16.8584D-01
20.1800D+01	19.6779D+01	20.2329D+01	20.1800D+01	50.2147D-01	-52.9190D-02
19.9900D+01	20.1360D+01	20.3950D+01	19.9900D+01	-14.6043D-01	-40.4972D-01
20.1200D+01	20.6498D+01	20.7460D+01	20.1200D+01	-52.9789D-01	-62.6043D-01
20.4500D+01	20.9943D+01	21.0317D+01	20.4500D+01	-54.4255D-01	-58.1669D-01
20.8520D+01	21.8994D+01	20.8999D+01	20.5500D+01	-10.4740D+00	-47.8643D-02
20.9950D+01	23.8676D+01	20.1867D+01	20.6500D+01	-28.7256D+00	80.8302D-01
20.9500D+01	26.0024D+01	19.2666D+01	20.7500D+01	-50.5240D+00	16.8338D+00
20.8770D+01	27.0611D+01	18.7543D+01	20.8500D+01	-61.8406D+00	21.2273D+00
20.8060D+01	25.5831D+01	19.0207D+01	20.9500D+01	-47.7707D+00	17.8529D+00
21.2110D+01	21.9280D+01	19.8584D+01	21.0500D+01	-71.7038D-01	13.5257D+00
21.1830D+01	18.1824D+01	20.7773D+01	21.1500D+01	30.0057D+00	40.5734D-01
21.4320D+01	15.9458D+01	21.5863D+01	21.2500D+01	54.8621D+00	-15.4309D-01
21.2670D+01	15.4900D+01	22.3155D+01	21.3500D+01	57.7701D+00	-10.4846D+00
21.6250D+01	15.9853D+01	22.8568D+01	21.4500D+01	56.3967D+00	-12.3176D+00
22.1330D+01	16.9319D+01	23.1878D+01	21.5500D+01	52.0107D+00	-10.5478D+00

QUADRATIC ERROR OLD MODEL: 2476.0242D+01

QUADRATIC ERROR NEW MODEL: [illegible]

Table 5.25

W2(T) : GOVERNMENTAL WAGE BILL IN PERIOD T

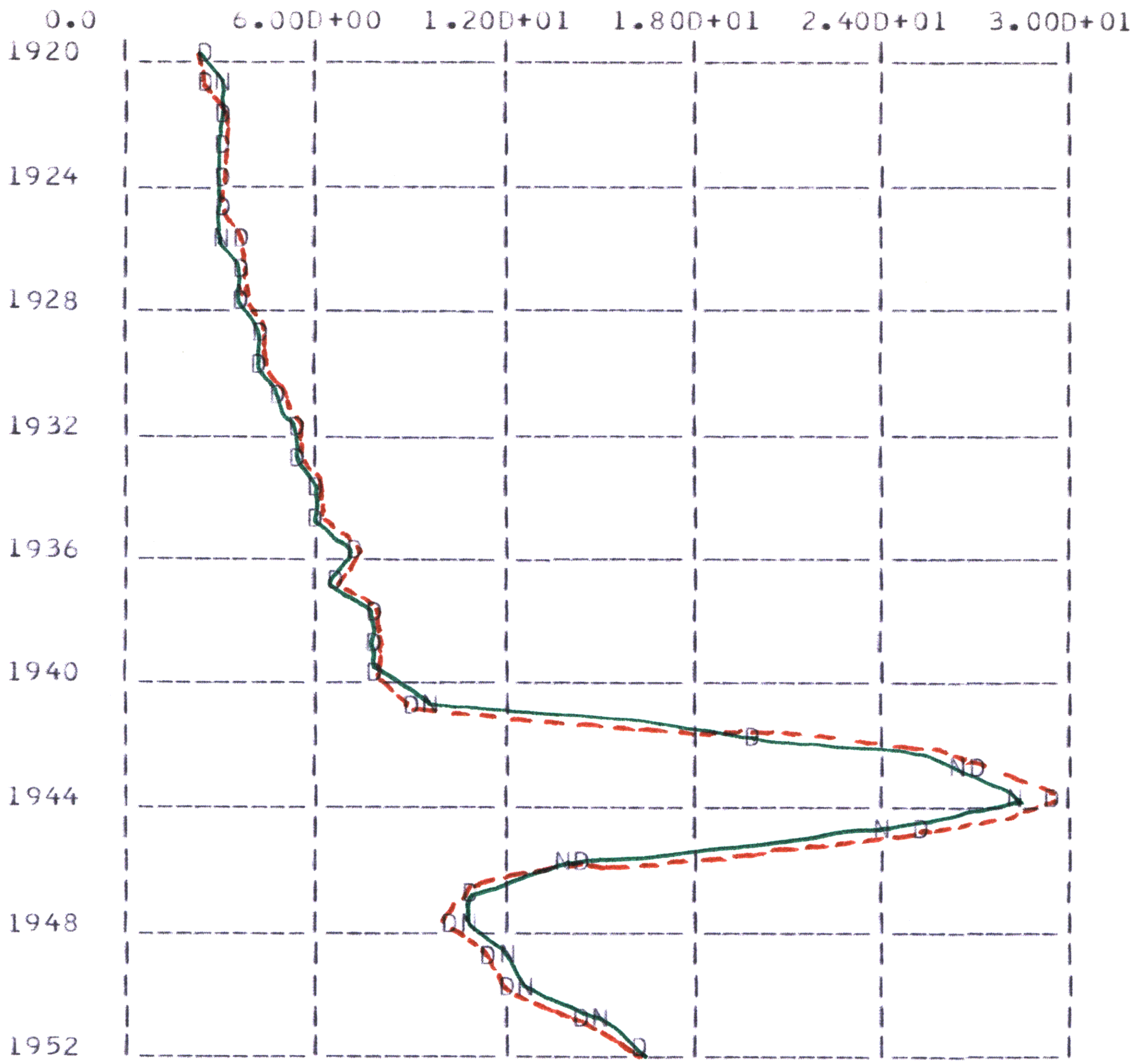


Figure 5.26

W2(T) : Government Wage Bill in Period T

Forecasting Experiment for FIML Structure

W2(T) : GOVERNMENTAL WAGE BILL IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
22.0000D-01	22.0000D-01	22.0000D-01	22.0000D-01	0.0	0.0
27.0000D-01	27.0000D-01	27.3170D-01	27.0000D-01	0.0	-31.7045D-03
29.0000D-01	29.0000D-01	29.1761D-01	29.0000D-01	0.0	-17.6100D-03
29.0000D-01	29.0000D-01	30.7358D-01	29.0000D-01	0.0	-17.3582D-02
31.0000D-01	31.0000D-01	32.5077D-01	31.0000D-01	0.0	-15.0769D-02
32.0000D-01	32.0000D-01	31.7565D-01	32.0000D-01	0.0	24.3493D-03
33.0000D-01	33.0000D-01	32.1897D-01	33.0000D-01	0.0	81.0279D-03
36.0000D-01	36.0000D-01	35.5123D-01	36.0000D-01	0.0	48.7745D-03
37.0000D-01	37.0000D-01	36.8980D-01	37.0000D-01	0.0	10.2007D-03
40.0000D-01	40.0000D-01	39.8761D-01	40.0000D-01	0.0	12.3868D-03
42.0000D-01	42.0000D-01	41.5962D-01	42.0000D-01	0.0	40.3797D-03
48.0000D-01	48.0000D-01	47.5397D-01	48.0000D-01	0.0	46.0291D-03
53.0000D-01	53.0000D-01	51.8310D-01	53.0000D-01	0.0	11.6897D-02
56.0000D-01	56.0000D-01	55.5050D-01	56.0000D-01	0.0	49.5022D-03
60.0000D-01	60.0000D-01	60.2220D-01	60.0000D-01	0.0	-22.2033D-03
61.0000D-01	61.0000D-01	60.0887D-01	61.0000D-01	0.0	91.1293D-03
74.0000D-01	74.0000D-01	72.7124D-01	74.0000D-01	0.0	12.8763D-02
67.0000D-01	67.0000D-01	67.9344D-01	67.0000D-01	0.0	-93.4432D-03
77.0000D-01	77.0000D-01	77.0776D-01	77.0000D-01	0.0	-77.5953D-04
78.0000D-01	78.0000D-01	77.1671D-01	78.0000D-01	0.0	83.2890D-03
80.0000D-01	80.0000D-01	79.5675D-01	80.0000D-01	0.0	43.2477D-03
91.4000D-01	91.4000D-01	94.6723D-01	91.4000D-01	0.0	-32.7230D-02
20.0100D+00	20.0100D+00	19.9333D+00	20.0100D+00	0.0	76.6912D-03
27.1200D+00	27.1200D+00	26.5641D+00	27.1200D+00	0.0	55.5914D-02
29.3700D+00	29.3700D+00	28.4652D+00	29.3700D+00	0.0	90.4800D-02
25.0900D+00	25.0900D+00	24.0088D+00	25.0900D+00	0.0	10.8118D-01
14.1800D+00	14.1800D+00	14.0213D+00	14.1800D+00	0.0	15.8715D-02
10.5000D+00	10.5000D+00	10.9791D+00	10.5000D+00	0.0	-47.9086D-02
10.3800D+00	10.3800D+00	11.0221D+00	10.3800D+00	0.0	-64.2120D-02
11.6200D+00	11.6200D+00	12.1296D+00	11.6200D+00	0.0	-50.9618D-02
12.1400D+00	12.1400D+00	12.6268D+00	12.1400D+00	0.0	-48.6769D-02
14.5200D+00	14.5200D+00	14.7697D+00	14.5200D+00	0.0	-24.9676D-02
16.0600D+00	16.0600D+00	16.0446D+00	16.0600D+00	0.0	15.3972D-03

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 3762.6822D-03

Table 5.26

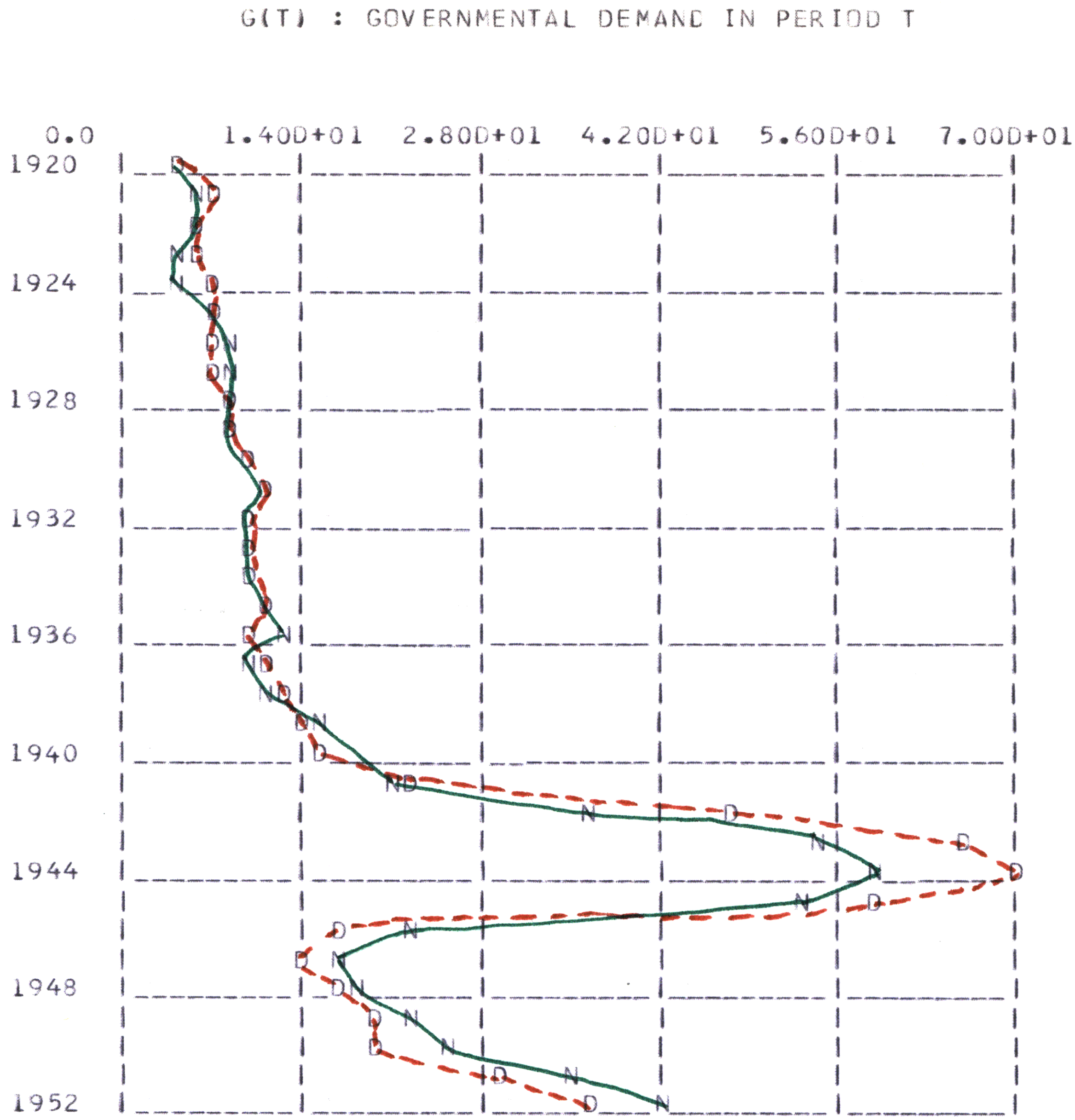


Figure 5.27

G(T) : Government Demand in Period T

Forecasting Experiment for FIML Structure

G(T) : GOVERNMENTAL DEMAND IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
46.0000D-01	46.0000D-01	46.0000D-01	46.0000D-01	0.0	0.0
66.0000D-01	66.0000D-01	56.4927D-01	66.0000D-01	0.0	95.0728D-02
61.0000D-01	61.0000D-01	51.9854D-01	61.0000D-01	0.0	90.1461D-02
57.0000D-01	57.0000D-01	45.5350D-01	57.0000D-01	0.0	11.4650D-01
66.0000D-01	66.0000D-01	46.5496D-01	66.0000D-01	0.0	19.4504D-01
65.0000D-01	65.0000D-01	66.0061D-01	65.0000D-01	0.0	-10.0607D-02
66.0000D-01	66.0000D-01	80.1412D-01	66.0000D-01	0.0	-14.1412D-01
76.0000D-01	76.0000D-01	87.9177D-01	76.0000D-01	0.0	-11.9177D-01
79.0000D-01	79.0000D-01	82.4724D-01	79.0000D-01	0.0	-34.7243D-02
81.0000D-01	81.0000D-01	81.5158D-01	81.0000D-01	0.0	-51.5774D-03
94.0000D-01	94.0000D-01	94.0596D-01	94.0000D-01	0.0	-59.6130D-04
10.7000D+00	10.7000D+00	10.7050D+00	10.7000D+00	0.0	-49.5482D-04
10.2000D+00	10.2000D+00	10.4909D+00	10.2000D+00	0.0	-29.0860D-02
93.0000D-01	93.0000D-01	98.2482D-01	93.0000D-01	0.0	-52.4821D-02
10.0000D+00	10.0000D+00	97.0603D-01	10.0000D+00	0.0	29.3974D-02
10.5000D+00	10.5000D+00	10.6387D+00	10.5000D+00	0.0	-13.8725D-02
10.3000D+00	10.3000D+00	12.0172D+00	10.3000D+00	0.0	-17.1717D-01
11.0000D+00	11.0000D+00	10.3902D+00	11.0000D+00	0.0	60.9840D-02
13.0000D+00	13.0000D+00	11.4179D+00	13.0000D+00	0.0	15.8213D-01
14.4000D+00	14.4000D+00	14.8732D+00	14.4000D+00	0.0	-47.3238D-02
15.4000D+00	15.4000D+00	15.2175D+00	15.4000D+00	0.0	18.2455D-02
22.1700D+00	22.1700D+00	21.2503D+00	22.1700D+00	0.0	91.9708D-02
47.4600D+00	47.4600D+00	36.4971D+00	47.4600D+00	0.0	10.9629D+00
65.8300D+00	65.8300D+00	53.9191D+00	65.8300D+00	0.0	11.9109D+00
69.9700D+00	69.9700D+00	58.8436D+00	69.9700D+00	0.0	11.1264D+00
58.1800D+00	58.1800D+00	53.2648D+00	58.1800D+00	0.0	49.1522D-01
17.0800D+00	17.0800D+00	21.7663D+00	17.0800D+00	0.0	-46.8633D-01
14.2000D+00	14.2000D+00	17.0569D+00	14.2000D+00	0.0	-28.5688D-01
16.7500D+00	16.7500D+00	18.7116D+00	16.7500D+00	0.0	-19.6161D-01
20.1700D+00	20.1700D+00	22.0855D+00	20.1700D+00	0.0	-19.1555D-01
19.9400D+00	19.9400D+00	25.0320D+00	19.9400D+00	0.0	-50.9199D-01
29.1400D+00	29.1400D+00	35.1736D+00	29.1400D+00	0.0	-60.3357D-01
36.0300D+00	36.0300D+00	41.3778D+00	36.0300D+00	0.0	-53.4778D-01

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 5563.4449D-01

Table 5.27

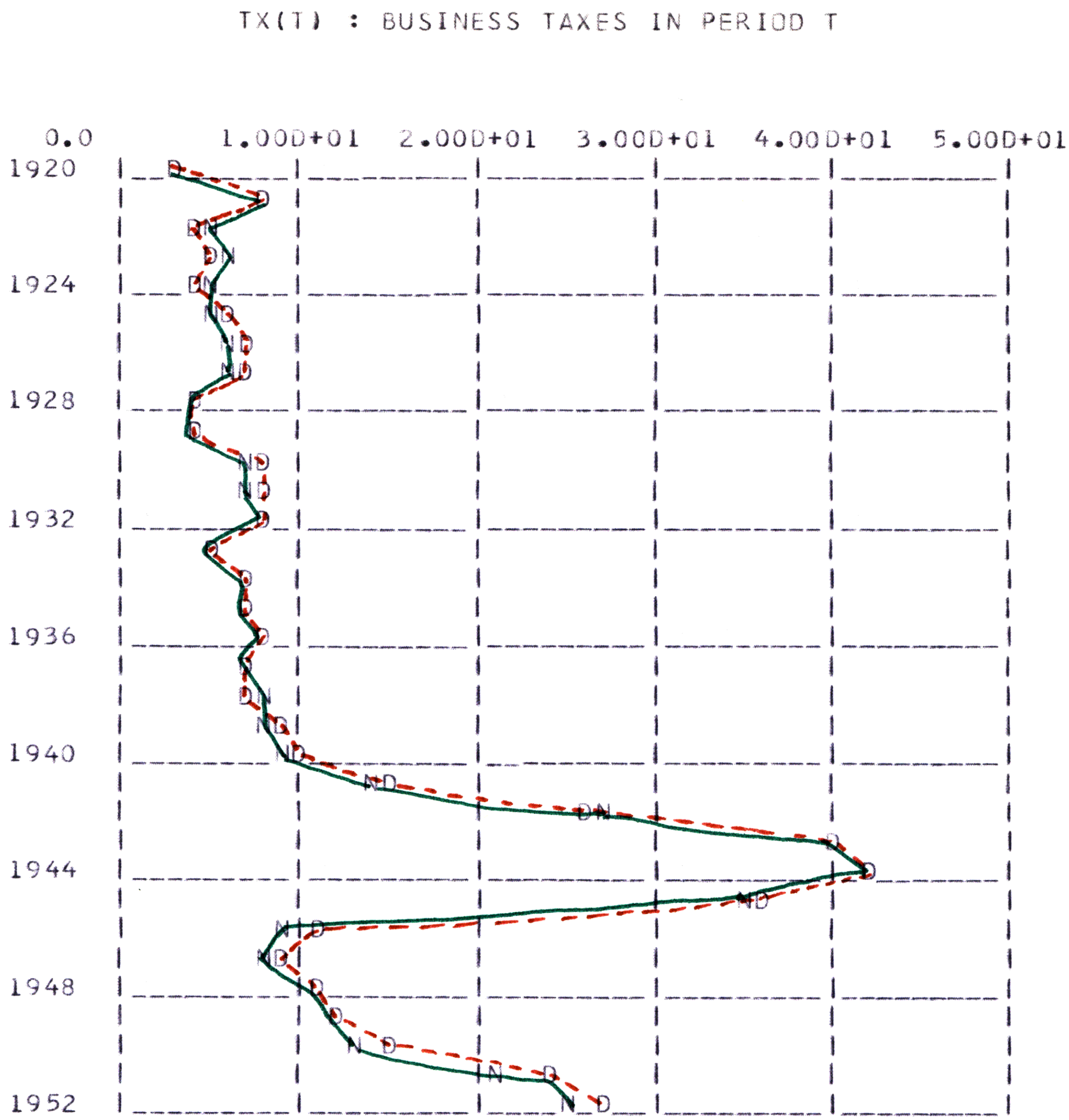


Figure 5.28

TX(T) : Business Taxes in Period T

Forecasting Experiment for FIML Structure

TX(T) : BUSINESS TAXES IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
34.0000D-01	34.0000D-01	34.0000D-01	34.0000D-01	0.0	0.0
77.0000D-01	77.0000D-01	81.6456D-01	77.0000D-01	0.0	-46.4563D-02
39.0000D-01	39.0000D-01	45.8031D-01	39.0000D-01	0.0	-68.0306D-02
47.0000D-01	47.0000D-01	55.1383D-01	47.0000D-01	0.0	-81.3833D-02
38.0000D-01	38.0000D-01	45.8720D-01	38.0000D-01	0.0	-78.7199D-02
55.0000D-01	55.0000D-01	54.0603D-01	55.0000D-01	0.0	93.9733D-03
70.0000D-01	70.0000D-01	64.3703D-01	70.0000D-01	0.0	56.2966D-02
67.0000D-01	67.0000D-01	62.7042D-01	67.0000D-01	0.0	42.9583D-02
42.0000D-01	42.0000D-01	41.2569D-01	42.0000D-01	0.0	74.3088D-03
40.0000D-01	40.0000D-01	39.4310D-01	40.0000D-01	0.0	56.8963D-03
77.0000D-01	77.0000D-01	74.9677D-01	77.0000D-01	0.0	20.3229D-02
75.0000D-01	75.0000D-01	72.4961D-01	75.0000D-01	0.0	25.0391D-02
83.0000D-01	83.0000D-01	79.5834D-01	83.0000D-01	0.0	34.1660D-02
54.0000D-01	54.0000D-01	51.2615D-01	54.0000D-01	0.0	27.3846D-02
68.0000D-01	68.0000D-01	67.6087D-01	68.0000D-01	0.0	39.1329D-03
72.0000D-01	72.0000D-01	68.9323D-01	72.0000D-01	0.0	30.6770D-02
83.0000D-01	83.0000D-01	75.8312D-01	83.0000D-01	0.0	71.6880D-02
67.0000D-01	67.0000D-01	68.2305D-01	67.0000D-01	0.0	-12.3049D-02
74.0000D-01	74.0000D-01	75.7112D-01	74.0000D-01	0.0	-17.1122D-02
89.0000D-01	89.0000D-01	82.8020D-01	89.0000D-01	0.0	61.9797D-02
96.0000D-01	96.0000D-01	89.6436D-01	96.0000D-01	0.0	63.5636D-02
15.3700D+00	15.3700D+00	14.3011D+00	15.3700D+00	0.0	10.6893D-01
26.2700D+00	26.2700D+00	27.3635D+00	26.2700D+00	0.0	-10.9352D-01
39.9700D+00	39.9700D+00	40.4420D+00	39.9700D+00	0.0	-47.1958D-02
41.6800D+00	41.6800D+00	41.7413D+00	41.6800D+00	0.0	-61.3109D-03
35.9100D+00	35.9100D+00	35.0596D+00	35.9100D+00	0.0	85.0369D-02
10.6200D+00	10.6200D+00	85.6071D-01	10.6200D+00	0.0	20.5929D-01
87.7000D-01	87.7000D-01	82.2765D-01	87.7000D-01	0.0	54.2354D-02
11.0200D+00	11.0200D+00	10.7530D+00	11.0200D+00	0.0	26.7015D-02
12.2200D+00	12.2200D+00	11.6922D+00	12.2200D+00	0.0	52.7777D-02
15.1500D+00	15.1500D+00	13.1749D+00	15.1500D+00	0.0	19.7506D-01
24.2100D+00	24.2100D+00	21.4552D+00	24.2100D+00	0.0	27.5483D-01
27.1100D+00	27.1100D+00	24.7542D+00	27.1100D+00	0.0	23.5581D-01

QUADRATIC ERROR OLD MODEL: 0.0

Table 5.28

QUADRATIC ERROR NEW MODEL: [illegible]

5.4 Comparing Forecast Accuracy of the "New" Models Against "Old" Models.

In the previous sections we have presented numerical results of the forecast experiment for three different estimation procedures. In this section we shall interpret these results as a whole.

In Table 5.56 the quadratic errors, for the different models and structures, are shown. From these results, it is clear the improvement on performance of the "new" models over the "old" models. Quadratic errors for the "old" models depend heavily on the estimation procedure used to obtaine the model. This is not the case for the "new" model where the differences are only slight. This fact confirms to a certain extent what we have concluded from the sensitivity experiments in Chapter Four, - the "new" model has a very low sensitivity to different estimation procedures and different model structures.

Among the "new" models a slight improvement on performance is observed to depend on the statistical contents of the "old" models. In this context, we observe that FIML "old" model, although it exhibits the worst performance among "old" models, yields to a "new" model with the best performance among "new" models. In a similar manner the "old" model obtained by 2SLS2 (restimation of model with 2SLS after droping non-significant variables) yields to a "new" model that performs better than the "new" model obtained with 2SLS.

		OLS	2SLS	FIML	OLS2	2SLS2
Consumption (C)	OLD	29523.38	20358.78	32841.41	28305.53	22588.52
	NEW	2021.11	1955.81	1391.27	2063.44	1941.03
Investment	OLD	3882.08	2016.26	5475.97	3894.22	2369.09
(I)	NEW	410.65	334.06	393.79	412.09	350.66
Private Wage	OLD	25092.72	16909.99	25087.63	24521.15	18499.39
(W1)	NEW	3512.27	1927.95	1783.67	3512.86	1901.90
National Income	OLD	53273.83	34509.13	62259.73	51383.35	38784.45
(Y)	NEW	483.49	294.44	141.54	464.20	223.11
Profits	OLD	10185.10	5904.06	13265.42	9980.77	6659.74
(P)	NEW	2603.45	2150.99	2284.38	2617.30	2179.44
Capital Stock	OLD	20660.03	9611.81	24760.24	18997.32	11324.54
(K)	NEW	2745.57	1560.72	1948.48	2740.22	1536.36
Governmental Wage	OLD	0.0	0.0	0.0	0.0	0.0
(W2)	NEW	6.6321	7.234	3.762	6.482	6.677
Governmental Expenditure	OLD	0.0	0.0	0.0	0.0	0.0
(G)	NEW	636.50	834.59	556.34	657.82	844.23
Taxes	OLD	0.0	0.0	0.0	0.0	0.0
(TX)	NEW	58.75	25.00	29.43	57.74	23.69

TABLE 5.56

QUADRATIC ERRORS FOR THE FORECAST EXPERIMENT CORRESPONDING TO THE DIFFERENT ESTIMATION PROCEDURES AND MODEL STRUCTURES

Although the Second World War is a very difficult period for an "Ex-Post" forecast experiment, the big disturbances during the period allow us to gain insight of the different models. Big oscillations for this period characterize each of the "old" models, but each oscilation varies in amplitude and frequency depending on the estimation procedure or model structure. This phenomenon is caused by the different positions of the eigenvalues corresponding to each model structure. On the other hand, the "new" models exhibit a very similar behavior among them for the same period. This similar behavior on the "new" models is caused by the likeness on the position of the eigenvalues of the "new" models, as it was discussed in Chapter Four.

Another fact observed during the forecast experiments is the ability of the "new" models to recover rapidly from big disturbances and to start tracking the historical values again. This property is not observed in the "old" models. By the contrary, the "old" models start diverging from the historical values after big disturbances, as the Second World War, are present in the system. This property observed on the "new" models could be explained by the fact that the new structures are "closed-loop" structures, and as such, they do have the property of handling the disturbances present in the system.

5.5 Some Remarks About The Experiment

In this Chapter we have shown that in general the forecasting properties of the "new" model have a very low sensitivity to different estimation procedures and different structures. However, we have said nothing about the sensitivity of the forecast to different cost matrices in the objective function and to different desired targets for the endogenous variables. It would be possible to analyze the sensitivity of the forecasts to the different parameters of the cost matrices and to the different desired targets in a systematic way. However, this would be a difficult task, first because of the large number of parameters involved in the cost matrices, and second because the infinite number of desired targets. Furthermore, it is not clear that we would learn very much from the results of such an analysis. Therefore, the sensitivity of the forecasts to different cost matrices and to different desired targets for the endogenous variables was explored in a much more limited manner.

Several experiments were made to carry out this limited search. First, the weights corresponding to the variables consumption (C) and national income (Y) were increased and the desired targets for these variables were adjusted as to reflect a more realistic knowledge of what happens in a war-time period; i.e., the targets for these particular variables were chosen to be closer to the historical values. The results for this run revealed some improvement on the performance of the variable investment (I) and capital stock (K) besides the expected improvement in consumption (C) and national income (Y), however, a decay in the performance of private wage (W1) and profits (P) was also observed. Next, a desired target closer to the historical values for profits was set along with an increase on the weight corresponding to this variable (the remaining variables were set to their original values). The results for this run revealed a substantial improvement on the performance of profits but a decay on the performance of the remaining variables.

It should be pointed out that for these last two experiments the results should not be interpreted faithfully because restrictions with the computer program did not allow to weigh separately the learning period (1920-1940) and the forecast period (1941-1952); in other words the computer program did not allow for time-varying cost matrices. Therefore, 4 change in the parameter of the matrices Q or R not only affected the forecast period but also the entire learning period, consequently the entire model was modified in its structure and performance.

Also, several experiments were made keeping the normalized weights for the cost matrices and trying different desired targets for the endogenous variables. The results for these experiments revealed that as far as the desired targets are not to far from the historical values the forecasts are insensitive to the desired targets. This last result, although not conclusive because the nature of the experiments, reveals a great potential for the forecasting properties of the "new" model.

Chapter VI

CONSTRUCTION OF THE NEW STRUCTURE BY MEANS OF A SUBOPTIMAL CONTROL LAW

6.1 INTRODUCTION

Up to this point, we have studied several properties of the new structure. We have shown how closed-loop structures improve the performance of standard econometric models and how the sensitivity to different estimation procedures is reduced. It is important to keep in mind, however, that in forecasting economic behavior large scale models are very often used. In these cases, one would like to know what would happen if instead of using the large-scale model to obtain the control law, a more aggregated model is used to obtain a suboptimal control law, and afterwards we match this suboptimal control law with the large-scale system so as to obtain the closed-loop structure or "new" model.

This scheme in a slightly different context, (calculation of optimal policies instead of calculation of the "new" model) has been studied by Wall and Wescott (1974) { }, { }, and Chow (1976) { }.

The basic idea of this approach is illustrated in Figure 6.1. In this case, the large-scale model constitutes the original model ("old" model). The suboptimal control law is obtained by means of a highly aggregated model suitable for control purposes. The "new" model is obtained by introducing the suboptimal control law into the original model so as to form the closed-loop structure.

In this chapter we shall study the properties of such an approach by means of a numerical experiment. Although, the models to be used to characterize the "Large-Scale" model and the "Highly Aggregated One" are not the best suitable for this purpose, they would still give us an approximate idea of the properties of the scheme presented in Figure 6.1. The following section will be aimed to describe the experiment. Next, numerical results will be presented, followed by an interpretation of the results.

6.2 Description of the Experiment

Two econometric models were used to characterize the approach presented in Figure 6.1. The "Large-Scale" model used in our experiment was Klein's Model I, descriped in detail in Chapter Three and used for the experiments of Chapters Four and Five. The highly aggregated model used was the Samuelson-Hicks Model, also described in Chapter Three.

As we know from previous chapters, Klein's model consists of nine output variables, three control variables, and two purely exogenous variables. On the other hand, Samuelson-Hicks model being a single equation model was modified so as to obtain three output variables, two control variables and one purely exogenous variable. This was explained in section six of Chapter Three.

By first step of this experiment was to obtain the control law by using the Samuelson-Hicks' model. In obtaining the control law three endogenous variables were considered: Consumption (C), Investment (I), and National Income (Y), and two control variables: Government Expenditure (G) and Taxes (TX). The experiment was run

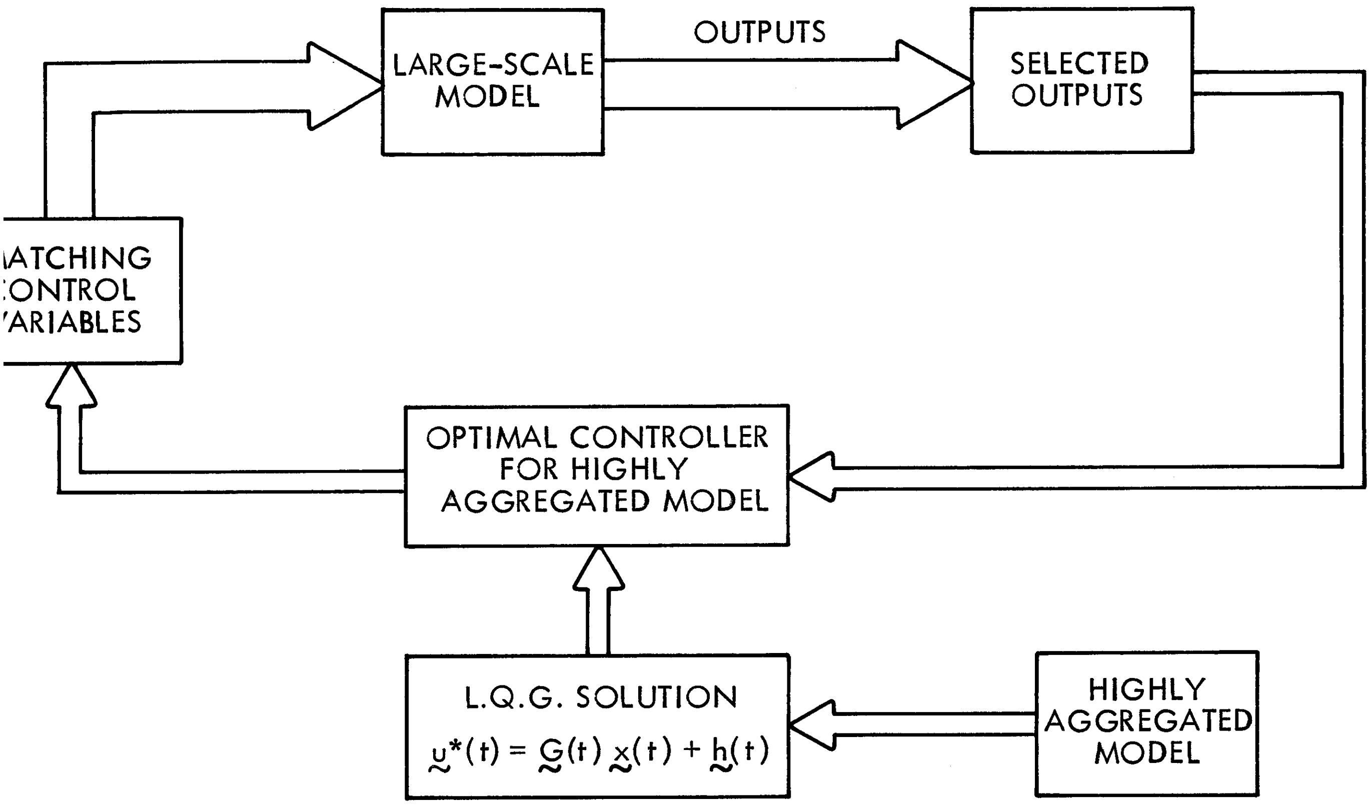


Figure 6.1

Suboptimal Controller Obtained With A Highly Aggregated Model Driving a Large-scale Model for the period 1920-1940. The desired targets for the endogenous and control variables were chosen to be their corresponding historical values. The diagonal elements of the cost matrices (Q and R) were the same values used for the corresponding variables in the sensitivity and forecast experiments of Chapters Four and Five.

The next step was to simulate simultaneously two different versions of the new structure. The first version was obtained by introducing, into the 2SLS structure of the Klein's model, the suboptimal policies obtained in the first step, i.e., the simulation was made in an open-loop fashion. This version was called the open-loop version of the new structure for notational purposes. The second version was obtained by reproducing in a very gross manner the conditions that would exist in a closed-loop simulation. Although, the suboptimal feedback gains were not introduced directly into the model, a rather more primitive approach was used. This was motivated by the fact that the computer program did not allow us to incorporate in a straightforward manner the feedback gains. The main idea in this approach was to choose the weights of the cost matrices so as to reproduce the condition that would exist in a truly closed-loop simulation. In this context the weights for the control variables were chosen to be very high so as to force the system to track the values of the control variables very closely. The weights of the endogenous variables present in the Samuelson-Hicks' model were set to their normalized values so as to include these variables into the feedback loop of the new structure. On the otherhand, the weights for the remaining endogenous variables were set to very low values so as to exclude them from the feedback-loop of the new structure.

The values of the different weights for the cost matrices are given in Table 6.1

$q_{11} = 15.75$	(C)		$r_{11} = 2973.0$
$q_{22} = 71.82$	(I)		$r_{22} = 8573.0$
$q_{33} = 0.0263$	(W1)		$r_{33} = 2601.0$
$q_{44} = 8.91$	(Y)		
$q_{55} = 0.04628$	(P)		
$q_{66} = 0.0091$	(K)		
$q_{77} = 0.1$	(W2)		
$q_{88} = 0.1$	(G)		
$q_{99} = 0.1$	(TX)		

Table 6.1

Weights For the Cost Matrices Q and R For The Aggregation Experiment

6.3 Obtention Of Optimal Policies With a Highly Aggregated Model.

For this experiment the Samuelson-Hicks model was used to obtain the optimal policies to be utilized to construct the new structure of the Klein's model.

The results are shown numerically and graphically on Tables 6.2 to 6.6 and on Figures 6.1 to 6.5. In each diagram time runs along the vertical axis, the historical values are represented by letter "D", the "Old" model by letter "O" and the new path obtained as a consequence of the optimal policies, is denoted by letter "N".

The results are suprising, since even for this highly aggregated model the new structure generates paths for the endogenous variable that are very close to the historical paths. The fact confirms once more the ability of the feedback to improve the performance of standard econometric models.

With the exception of investment (I) the endogenous variables track remarkably well the historical values.

The optimal policies are presented on Tables 6.5 and 6.6 and on Figures 6.4 and 6.5. The values of taxes (TX) are very close to the historical values. However, government expenditure (G) presents departures from the historical values.

The "old" model for the periods 1925-1928 and 1930-1934 does not follow the big oscilations present in the historical data. The "new" structure, in order to correct for this departure, uses feedback through the policy variables. This is done mainly through government expenditure (G). This fact explains the reason why the optimal values for government expenditure depart considerably from the historical values for the same periods. (1925-1928, 1930-1934).

C(T) : CONSUMPTICN IN PERICD T

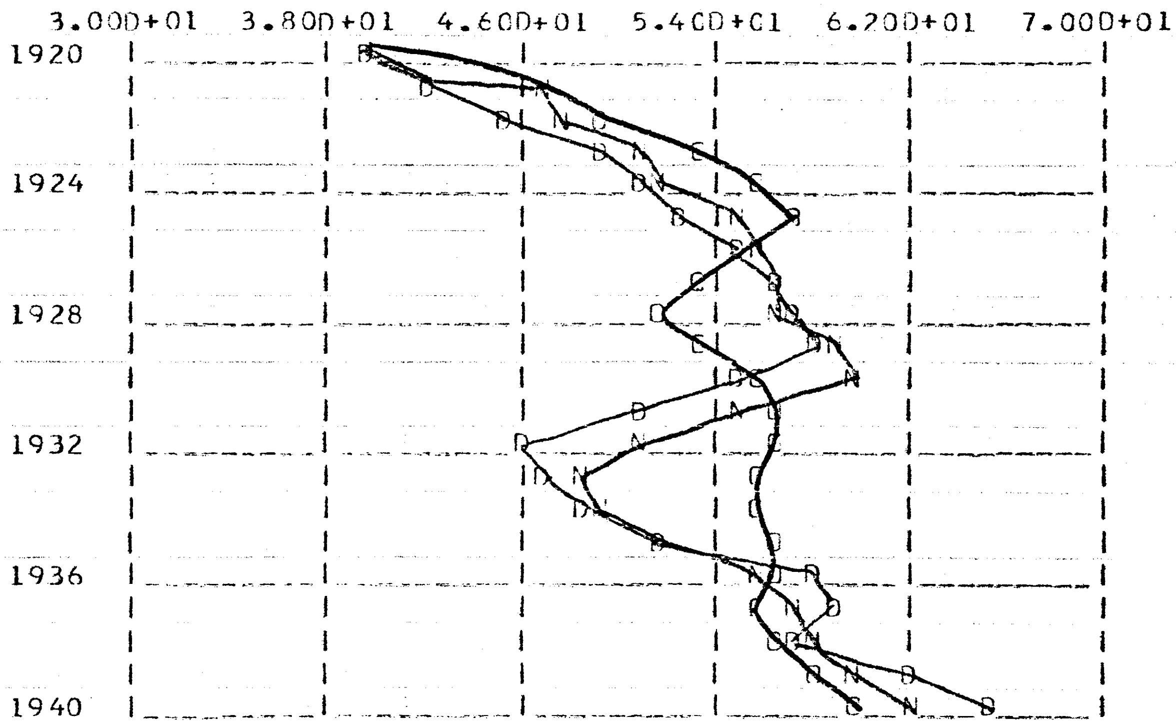


Figure 6.2

C(T) : Consumption in Period T

Obtention of Sub-optimal Policies with Samuelson-Hicks' Model

C(T) : CONSUMPTION IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
39.8000D+00	39.8000D+00	39.8000D+00	39.8000D+00	0.0	0.0
41.9000D+00	46.8164D+00	46.8164D+00	41.9000D+00	-49.1639D-01	-49.1639D-01
45.0000D+00	49.1208D+00	47.3474D+00	45.0000D+00	-41.2078D-01	-23.4741D-01
49.2000D+00	53.3245D+00	50.5410D+00	49.2000D+00	-41.2455D-01	-13.4102D-01
50.6000D+00	55.4495D+00	51.9689D+00	50.6000D+00	-48.4952D-01	-13.6888D-01
52.6000D+00	57.0291D+00	54.4217D+00	52.6000D+00	-44.2912D-01	-18.2172D-01
55.1000D+00	55.9719D+00	55.9751D+00	55.1000D+00	-87.1852D-02	-87.5088D-02
56.2000D+00	53.0417D+00	56.1623D+00	56.2000D+00	31.5827D-01	37.6546D-03
57.3000D+00	51.4349D+00	56.7903D+00	57.3000D+00	58.6512D-01	50.9748D-02
57.8000D+00	53.1682D+00	59.1036D+00	57.8000D+00	46.3181D-01	-13.0362D-01
55.0000D+00	55.9868D+00	59.2924D+00	55.0000D+00	-98.6770D-02	-42.9242D-01
50.9000D+00	56.4014D+00	55.0954D+00	50.9000D+00	-55.0144D-01	-41.9544D-01
45.6000D+00	56.7618D+00	50.9526D+00	45.6000D+00	-11.1618D+00	-53.5256D-01
46.5000D+00	55.7073D+00	48.0109D+00	46.5000D+00	-92.0733D-01	-15.1087D-01
48.7000D+00	55.9822D+00	49.0468D+00	48.7000D+00	-72.8221D-01	-34.6822D-02
51.3000D+00	56.0631D+00	51.7115D+00	51.3000D+00	-47.6306D-01	-41.1549D-02
57.7000D+00	56.1893D+00	55.5304D+00	57.7000D+00	15.1074D-01	21.6963D-01
58.7000D+00	55.2920D+00	57.0983D+00	58.7000D+00	34.0799D-01	16.0170D-01
57.5000D+00	56.1165D+00	57.6560D+00	57.5000D+00	13.8346D-01	-15.5980D-02
61.6000D+00	58.2104D+00	59.5914D+00	61.6000D+00	33.8964D-01	20.0864D-01
65.0000D+00	59.8931D+00	61.7801D+00	65.0000D+00	51.0692D-01	32.1994D-01

QUADRATIC ERROR OLD MODEL: 5375.8496D-01

QUADRATIC ERROR NEW MODEL: 1283.4712D-01

Table 6.2

C(T) : Consumption in Period T

Obtention of Sub-optimal Policies with Samuelson-Hicks' Model

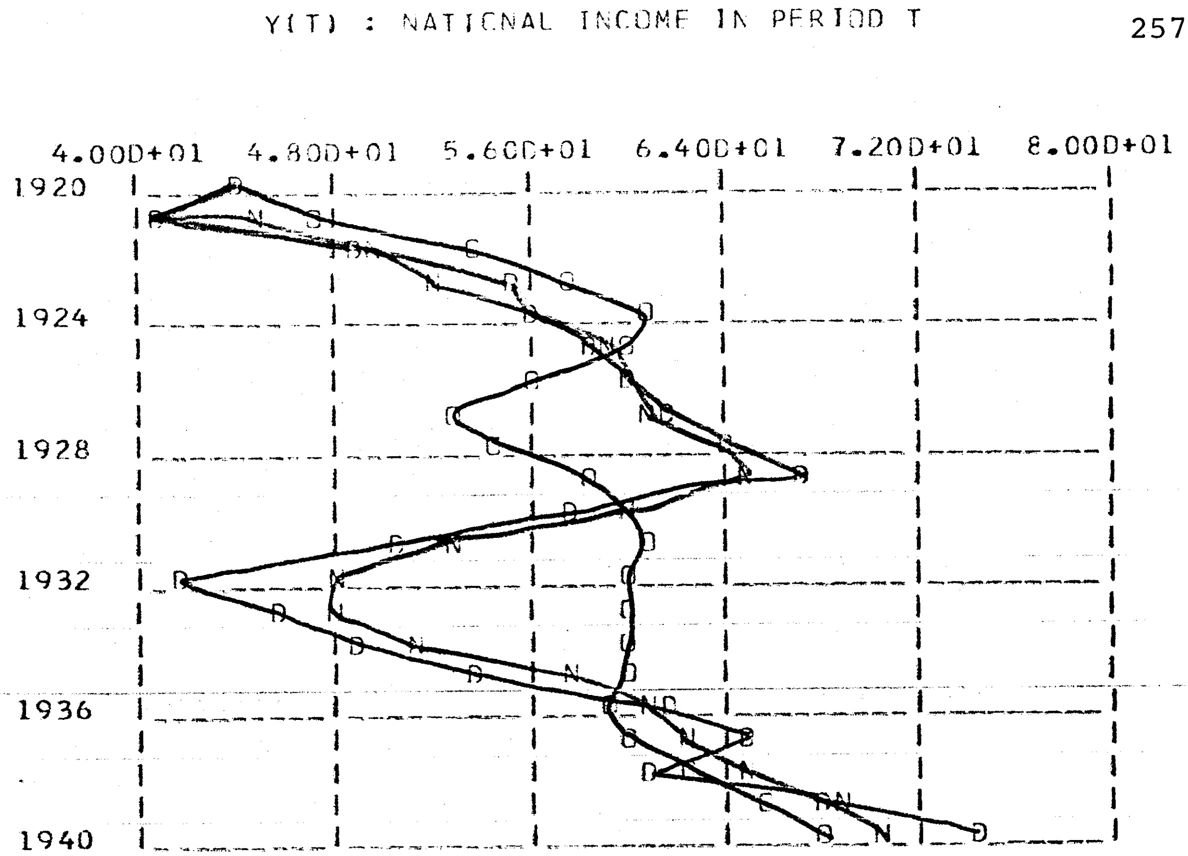


Figure 6.3

Y(T) : National Income In Period T

Obtention of Sub-optimal Policies With Samuelson-Hicks' Model

Y(T) : NATIONAL INCOME IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
43.7000D+00	43.7000D+00	43.7000D+00	43.7000D+00	0.0	0.0
40.6000D+00	47.1323D+00	44.7828D+00	40.6000D+00	-65.3234D-01	-41.8277D-01
49.1000D+00	53.4677D+00	49.2556D+00	49.1000D+00	-43.6765D-01	-15.5594D-02
55.4000D+00	57.6963D+00	52.1451D+00	55.4000D+00	-22.9627D-01	32.5487D-01
56.4000D+00	60.7324D+00	56.0395D+00	56.4000D+00	-43.3238D-01	36.0497D-02
58.7000D+00	60.0088D+00	58.9663D+00	58.7000D+00	-13.0882D-01	-26.6292D-02
60.3000D+00	55.9652D+00	59.8673D+00	60.3000D+00	43.3477D-01	43.2744D-02
61.3000D+00	52.9343D+00	60.9002D+00	61.3000D+00	83.6571D-01	39.9842D-02
64.0000D+00	54.5547D+00	64.1956D+00	64.0000D+00	94.4529D-01	-19.5594D-02
67.0000D+00	58.6506D+00	65.1808D+00	67.0000D+00	83.4944D-01	18.1916D-01
57.7000D+00	60.1136D+00	59.8399D+00	57.7000D+00	-24.1360D-01	-21.3993D-01
50.7000D+00	60.9174D+00	53.1596D+00	50.7000D+00	-10.2174D+00	-24.5956D-01
41.3000D+00	59.6996D+00	47.7719D+00	41.3000D+00	-18.3996D+00	-64.7189D-01
45.3000D+00	59.7922D+00	47.9427D+00	45.3000D+00	-14.4922D+00	-26.4265D-01
48.9000D+00	59.9199D+00	51.5113D+00	48.9000D+00	-11.0199D+00	-26.1131D-01
53.3000D+00	60.1156D+00	57.3670D+00	53.3000D+00	-68.1564D-01	-40.6700D-01
61.8000D+00	58.9705D+00	60.7506D+00	61.8000D+00	28.2950D-01	10.4941D-01
65.0000D+00	59.8075D+00	62.2442D+00	65.0000D+00	51.9249D-01	27.5578D-01
61.2000D+00	62.7684D+00	65.1416D+00	61.2000D+00	-15.6837D-01	-39.4163D-01
68.4000D+00	65.6583D+00	68.6878D+00	68.4000D+00	27.4169D-01	-28.7798D-02
74.1000D+00	67.6111D+00	70.2956D+00	74.1000D+00	64.8890D-01	38.0442D-01

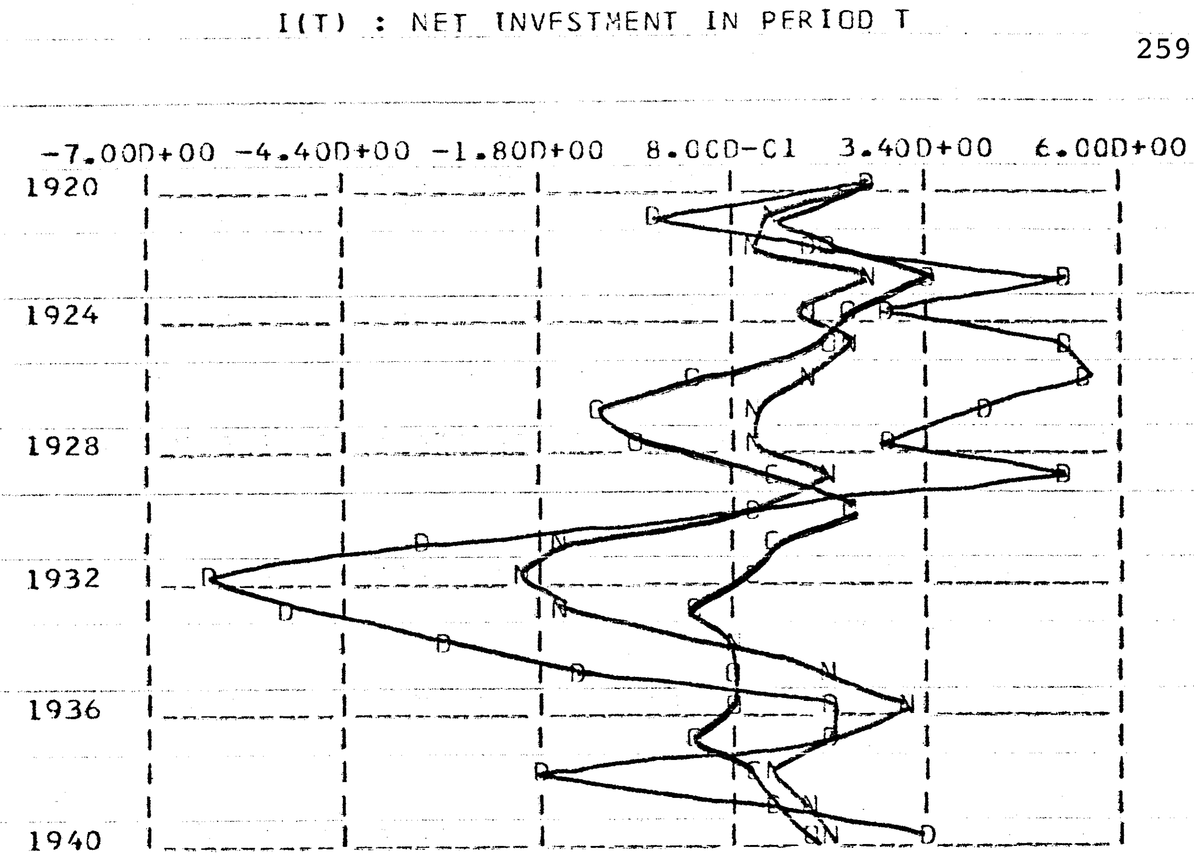
QUADRATIC ERROR OLD MODEL: 1248.9372D+00

QUADRATIC ERROR NEW MODEL: 1536.5514D-01

Table 6.3

Y(T) : National Income In Period T

Obtention of Sub-optimal Policies With Samuelson-Hicks' Model



<u>Figure 6.4</u>

I(T) : Net Investment in Period T

<u>Obtention of Sub-optimal Policies With Samuelson-Hicks' Model</u>

I(T) : NET INVESTMENT IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
27.0000D-01	27.0000D-01	27.0000D-01	27.0000D-01	0.0	0.0
-20.0000D-02	14.1595D-01	14.1595D-01	-20.0000D-02	-16.1595D-01	-16.1595D-01
19.0000D-01	21.4688D-01	11.5552D-01	19.0000D-01	-24.6878D-02	74.4478D-02
52.0000D-01	33.7173D-01	25.8589D-01	52.0000D-01	18.2827D-01	26.1411D-01
30.0000D-01	24.8285D-01	19.1785D-01	30.0000D-01	51.7149D-02	10.8215D-01
51.0000D-01	19.7969D-01	23.4182D-01	51.0000D-01	31.2031D-01	27.5818D-01
56.0000D-01	39.3379D-02	19.3357D-01	56.0000D-01	52.0662D-01	36.6643D-01
42.0000D-01	-10.0744D-01	10.7881D-01	42.0000D-01	52.0744D-01	31.2119D-01
30.0000D-01	-58.0174D-02	11.3448D-01	30.0000D-01	35.8017D-01	18.6552D-01
51.0000D-01	13.8237D-01	20.8911D-01	51.0000D-01	37.1763D-01	30.1089D-01
10.0000D-01	24.2684D-01	11.1438D-01	10.0000D-01	-14.2684D-01	-11.4377D-02
-34.0000D-01	13.1597D-01	-15.5482D-01	-34.0000D-01	-47.1597D-01	-18.4518D-01
-62.0000D-01	10.3782D-01	-21.1998D-01	-62.0000D-01	-72.3782D-01	-40.8002D-01
-51.0000D-01	18.4846D-02	-15.7455D-01	-51.0000D-01	-52.8485D-01	-35.2545D-01
-30.0000D-01	73.7723D-02	77.0720D-02	-30.0000D-01	-37.3772D-01	-37.7072D-01
-13.0000D-01	75.2578D-02	22.0439D-01	-13.0000D-01	-20.5258D-01	-35.0439D-01
21.0000D-01	78.1243D-02	31.6936D-01	21.0000D-01	13.1876D-01	-10.6936D-01
20.0000D-01	21.5502D-02	21.2631D-01	20.0000D-01	17.8450D-01	-12.6307D-02
-19.0000D-01	10.5183D-01	13.2888D-01	-19.0000D-01	-29.5183D-01	-32.2888D-01
13.0000D-01	19.4795D-01	19.2117D-01	13.0000D-01	-64.7946D-02	-62.1174D-02
33.0000D-01	19.1802D-01	21.9490D-01	33.0000D-01	13.8198D-01	11.0510D-01

QUADRATIC ERROR OLD MODEL: 2356.2537D-01

QUADRATIC ERROR NEW MODEL: 1266.9230D-01

Table 6.4

I(T) : Net Investment In Period T

Obtention Of Sub-optimal Policies With Samuelson-Hicks' Model

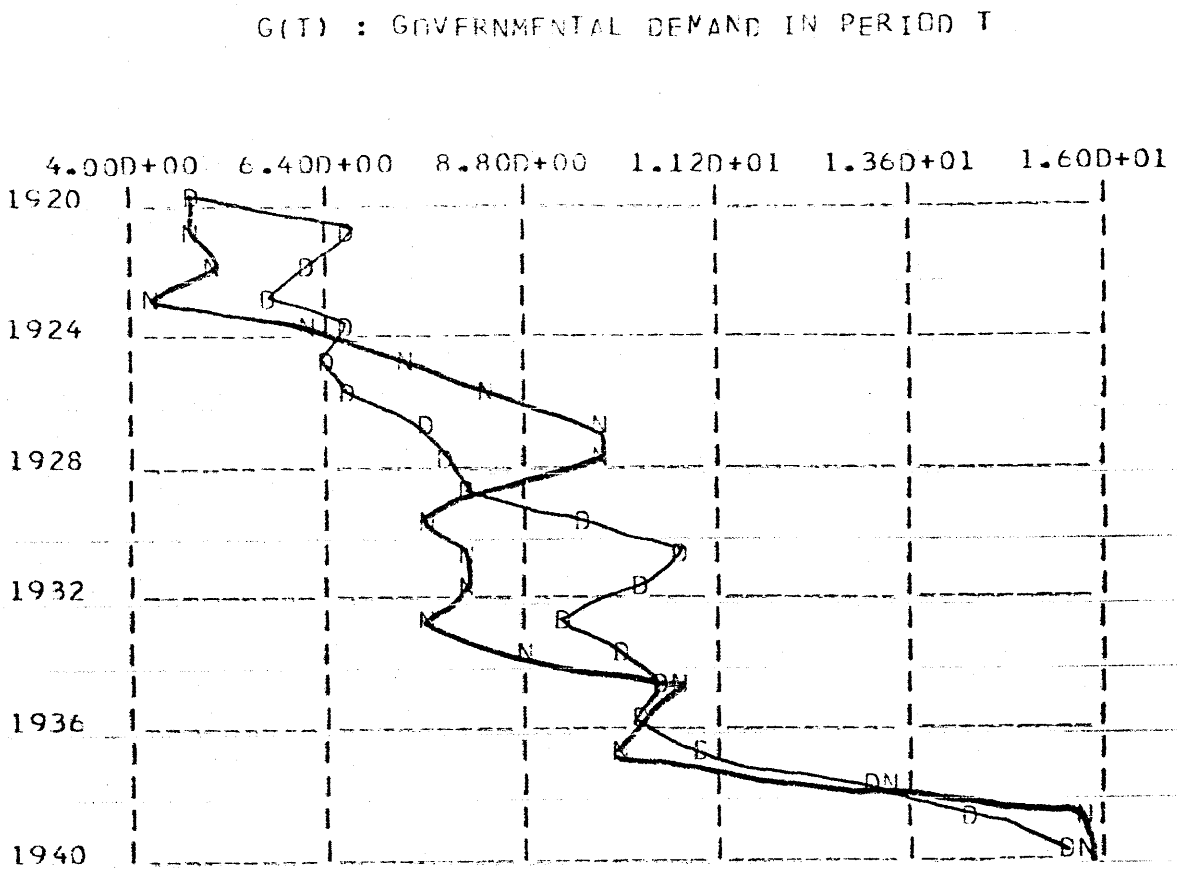


Figure 6.5

G(T) : Govermental Demand In Period T

Obtention Of Sub-optimal Policies With Samuelson- Hicks' Model

G(T) : GOVERNMENTAL DEMAND IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
46.0000D-01	46.0000D-01	46.0000D-01	46.0000D-01	0.0	0.0
66.0000D-01	66.0000D-01	48.3623D-01	66.0000D-01	0.0	17.6377D-01
61.0000D-01	61.0000D-01	50.1352D-01	61.0000D-01	0.0	10.8648D-01
57.0000D-01	57.0000D-01	42.1232D-01	57.0000D-01	0.0	14.8768D-01
66.0000D-01	66.0000D-01	61.1414D-01	66.0000D-01	0.0	48.5863D-02
65.0000D-01	65.0000D-01	74.0287D-01	65.0000D-01	0.0	-90.2875D-02
66.0000D-01	66.0000D-01	83.7055D-01	66.0000D-01	0.0	-17.7055D-01
76.0000D-01	76.0000D-01	96.7112D-01	76.0000D-01	0.0	-20.7112D-01
79.0000D-01	79.0000D-01	98.2989D-01	79.0000D-01	0.0	-19.2989D-01
81.0000D-01	81.0000D-01	80.1601D-01	81.0000D-01	0.0	83.9895D-03
94.0000D-01	94.0000D-01	76.9831D-01	94.0000D-01	0.0	17.0169D-01
10.7000D+00	10.7000D+00	80.1178D-01	10.7000D+00	0.0	26.8822D-01
10.2000D+00	10.2000D+00	79.7748D-01	10.2000D+00	0.0	22.2252D-01
93.0000D-01	93.0000D-01	75.0313D-01	93.0000D-01	0.0	17.9687D-01
10.0000D+00	10.0000D+00	88.6930D-01	10.0000D+00	0.0	11.3070D-01
10.5000D+00	10.5000D+00	10.6134D+00	10.5000D+00	0.0	-11.3396D-02
10.3000D+00	10.3000D+00	10.3382D+00	10.3000D+00	0.0	-38.1731D-03
11.0000D+00	11.0000D+00	10.0388D+00	11.0000D+00	0.0	96.1160D-02
13.0000D+00	13.0000D+00	13.4180D+00	13.0000D+00	0.0	-41.7956D-02
14.4000D+00	14.4000D+00	15.6576D+00	14.4000D+00	0.0	-12.5758D-01
15.4000D+00	15.4000D+00	15.7908D+00	15.4000D+00	0.0	-39.0820D-02

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 4112.7868D-02

Table 6.5

G(T) : Govermental Demand In Period T

Obtention Of Sub-optimal Policies With Samuelson-Hicks' Model

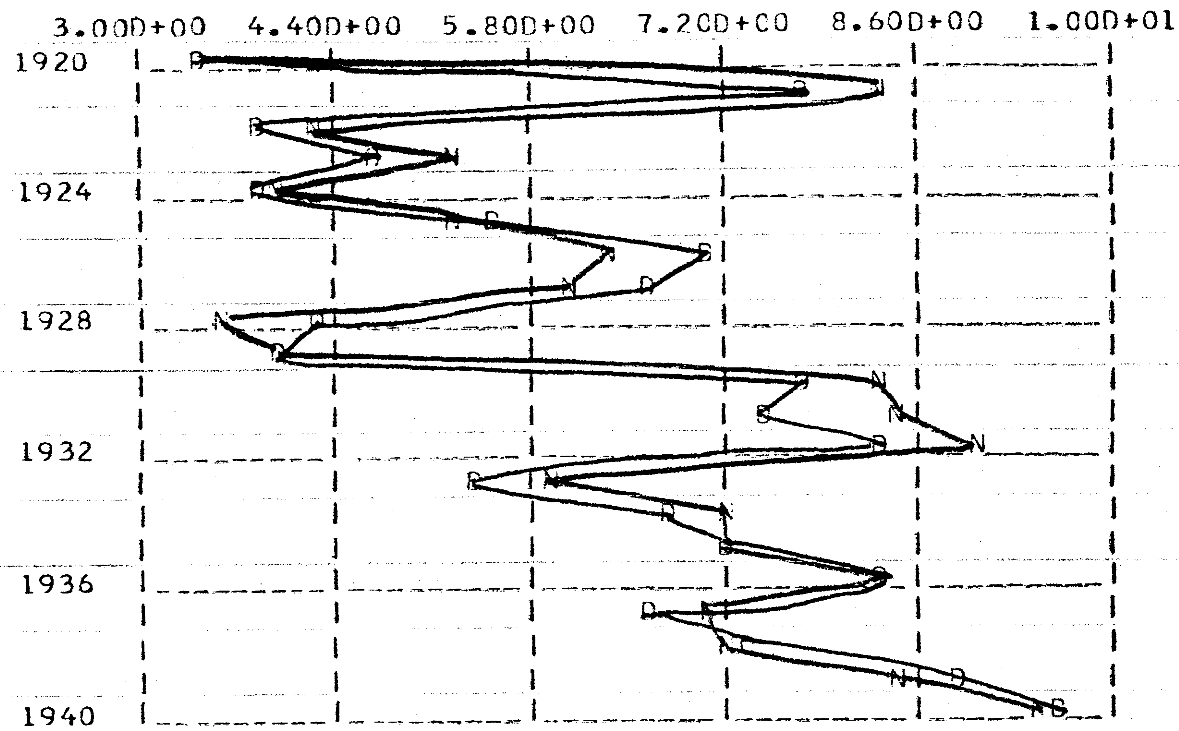


Figure 6.6

Tx(T) : Business Taxes In Period T

Obtention Of Sub-optimal Policies With Samuelson-Hicks' Model

TX(T) : BUSINESS TAXES IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
34.0000D-01	34.0000D-01	34.0000D-01	34.0000D-01	0.0	0.0
77.0000D-01	77.0000D-01	82.8580D-01	77.0000D-01	0.0	-58.5801D-02
39.0000D-01	39.0000D-01	42.6085D-01	39.0000D-01	0.0	-36.0854D-02
47.0000D-01	47.0000D-01	51.9410D-01	47.0000D-01	0.0	-49.4104D-02
38.0000D-01	38.0000D-01	39.6137D-01	38.0000D-01	0.0	-16.1370D-02
55.0000D-01	55.0000D-01	52.0013D-01	55.0000D-01	0.0	29.9871D-02
70.0000D-01	70.0000D-01	64.1195D-01	70.0000D-01	0.0	58.8051D-02
67.0000D-01	67.0000D-01	60.1212D-01	67.0000D-01	0.0	68.7880D-02
42.0000D-01	42.0000D-01	35.5903D-01	42.0000D-01	0.0	64.0973D-02
40.0000D-01	40.0000D-01	40.2790D-01	40.0000D-01	0.0	-27.8954D-03
77.0000D-01	77.0000D-01	82.6518D-01	77.0000D-01	0.0	-56.5182D-02
75.0000D-01	75.0000D-01	83.9284D-01	75.0000D-01	0.0	-89.2837D-02
83.0000D-01	83.0000D-01	90.3817D-01	83.0000D-01	0.0	-73.8165D-02
54.0000D-01	54.0000D-01	59.9679D-01	54.0000D-01	0.0	-59.6795D-02
68.0000D-01	68.0000D-01	71.7554D-01	68.0000D-01	0.0	-37.5538D-02
72.0000D-01	72.0000D-01	71.6234D-01	72.0000D-01	0.0	37.6622D-03
83.0000D-01	83.0000D-01	82.8732D-01	83.0000D-01	0.0	12.6784D-03
67.0000D-01	67.0000D-01	70.1923D-01	67.0000D-01	0.0	-31.9230D-02
74.0000D-01	74.0000D-01	72.6118D-01	74.0000D-01	0.0	13.8816D-02
89.0000D-01	89.0000D-01	84.8232D-01	89.0000D-01	0.0	41.7680D-02
96.0000D-01	96.0000D-01	94.7020D-01	96.0000D-01	0.0	12.9803D-02

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 4536.8197D-03

Table 6.6

Tx(T) : Business Taxes In Period T

Obtention Of Sub-optimal Policies With Samuelson-Hicks' Model

6.4 Simulating The Open-Loop and Closed-Loop Versions Of The Less-Aggregated Model Using the Optimal Policies Obtained With The Highly-Aggregated Model

For this experiment the open-loop version was obtained by simulating the original structure ("old" model) of the 2SLS version of Klein's model for the period 1920-1940. Two of the control variables (government expenditure and taxes) were the optimal values obtained in the previous section. The remaining control variable (government wage bill (W2)) was set equal to its historical values.

The closed-loop version was obtained by solving the optimal tracking problem on the original structure of the 2SLS version of Klein's model, and with the desired targets for two of the control variables (government expenditure and taxes) chosen to be the optimal values obtained with the highly aggregated model. The remaining targets were set equal to the historical values. Furthermore, the weights of the cost matrices corresponding to the endogenous variables not present in the highly aggregated model (capital stock, profits, private wage bill) were set to very low values. The previous arrangements were made so as to reproduce to some extent the conditions that would prevail in matching a large-scale system with a sub optimal-controller obtained with an aggregated model.

The results for these two versions are presented simultaneously on Tables 6.6 to 6.14 and on Figures 6.5 to 6.13. In each diagram time runs along the vertical axis, the historical values are represented by letter "D" the "open-loop" version by letter "O" and the closed-loop version is denoted by letter "N".

The results show that the closed-loop version has a better performance than the open-loop version. This difference is emphasized after the period corresponding to the year 1932. This is due mainly to the fact that the open-loop version can not handle such big disturbances as the great depression.

However, the open-loop version exhibits a performance that is superior to the behavior of the "old" model. This is the consequence of the use of optimal policies instead of the historical values.

The three endogenous variables present in the Samuelson-Hicks model (consumption, investment, and national income) track slightly better the historical values than the remaining endogenous variables. But the differences are very small. This result shows that for this particular example the closed-loop form works even if the control law is obtaining by means of a smaller model.

C(T) : CONSUMPTION IN PERIOD T

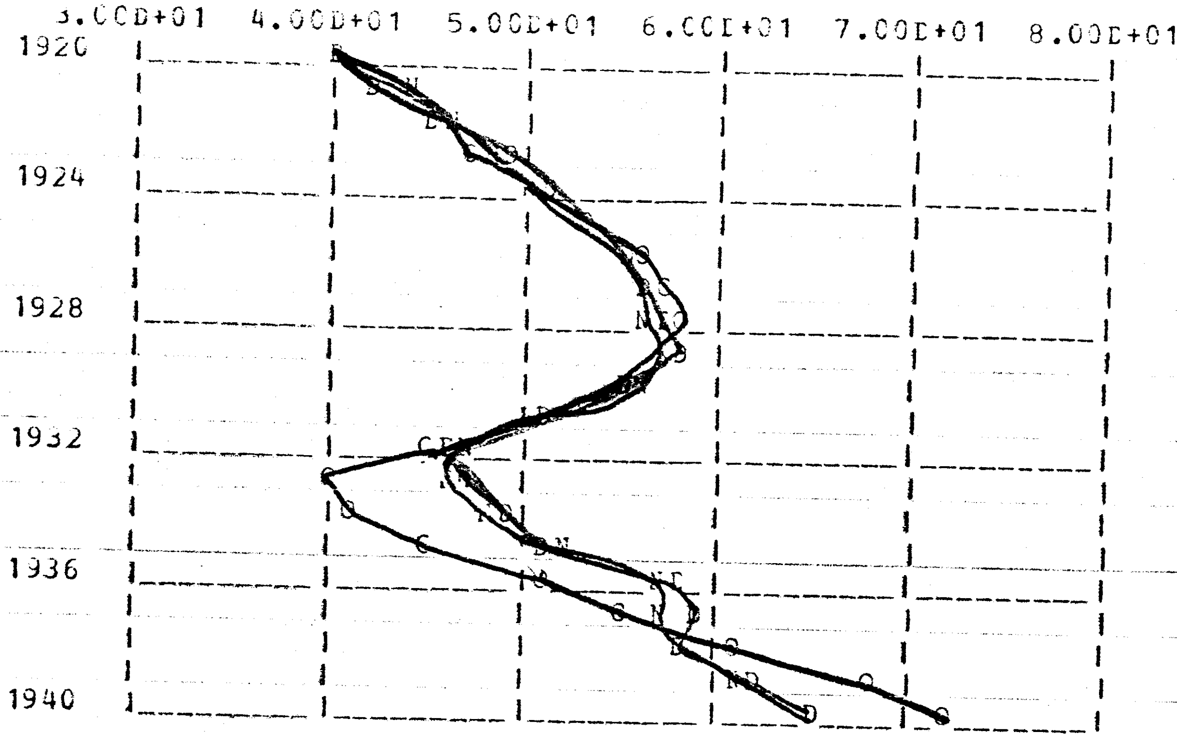


Figure 6.7

C(T) : Consumption In Period T

Open and Closed-loop Versions of the New Structure

C(T) : CONSUMPTION IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
39.8000D+00	39.8000D+00	39.8000D+00	39.8000D+00	0.0	0.0
41.9000D+00	43.9816D+00	43.8181D+00	41.9000D+00	-20.8160D-01	-19.1811D-01
45.0000D+00	44.9170D+00	45.5028D+00	45.0000D+00	82.9504D-03	-50.2812D-02
49.2000D+00	46.8450D+00	48.3140D+00	49.2000D+00	23.5503D-01	88.5979D-02
50.6000D+00	49.5014D+00	50.2395D+00	50.6000D+00	10.9855D-01	36.0453D-02
52.6000D+00	53.2119D+00	52.6647D+00	52.6000D+00	-61.1862D-02	-64.7468D-03
55.1000D+00	55.9340D+00	54.6183D+00	55.1000D+00	-83.3994D-02	48.1664D-02
56.2000D+00	57.2348D+00	55.5728D+00	56.2000D+00	-10.3484D-01	62.7248D-02
57.3000D+00	57.8827D+00	56.3116D+00	57.3000D+00	-58.2661D-02	98.8382D-02
57.8000D+00	58.2622D+00	57.1921D+00	57.8000D+00	-46.2175D-02	60.7913D-02
55.0000D+00	56.1814D+00	55.6369D+00	55.0000D+00	-11.8143D-01	-63.6861D-02
50.9000D+00	50.7225D+00	51.4801D+00	50.9000D+00	17.7514D-02	-58.0087D-02
45.6000D+00	44.6062D+00	47.4557D+00	45.6000D+00	99.3794D-02	-18.5574D-01
46.5000D+00	39.9447D+00	45.7507D+00	46.5000D+00	65.5527D-01	74.9344D-02
48.7000D+00	40.5595D+00	47.9316D+00	48.7000D+00	81.4050D-01	76.8398D-02
51.3000D+00	44.9394D+00	51.5734D+00	51.3000D+00	63.6059D-01	-27.3386D-02
57.7000D+00	51.4023D+00	56.5932D+00	57.7000D+00	62.9766D-01	11.0678D-01
58.7000D+00	54.7748D+00	57.1068D+00	58.7000D+00	39.2520D-01	15.9319D-01
57.5000D+00	60.8424D+00	58.0142D+00	57.5000D+00	-33.4241D-01	-51.4217D-02
61.6000D+00	67.5767D+00	60.9671D+00	61.6000D+00	-59.7666D-01	63.2875D-02
65.0000D+00	72.3428D+00	64.9347D+00	65.0000D+00	-73.4280D-01	65.3135D-03

QUADRATIC ERROR OLD MODEL: 3217.7480D-01

QUADRATIC ERROR NEW MODEL: 1666.7914D-02

Table 6.7

C(T) : Consumption In Period T

Open and Closed-loop Versions of the New Structure

I(T) : NET INVESTMENT IN PERIOD T

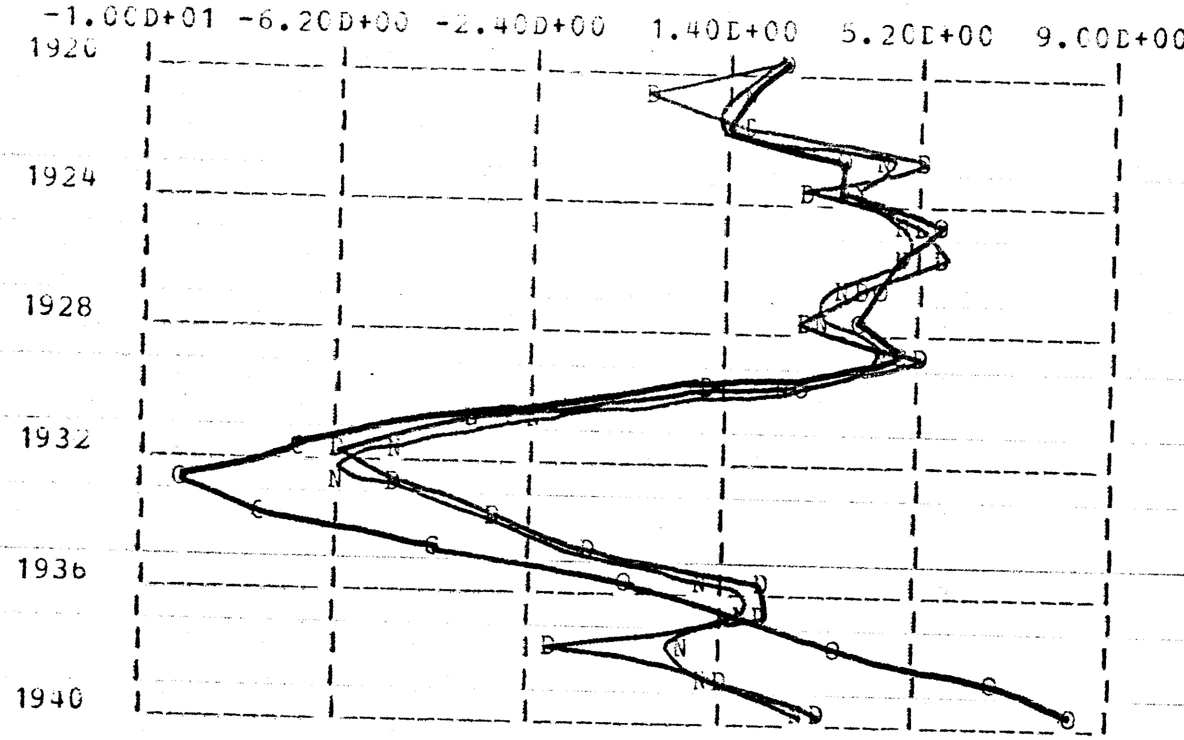


Figure 6.8

I(T) : Net Investment In Period T

Open and Closed-loop Versions of the New Structure

I(T) : NET INVESTMENT IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
27.0000D-01	27.0000D-01	27.0000D-01	27.0000D-01	0.0	0.0
-20.0000D-02	18.5890D-01	18.6052D-01	-20.0000D-02	-20.5890D-01	-20.6052D-01
19.0000D-01	12.6812D-01	13.6747D-01	19.0000D-01	63.1879D-02	53.2530D-02
52.0000D-01	35.3393D-01	44.2281D-01	52.0000D-01	16.6607D-01	77.7192D-02
30.0000D-01	37.6788D-01	42.1482D-01	30.0000D-01	-76.7884D-02	-12.1482D-01
51.0000D-01	54.5987D-01	48.8272D-01	51.0000D-01	-35.9871D-02	21.7285D-02
56.0000D-01	57.0466D-01	47.4726D-01	56.0000D-01	-10.4658D-02	85.2739D-02
42.0000D-01	45.8597D-01	36.2801D-01	42.0000D-01	-38.5969D-02	57.1989D-02
30.0000D-01	41.5283D-01	33.0103D-01	30.0000D-01	-11.5283D-01	-30.1026D-02
51.0000D-01	49.2117D-01	44.7759D-01	51.0000D-01	17.8833D-02	62.2411D-02
10.0000D-01	27.6398D-01	27.1835D-01	10.0000D-01	-17.6398D-01	-17.1835D-01
-34.0000D-01	-29.6142D-01	-23.3592D-01	-34.0000D-01	-43.8576D-02	-10.6408D-01
-62.0000D-01	-71.0349D-01	-52.4371D-01	-62.0000D-01	90.3492D-02	-95.6291D-02
-51.0000D-01	-94.2738D-01	-61.3270D-01	-51.0000D-01	43.2738D-01	10.3270D-01
-30.0000D-01	-75.3687D-01	-33.0954D-01	-30.0000D-01	45.3687D-01	30.9538D-02
-13.0000D-01	-44.6786D-01	-13.7306D-01	-13.0000D-01	31.6786D-01	73.0604D-03
21.0000D-01	-33.4759D-02	11.3599D-01	21.0000D-01	24.3476D-01	96.4011D-02
20.0000D-01	16.2268D-01	16.3363D-01	20.0000D-01	37.7320D-02	36.6372D-02
-19.0000D-01	36.8444D-01	51.6346D-02	-19.0000D-01	-55.8444D-01	-24.1635D-01
13.0000D-01	66.5352D-01	10.2347D-01	13.0000D-01	-53.5352D-01	27.6533D-02
33.0000D-01	81.7554D-01	29.5712D-01	33.0000D-01	-48.7554D-01	34.2883D-02

QUADRATIC ERROR OLD MODEL: 1528.0661D-01

QUADRATIC ERROR NEW MODEL: 2145.2136D-02

Table 6.8

I(T) : Net Investment In Period T

Open and Closed-loop Versions of the New Structure

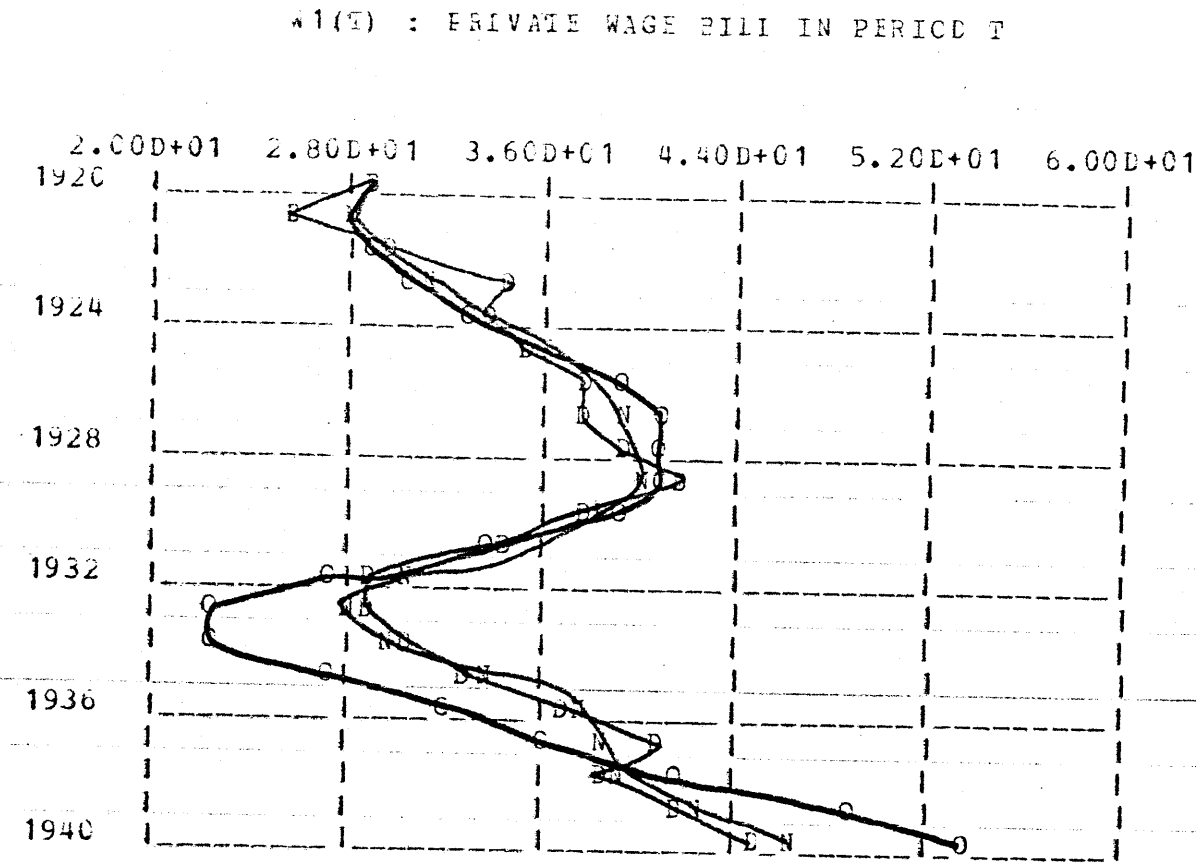


Figure 6.9

W1(T) : Private Wage Bill In Period T

Open and Closed-loop Versions of the New Structure

W1(T) : PRIVATE WAGE BILL IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
28.8000D+00	28.8000D+00	28.8000D+00	28.8000D+00	0.0	0.0
25.5000D+00	27.7412D+00	27.6642D+00	25.5000D+00	-22.4124D-01	-21.6425D-01
29.3000D+00	28.5642D+00	29.2421D+00	29.3000D+00	73.5784D-02	57.9302D-03
34.1000D+00	30.1301D+00	31.4642D+00	34.1000D+00	39.6988D-01	26.3579D-01
33.9000D+00	32.7331D+00	33.4056D+00	33.9000D+00	11.6693D-01	49.4434D-02
35.4000D+00	36.3586D+00	35.8526D+00	35.4000D+00	-95.8643D-02	-45.2589D-02
37.4000D+00	39.2319D+00	37.9311D+00	37.4000D+00	-18.3188D-01	-53.1098D-02
37.9000D+00	40.5387D+00	38.8730D+00	37.9000D+00	-26.3866D-01	-97.2975D-02
39.2000D+00	41.0010D+00	39.4593D+00	39.2000D+00	-18.0099D-01	-25.9305D-02
41.3000D+00	40.7994D+00	39.6861D+00	41.3000D+00	50.0567D-02	16.1388D-01
37.9000D+00	38.8455D+00	38.3445D+00	37.9000D+00	-94.5523D-02	-44.4534D-02
34.5000D+00	33.4995D+00	34.2947D+00	34.5000D+00	10.0049D-01	20.5317D-02
29.0000D+00	27.2179D+00	30.2092D+00	29.0000D+00	17.8212D-01	-12.0917D-01
28.5000D+00	22.2822D+00	28.0572D+00	28.5000D+00	62.1778D-01	44.2800D-02
30.6000D+00	22.4246D+00	29.6352D+00	30.6000D+00	81.7538D-01	96.4776D-02
33.2000D+00	26.8579D+00	33.4862D+00	33.2000D+00	63.4211D-01	-28.6194D-02
36.8000D+00	32.2744D+00	37.4511D+00	36.8000D+00	45.2563D-01	-65.1057D-02
41.0000D+00	36.3502D+00	38.4001D+00	41.0000D+00	46.4983D-01	25.9985D-01
38.2000D+00	41.7614D+00	38.9223D+00	38.2000D+00	-35.6144D-01	-72.2301D-02
41.6000D+00	48.5716D+00	42.0539D+00	41.6000D+00	-69.7158D-01	-45.3917D-02
45.0000D+00	53.3536D+00	46.0133D+00	45.0000D+00	-83.5364D-01	-10.1333D-01

QUADRATIC ERROR OLD MODEL: 3613.8104D-01

QUADRATIC ERROR NEW MODEL: 2783.2919D-02

Table 6.9

W1 (T) : Private Wage Bill In Period T

Open and Closed-loop Versions of the New Structure

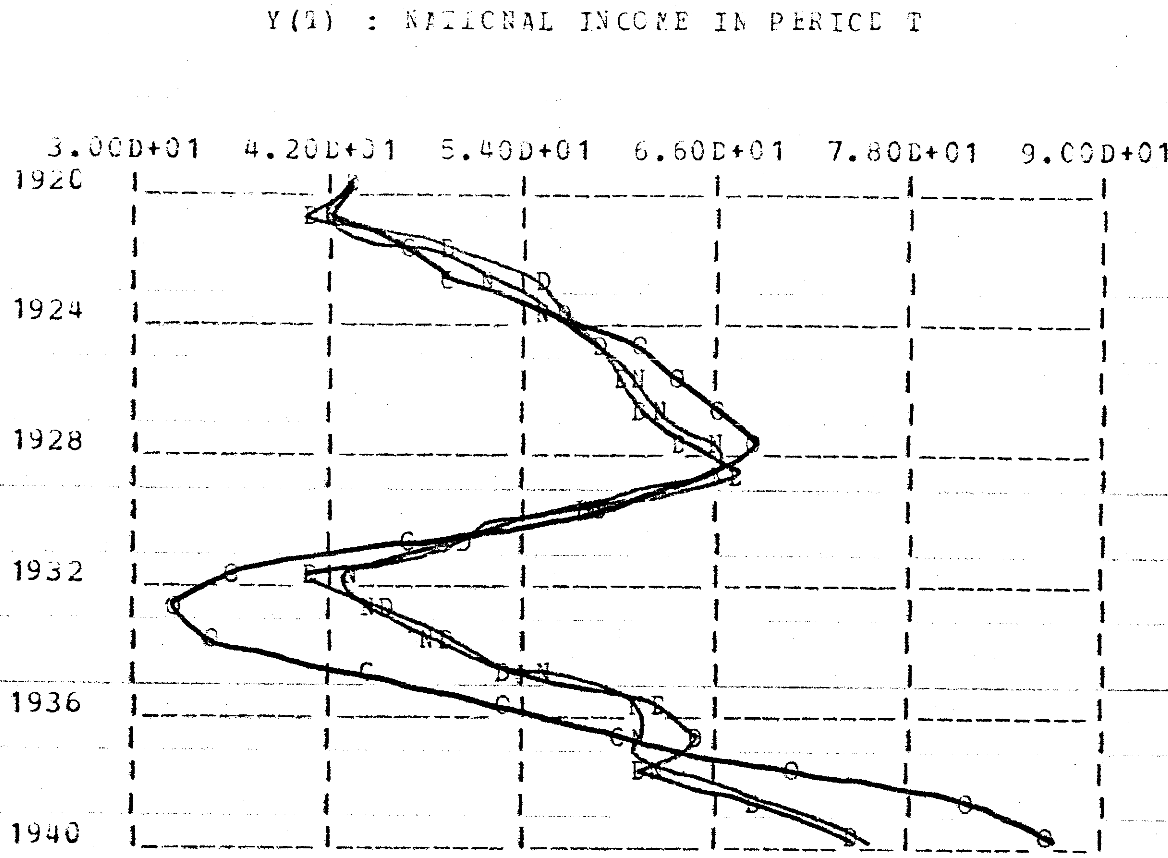


Figure 6.10

Y(T) : National Income In Period T

Open and Closed-loop Versions of the New Structure

Y(T) : NATIONAL INCOME IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
43.7000D+00	43.7000D+00	43.7000D+00	43.7000D+00	0.0	0.0
40.6000D+00	42.3909D+00	42.2148D+00	40.6000D+00	-17.9093D-01	-16.1480D-01
49.1000D+00	46.9378D+00	48.7795D+00	49.1000D+00	21.6216D-01	32.0537D-02
55.4000D+00	49.3971D+00	51.7960D+00	55.4000D+00	60.0289D-01	36.0403D-01
56.4000D+00	55.4221D+00	55.7765D+00	56.4000D+00	97.7900D-02	62.3452D-02
58.7000D+00	60.8745D+00	59.3101D+00	58.7000D+00	-21.7447D-01	-61.0090D-02
60.3000D+00	63.5973D+00	61.0273D+00	60.3000D+00	-32.9725D-01	-72.7301D-02
61.3000D+00	65.4798D+00	62.4279D+00	61.3000D+00	-41.7981D-01	-11.2787D-01
64.0000D+00	68.3063D+00	65.7082D+00	64.0000D+00	-43.0635D-01	-17.0817D-01
67.0000D+00	67.1715D+00	65.4739D+00	67.0000D+00	-17.1452D-02	15.2606D-01
57.7000D+00	58.3785D+00	57.9768D+00	57.7000D+00	-67.8538D-02	-27.6821D-02
50.7000D+00	47.3800D+00	49.9916D+00	50.7000D+00	33.2000D-01	70.8407D-02
41.3000D+00	36.4420D+00	43.4017D+00	41.3000D+00	48.5798D-01	-21.0167D-01
45.3000D+00	32.0237D+00	44.1531D+00	45.3000D+00	13.2763D+00	11.4695D-01
48.9000D+00	34.7164D+00	47.8730D+00	48.9000D+00	14.1836D+00	10.2696D-01
53.3000D+00	43.9226D+00	54.9166D+00	53.3000D+00	93.7739D-01	-16.1664D-01
61.8000D+00	53.1185D+00	61.4088D+00	61.8000D+00	86.8154D-01	39.1207D-02
65.0000D+00	59.4171D+00	60.6184D+00	65.0000D+00	55.8295D-01	43.8156D-01
61.2000D+00	70.6837D+00	62.5109D+00	61.2000D+00	-94.8367D-01	-13.1093D-01
68.4000D+00	81.4055D+00	68.6648D+00	68.4000D+00	-13.0055D+00	-26.4801D-02
74.1000D+00	86.8389D+00	74.4222D+00	74.1000D+00	-12.7389D+00	-32.2210D-02

QUADRATIC ERROR OLD MODEL: 1124.8726D+00

QUADRATIC ERROR NEW MODEL: 5473.0690D-02

Table 6.10

Y(T) : National Income In Period T

Open and Closed-loop Versions of the New Structure

P(T) : NON-WAGE INCOME(PROFITS) IN PERIOD T

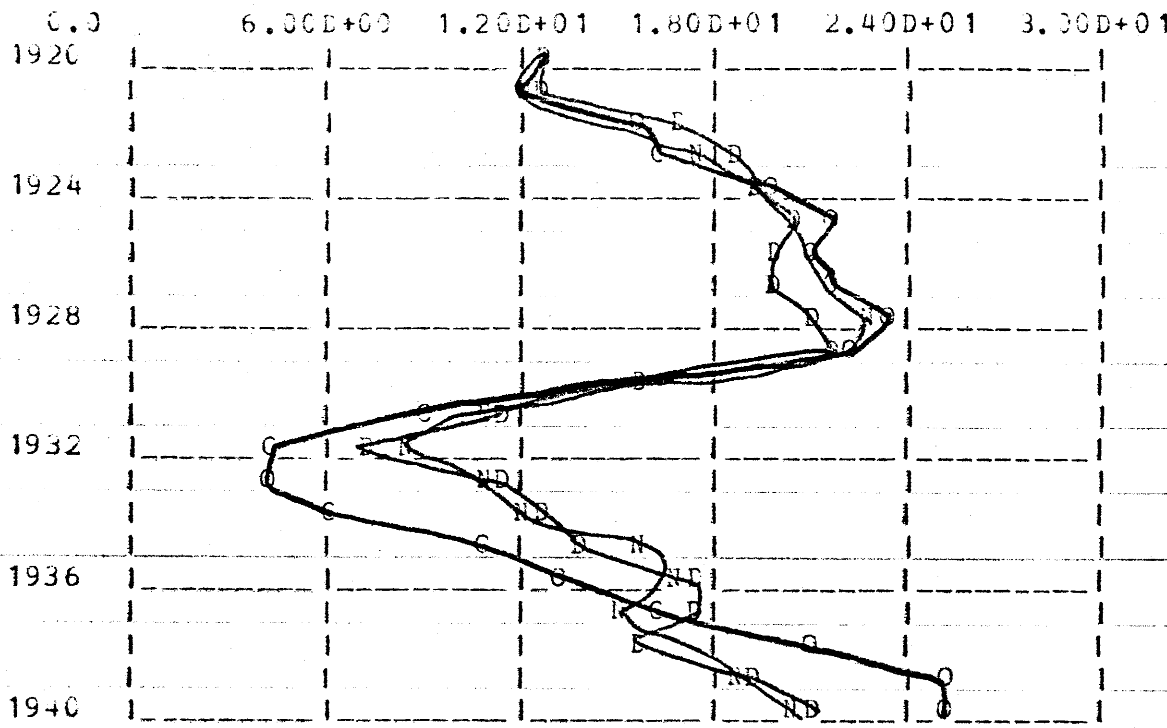


Figure 6.11

P(T) : Non-wage Income (Profits) In Period T

Open and Closed-loop Versions of the New Structure

P(T) : NON-WAGE INCOME(PROFITS) IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
12.7000D+00	12.7000D+00	12.7000D+00	12.7000D+00	0.0	0.0
12.4000D+00	11.9497D+00	11.9735D+00	12.4000D+00	45.0309D-02	42.6456D-02
16.9000D+00	15.4736D+00	16.7009D+00	16.9000D+00	14.2638D-01	19.9147D-02
18.4000D+00	16.3670D+00	17.2996D+00	18.4000D+00	20.3300D-01	11.0044D-01
19.4000D+00	19.5890D+00	19.2069D+00	19.4000D+00	-18.9028D-02	19.3084D-02
20.1000D+00	21.3158D+00	20.2600D+00	20.1000D+00	-12.1583D-01	-15.9999D-02
19.6000D+00	21.0654D+00	19.7842D+00	19.6000D+00	-14.6537D-01	-18.4199D-02
19.8000D+00	21.3411D+00	19.9443D+00	19.8000D+00	-15.4115D-01	-14.4314D-02
21.1000D+00	23.6054D+00	22.5544D+00	21.1000D+00	-25.0536D-01	-14.5441D-01
21.7000D+00	22.3720D+00	21.7126D+00	21.7000D+00	-67.2019D-02	-12.6403D-03
15.6000D+00	15.3330D+00	15.4697D+00	15.6000D+00	26.6985D-02	13.0309D-02
11.4000D+00	90.8050D-01	10.9387D+00	11.4000D+00	23.1950D-01	46.1276D-02
70.0000D-01	39.2414D-01	81.1144D-01	70.0000D-01	30.7586D-01	-11.1144D-01
11.2000D+00	41.4148D-01	10.5446D+00	11.2000D+00	70.5852D-01	65.5373D-02
12.3000D+00	62.9177D-01	12.2326D+00	12.3000D+00	60.0823D-01	67.4147D-03
14.0000D+00	10.9647D+00	15.4363D+00	14.0000D+00	30.3528D-01	-14.3633D-01
17.6000D+00	13.4441D+00	16.5676D+00	17.6000D+00	41.5591D-01	10.3240D-01
17.3000D+00	16.3669D+00	15.2860D+00	17.3000D+00	93.3113D-02	20.1404D-01
15.3000D+00	21.2222D+00	15.8648D+00	15.3000D+00	-59.2223D-01	-56.4757D-02
19.0000D+00	25.0339D+00	18.7698D+00	19.0000D+00	-60.3388D-01	23.0159D-02
21.1000D+00	25.4853D+00	20.4209D+00	21.1000D+00	-43.8529D-01	67.9122D-02

QUADRATIC ERROR OLD MODEL: 2380.3573D-01

QUADRATIC ERROR NEW MODEL: 1358.3111D-02

Table 6.11

P(T) : Non-wage Income (Profits) In Period T

Open and Closed-loop Versions of the New Structure

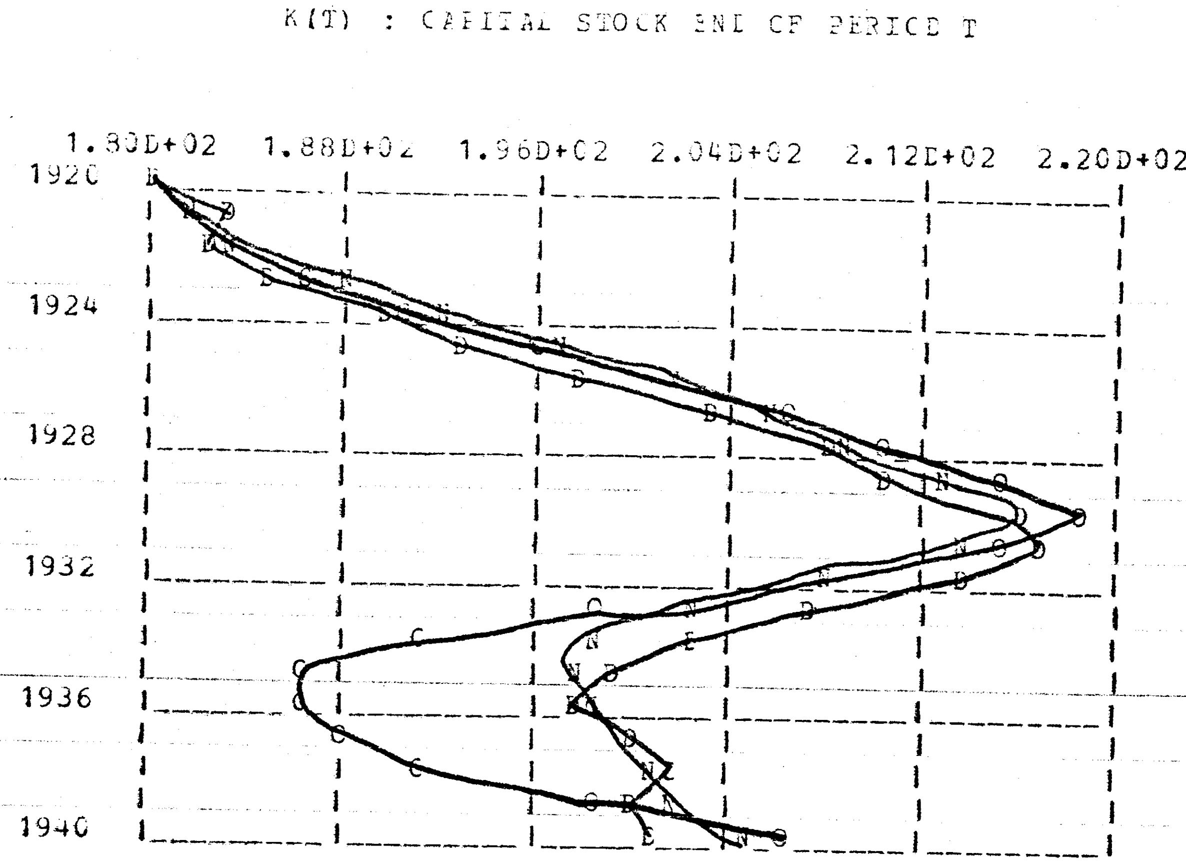


Figure 6.12

K(T) : Capitol Stock End Of Period T

Open and Closed-loop Versions of the New Structure

K(T) : CAPITAL STOCK END OF PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
18.0100D+01	18.0100D+01	18.0100D+01	18.0100D+01	0.0	0.0
18.2800D+01	18.1959D+01	18.1961D+01	18.2800D+01	84.1100D-02	83.9482D-02
18.2600D+01	18.3227D+01	18.3328D+01	18.2600D+01	-62.7021D-02	-72.7988D-02
18.4500D+01	18.6761D+01	18.7751D+01	18.4500D+01	-22.6095D-01	-32.5080D-01
18.9700D+01	19.0529D+01	19.1966D+01	18.9700D+01	-82.8832D-02	-22.6562D-01
19.2700D+01	19.5989D+01	19.6848D+01	19.2700D+01	-32.8870D-01	-41.4833D-01
19.7800D+01	20.1693D+01	20.1596D+01	19.7800D+01	-38.9336D-01	-37.9559D-01
20.3400D+01	20.6279D+01	20.5224D+01	20.3400D+01	-28.7933D-01	-18.2361D-01
20.7600D+01	21.0432D+01	20.8525D+01	20.7600D+01	-28.3216D-01	-92.4632D-02
21.0600D+01	21.5353D+01	21.3002D+01	21.0600D+01	-47.5332D-01	-24.0222D-01
21.5700D+01	21.8117D+01	21.5721D+01	21.5700D+01	-24.1731D-01	-20.5737D-03
21.6700D+01	21.5156D+01	21.3385D+01	21.6700D+01	15.4412D-01	33.1535D-01
21.3300D+01	20.8052D+01	20.8141D+01	21.3300D+01	52.4761D-01	51.5906D-01
20.7100D+01	19.8625D+01	20.2008D+01	20.7100D+01	84.7498D-01	50.9176D-01
20.2000D+01	19.1088D+01	19.8699D+01	20.2000D+01	10.9119D+00	33.0130D-01
19.9000D+01	18.6620D+01	19.7326D+01	19.9000D+01	12.3797D+00	16.7436D-01
19.7700D+01	18.6286D+01	19.8462D+01	19.7700D+01	11.4145D+00	-76.1629D-02
19.9800D+01	18.7908D+01	20.0095D+01	19.9800D+01	11.8918D+00	-29.5258D-02
20.1800D+01	19.1593D+01	20.0612D+01	20.1800D+01	10.2074D+00	11.8840D-01
19.9900D+01	19.8246D+01	20.1635D+01	19.9900D+01	16.5384D-01	-17.3507D-01
20.1200D+01	20.6422D+01	20.4592D+01	20.1200D+01	-52.2171D-01	-33.9219D-01

QUADRATIC ERROR OLD MODEL: 8575.9167D-01

QUADRATIC ERROR NEW MODEL: 1523.3466D-01

Table 6.12

K(T) : Capitol Stock End Of Period T

Open and Closed-loop Versions of the New Structure

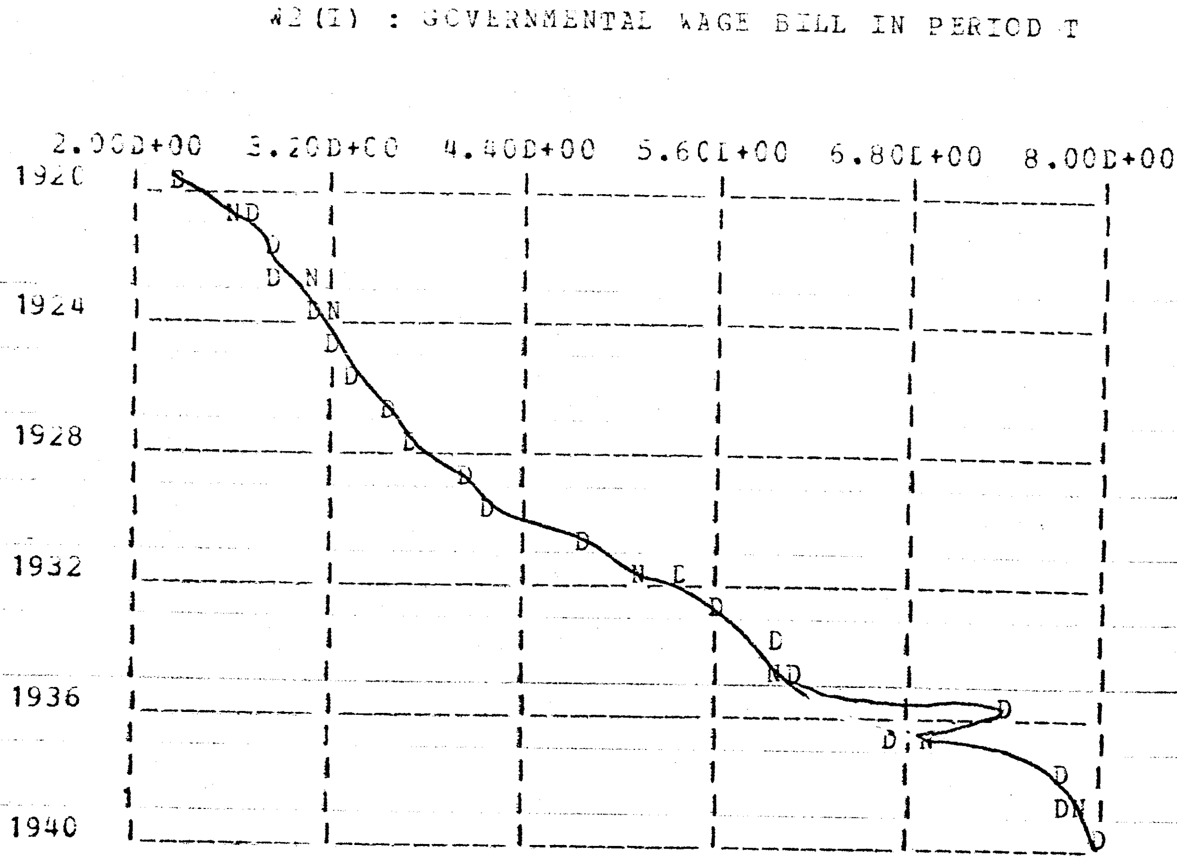


Figure 6.13

W2 (T) : Govermental Wage Bill In Period T

Open and Closed-loop Versions of the New Structure

W2(T) : GOVERNMENTAL WAGE BILL IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
22.0000D-01	22.0000D-01	22.0000D-01	22.0000D-01	0.0	0.0
27.0000D-01	27.0000D-01	25.7701D-01	27.0000D-01	0.0	12.2993D-02
29.0000D-01	29.0000D-01	28.3654D-01	29.0000D-01	0.0	63.4595D-03
29.0000D-01	29.0000D-01	30.3220D-01	29.0000D-01	0.0	-13.2205D-02
31.0000D-01	31.0000D-01	31.6407D-01	31.0000D-01	0.0	-64.0653D-03
32.0000D-01	32.0000D-01	31.9750D-01	32.0000D-01	0.0	24.9736D-04
33.0000D-01	33.0000D-01	33.1200D-01	33.0000D-01	0.0	-12.0042D-03
36.0000D-01	36.0000D-01	36.1058D-01	36.0000D-01	0.0	-10.5763D-03
37.0000D-01	37.0000D-01	36.9446D-01	37.0000D-01	0.0	55.4490D-04
40.0000D-01	40.0000D-01	40.7517D-01	40.0000D-01	0.0	-75.1713D-03
42.0000D-01	42.0000D-01	41.6260D-01	42.0000D-01	0.0	37.4031D-03
48.0000D-01	48.0000D-01	47.5819D-01	48.0000D-01	0.0	41.8140D-03
53.0000D-01	53.0000D-01	50.8106D-01	53.0000D-01	0.0	21.8937D-02
56.0000D-01	56.0000D-01	55.5122D-01	56.0000D-01	0.0	48.7760D-03
60.0000D-01	60.0000D-01	60.0523D-01	60.0000D-01	0.0	-52.2847D-04
61.0000D-01	61.0000D-01	59.9411D-01	61.0000D-01	0.0	10.5888D-02
74.0000D-01	74.0000D-01	73.9013D-01	74.0000D-01	0.0	98.6524D-04
67.0000D-01	67.0000D-01	69.3234D-01	67.0000D-01	0.0	-23.2339D-02
77.0000D-01	77.0000D-01	77.2387D-01	77.0000D-01	0.0	-23.8692D-03
78.0000D-01	78.0000D-01	78.4104D-01	78.0000D-01	0.0	-41.0426D-03
80.0000D-01	80.0000D-01	79.8800D-01	80.0000D-01	0.0	12.0008D-03

QUADRATIC ERROR OLD MODEL: 0.0

QUADRATIC ERROR NEW MODEL: 1678.5665D-04

Table 6.13

W2 (T) : Govermental Wage Bill In Period T

Open and Closed-loop Versions of the New Structure

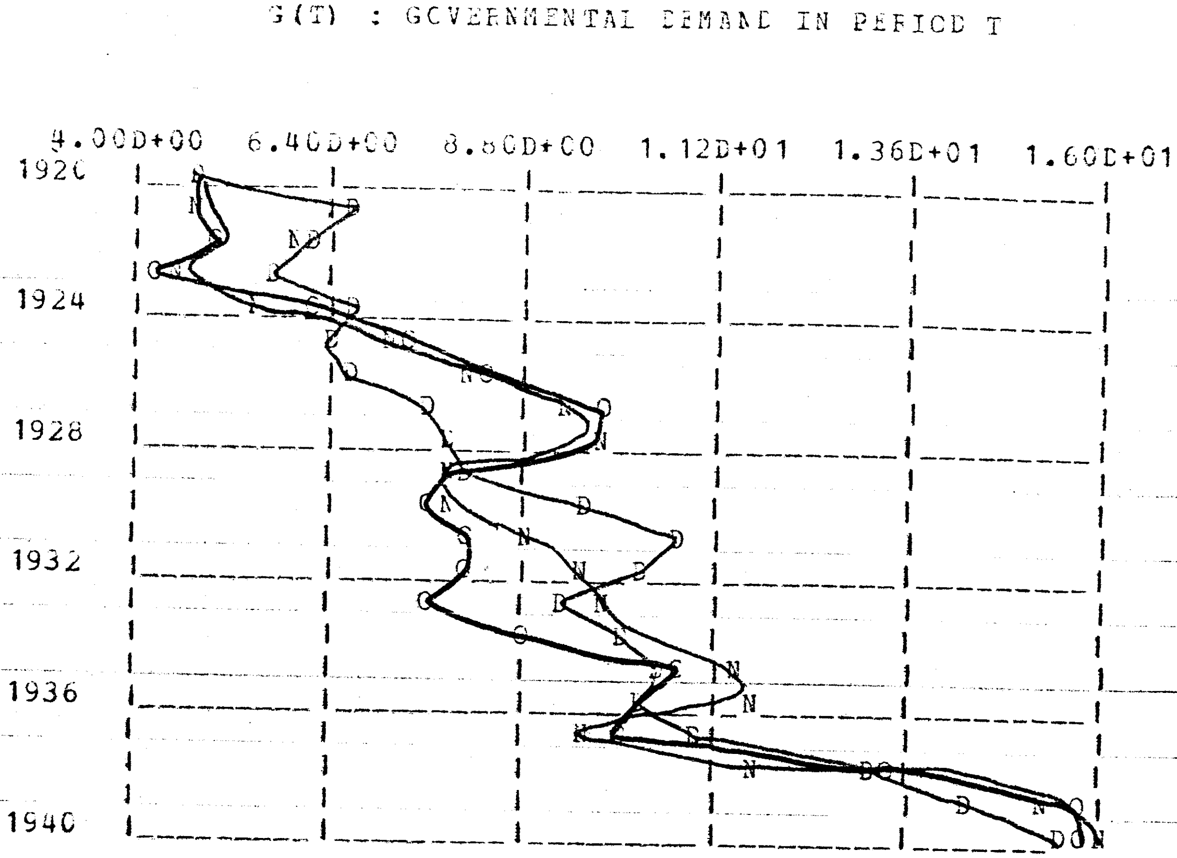


Figure 6.14

G(T) : Govermental Demand In Period T

Open and Closed-loop Versions of the New Structure

G(T) : GOVERNMENTAL DEMAND IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
46.0000D-01	46.0000D-01	46.0000D-01	46.0000D-01	0.0	0.0
66.0000D-01	48.3623D-01	46.8431D-01	66.0000D-01	17.6377D-01	19.1569D-01
61.0000D-01	50.1352D-01	60.2999D-01	61.0000D-01	10.8648D-01	70.0084D-03
57.0000D-01	42.1232D-01	45.0510D-01	57.0000D-01	14.8768D-01	11.9490D-01
66.0000D-01	61.1414D-01	55.3581D-01	66.0000D-01	48.5860D-02	10.6419D-01
65.0000D-01	74.0287D-01	70.2834D-01	65.0000D-01	-90.2870D-02	-52.8344D-02
66.0000D-01	83.7055D-01	80.9972D-01	66.0000D-01	-17.7055D-01	-14.9972D-01
76.0000D-01	96.7112D-01	93.1441D-01	76.0000D-01	-20.7112D-01	-17.1441D-01
79.0000D-01	98.2989D-01	97.5971D-01	79.0000D-01	-19.2989D-01	-18.5971D-01
81.0000D-01	80.1601D-01	79.5591D-01	81.0000D-01	83.9900D-03	14.4087D-02
94.0000D-01	76.9831D-01	77.4542D-01	94.0000D-01	17.0169D-01	16.5458D-01
10.7000D+00	80.1178D-01	87.8319D-01	10.7000D+00	26.8822D-01	19.1681D-01
10.2000D+00	79.7748D-01	94.8219D-01	10.2000D+00	22.2252D-01	71.7806D-02
93.0000D-01	75.0313D-01	97.9467D-01	93.0000D-01	17.9687D-01	-49.4669D-02
10.0000D+00	88.6930D-01	10.0389D+00	10.0000D+00	11.3070D-01	-38.8750D-03
10.5000D+00	10.6134D+00	11.5091D+00	10.5000D+00	-11.3400D-02	-10.0905D-01
10.3000D+00	10.3382D+00	11.7071D+00	10.3000D+00	-38.2000D-03	-14.0706D-01
11.0000D+00	10.0388D+00	94.2028D-01	11.0000D+00	96.1200D-02	15.7972D-01
13.0000D+00	13.4180D+00	11.7362D+00	13.0000D+00	-41.8000D-02	12.6383D-01
14.4000D+00	15.6576D+00	15.2231D+00	14.4000D+00	-12.5760D-01	-82.3117D-02
15.4000D+00	15.7908D+00	15.8888D+00	15.4000D+00	-39.0800D-02	-48.8767D-02

QUADRATIC ERROR OLD MODEL: 4112.7990D-02

QUADRATIC ERROR NEW MODEL: 3036.2336D-02

Table 6.14

G(T) : Govermental Demand In Period T

Open and Closed-loop Versions of the New Structure

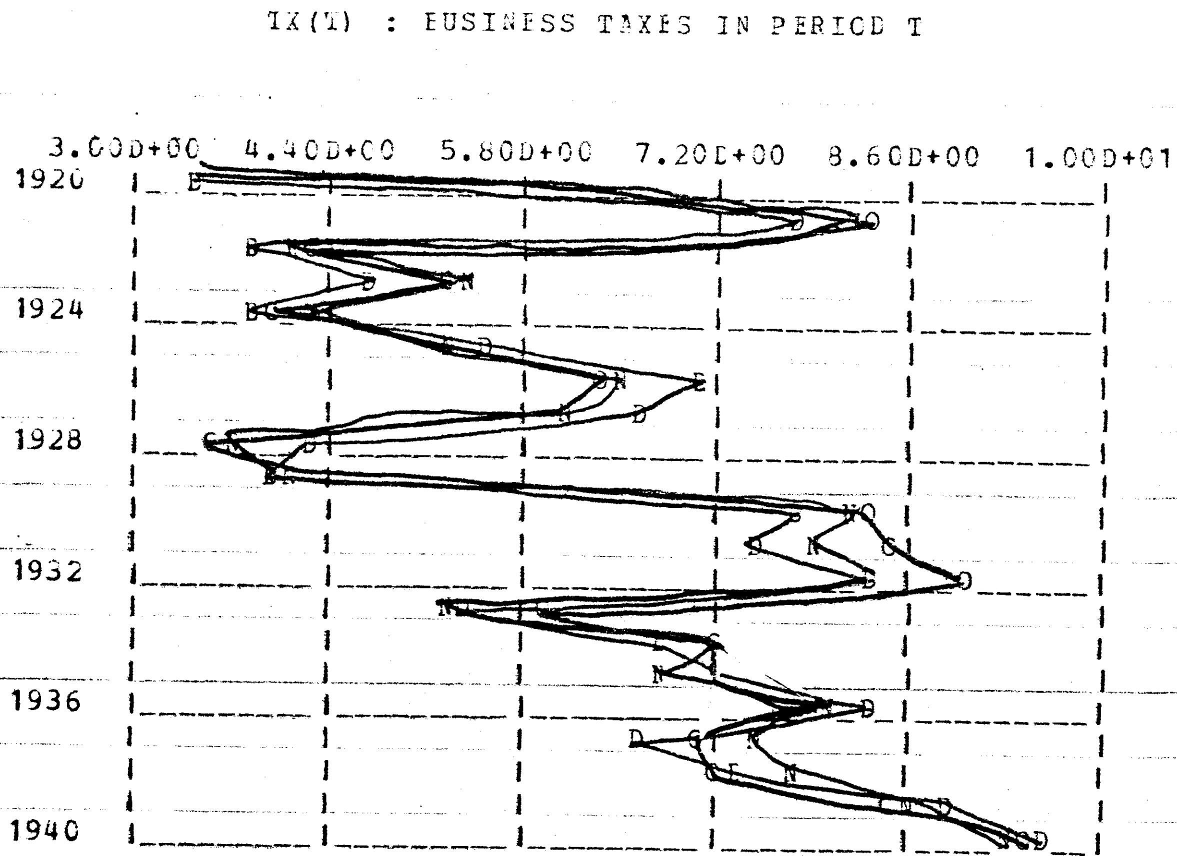


Figure 6.15

Tx(T) : Business Taxes In Period T

Open and Closed-loop Versions of the New Structure

TX(T) : BUSINESS TAXES IN PERIOD T

HIST VALUES	OLD MODEL	NEW MODEL	DESIRED VAL	ERR.OLD MOD	ERR.NEW MOD
34.0000D-01	34.0000D-01	34.0000D-01	34.0000D-01	0.0	0.0
77.0000D-01	82.8580D-01	81.4813D-01	77.0000D-01	-58.5800D-02	-44.8134D-02
39.0000D-01	42.6085D-01	41.2081D-01	39.0000D-01	-36.0850D-02	-22.0811D-02
47.0000D-01	51.9410D-01	54.4595D-01	47.0000D-01	-49.4100D-02	-74.5951D-02
38.0000D-01	39.6137D-01	42.1363D-01	38.0000D-01	-16.1370D-02	-41.3629D-02
55.0000D-01	52.0013D-01	52.6572D-01	55.0000D-01	29.9870D-02	23.4284D-02
70.0000D-01	64.1195D-01	64.3802D-01	70.0000D-01	58.8050D-02	56.1983D-02
67.0000D-01	60.1212D-01	60.8731D-01	67.0000D-01	68.7880D-02	61.2694D-02
42.0000D-01	35.5903D-01	36.6419D-01	42.0000D-01	64.0970D-02	53.5814D-02
40.0000D-01	40.2790D-01	41.5165D-01	40.0000D-01	-27.9000D-03	-15.1652D-02
77.0000D-01	82.6518D-01	81.2381D-01	77.0000D-01	-56.5180D-02	-42.3808D-02
75.0000D-01	83.9284D-01	79.3576D-01	75.0000D-01	-89.2840D-02	-43.5756D-02
83.0000D-01	90.3817D-01	82.9255D-01	83.0000D-01	-73.8170D-02	74.4890D-04
54.0000D-01	59.9679D-01	52.5957D-01	54.0000D-01	-59.6790D-02	14.0428D-02
68.0000D-01	71.7554D-01	67.8790D-01	68.0000D-01	-37.5540D-02	12.0989D-03
72.0000D-01	71.6234D-01	67.9274D-01	72.0000D-01	37.6600D-03	40.7263D-02
83.0000D-01	82.8732D-01	80.2748D-01	83.0000D-01	12.6800D-03	27.2525D-02
67.0000D-01	70.1923D-01	75.4227D-01	67.0000D-01	-31.9230D-02	-84.2270D-02
74.0000D-01	72.6118D-01	77.5581D-01	74.0000D-01	13.8820D-02	-35.5807D-02
89.0000D-01	84.8232D-01	85.4891D-01	89.0000D-01	41.7680D-02	35.1092D-02
96.0000D-01	94.7020D-01	93.5836D-01	96.0000D-01	12.9800D-02	24.1641D-02

QUADRATIC ERROR OLD MODEL: 4536.8118D-03

QUADRATIC ERROR NEW MODEL: 3680.5422D-03

Table 6.15

Tx (T) : Business Taxes In Period T

Open and Closed-loop Versions of the New Structure

6.5 Interpretation Of The Results

In the foregoing sections of this chapter we have presented numerical results concerning the properties of the "new" model when this is constructed by means of an imperfect feedback loop obtained with a highly aggregated model. These results have been presented for two versions of the "new" model: open-loop and closed-loop. In this section we shall interpret the results by comparing them against the results obtained for the "new" model when it was constructed with a full-size optimal controller, i.e., the results presented in Chapter Four.

In Table 6.15 the quadratic errors, for the two versions of the imperfect "new" model, the complete version of the "new" model for the 2SLS structure, and the original 2SLS model, have been tabulated.

From these results we observe that the performance of the closed-loop version of the incomplete "new" model is very similar to the performance of the complete "new" model, specially for the endogenous variables included in the feedback loop (consumption, investment, and national income).

Eventhough, the quadratic errors for the "old" model and the open-loop version of the incomplete "new" model are similar. This does not mean that their behaviors coincide. Observing figures 6.6 to 6.14 we see the ability of the open-loop version to track the turn points of the historical values in a much better fashion than the "old" model. The reason of the big quadratic errors for the open-loop version is the inability of this version to recover from big disturbances present in the system. In this context, we

	OPEN-LOOP INCOMPLETE "NEW" MODEL	CLOSED-LOOP INCOMPLETE "NEW" MODEL	2SLS "NEW" MODEL	2SLS "OLD" MODEL
Consumption	321.774	26.667	21.25	354.29
Investment	152.806	21.452	24.65	164.98
Private Wage Bill	361.381	47.8329	29.21	315.11
National Income	1124.872	54.730	54.54	976.16
Profits	238.035	33.58	13.08	223.72
Capital Stock	857.59	172.334	157.55	729.12
Government Wage Bill	0.0	0.16	0.1702	0.0
Government Expenditure	41.127	30.362	23.41	0.0
Taxes	4.536	3.680	3.155	0.0

TABLE 6.16

QUADRATIC ERRORS FOR DIFFERENT VERSIONS OF THE 2SLS KLEIN'S MODEL I observe that most of the quadratic error, observed in the open-loop version, corresponds to the period after the great depression (1930-1940).

Another important observation is that the results show clearly the importance of the presence of a feedback loop into the model. Even, if this feedback loop is obtained by means of more aggregated models.

Chapter VII

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

7.1 Summary

The thesis was an attempt to introduce feedback control theory ideas that could be used to improve the performance of standard macroeconometric models.

With this purpose, a "new" model was derived by solving the finite horizon optimal control problem and incorporating the control law into the original model so as to obtain a closed-loop structure. A possible justification of this approach in economic terms was presented by means of including the policy makers' behavior into the original model.

Two numerical experiments were implemented to test the sensitivity of the "new" model to different estimation procedures and to study its forecasting properties. A particular macro-econometric model, Klein's Model I, was chosen to implement them.

Attention was also given to the properties of the "new" model when this was obtained by means of a suboptimal control law i.e., the solution of the optimal control problem was obtained by using a more aggregated model rather than the original model.

7.2 Conclusions

The purpose of this section is to attempt to unify the results presented earlier and to comment some areas of possible interest.

The first question to be raised in this thesis concerned the sensibility of present econometric models to estimation procedures and model structures. The issue was discussed in Chapter I, and it was concluded that a possible solution for this problem could be the use of a feedback formulation. To justify for the incorporation of a feedback for mulation into the original model, an economic theory was presented in terms of a possible interpretation of the behavior of policy makers. It was argued that policy makers behave as to minimize certain objective function and that their response is given in a closed-loop fashion, i.e. after observing the levels of selected endogenous variables.

The next issue was concerned with how to present a mathematical formulation that would include all of the previous ideas. This was done in Chapter Two, and as a consequence a "new" econometric model was introduced.

In Chapter Four, the experiment to study the sensitivity of the "new" model to different estimation procedures and model structures, showed that the performance of the "new" model is, in general, not affected by different estimation procedures or model structures, however, small improvements were observed on the performance of "new" models when the statistical contents of the original models were improved.

A possible explanation for these results was given in section five of Chapter Four in terms of the position of the model eigenvalues on the "z" plane. This study showed how the eigenvalues of the "new" model corresponding to the different model structures were confined to small regions on the "z" plane. This was not the case for the eigenvalues of the original model.

In Chapter Five, the experiment to study the forecasting properties of the "new" model, confirmed the insensitivity of the "new" model to different estimation procedures and model structures. It was observed the ability of the "new" model to predict turn points for the values of endogenous variables, and although, the period of time in which the forecasting experiment was run was not the more appropriated one,- Second World War Period,- the "new" model exhibited the ability of recovering rapidly from big disturbances, as World War II, and to start predicting the historical values with acceptable accuracy again.

The experiments of Chapter Six, allowed us to gain some insight with the problems related to the obtention of the new structure by means of a suboptimal control law, and although, the results are not conclusive because the nature of the experiments, the results seem to indicate that similar results, as the ones obtained in previous chapters, can be expected by using new structures obtained with suboptimal control laws.

The conclusion of this research, even though, obtained with a simple macroeconometric model, can be generalized on the premise that the particular model used is a good representation of macroeconomic models. It is an open question as to whether different results may be obtained if one used a much larger or complicated model.

In any case, this study helped to show the importance of a feedback formulation in an econometric context.

We hope, it will contribute to the cross fertilization of ideas between economists and control engineers.

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APPENDIX A

DERIVATION OF SOLUTION FOR THE FINITE HORIZON OPTIMAL LINEAR-QUADRATIC-GAUSSIAN CONTROL PROBLEM

LINEAR-QUADRATIC-GAUSSIAN (LQG) PROBLEM.-

Consider the dynamics of the following "Linear" System:

$$x(t+1) = A\,x(t) + B\,u(t) + D\,v(t) + L\,\xi(t) \qquad (A1.1)$$

$$y(t) = C\,x(t) + N\,u(t) \qquad (A1.2)$$

Where:

$x(t)$: State Variable Vector

$u(t)$: Control Variable Vector (Instruments)

$v(t)$: Exogenous Deterministic Variable Vector

$\xi(t)$: Time-Uncorrelated Disturbance Vector

$y(t)$: Output Variable Vector (Endogenous)

With:

$\theta = E\,\{\xi\,\xi'\}$: Covariance of the disturbance vector

We want to obtain the sequence:

$\{u^*(t) \quad t = 1,2,\ldots.\ N\}$

Such that the "Quadratic" cost:

$$J = E\{([y(N) - y_d(N)]'\,Q(N)\,[y(N) - y_d(N)]) + \sum_{t=0}^{N-1} ([y(t) - y_d(t)]'\,Q(t)\,[y(t) - y_d(t)] + [M(t) - u_d(t)]'\,R(t)[M(t) - u_d(t)])\} \qquad (A1.3)$$

Where:

$\{y_d(t)\}$: Sequence of desired output variables (endogenous)

$\{u_d(t)\}$: Sequence of desired control variables (instruments)

N : Horizon planning time

Would be minimized.

We will use dynamic programming to solve the finite time optimal control problem:

The functional equation for our problem will be given by:

$$V(x,t) = \min_{u(t),\, u(t+1),\ldots u(n-1)} E\{([y(n)-y_d(n)]'[Q(n)[y(n)-y_d(n)])$$
$$+ \sum_{s=t}^{n-1} ([y(s) - y_d(s)]' Q(s) [y(s) - y_d(s)]$$
$$+ [u(s) - u_d(s)]' R(s) [u(s) - u_d(s)])\} \qquad (A1.4)$$

From (A1.4) the functional equation becomes:

$$V(x,t) = \min_{u(t)} E\{[y(t) - y_d(t)]' Q(t)[y(t) - y_d(t)]$$
$$+ [u(t) - u_d(t)]' R(t) [u(t) - u_d(t)]$$
$$+ V(x,t+1)/x\} \qquad (A1.5)$$

or:

$$V(x,t) = \min_{u(t)} ([y(t) - y_d(t)]' Q(t)[y(t) - y_d(t)]$$
$$+[u(t) - u_d(t)]' R(t)[u(t) - u_d(t)]$$
$$+ E\{V(x,t+1)/x\} \qquad (A1.6)$$

for the terminal time t=n the functional equation is given by:

$$V(x,n) = \min_{m(n)} E\{[y(n) - y_d(n)]' Q(n)[y(n) - y_d(n)]/x\} \qquad (A1.7)$$

replacing in (A1.7) the value of y(n) given by (A1.2):

$$V(x,n) = \min_{u(n)} E\{[Cx(n) + Nu(n) - y_d(n)]' Q(n).$$
$$[Cx(n) + Nu(n) - y_d(n)]/x\} \qquad (A1.8)$$

expanding (A1.8):

$$V(x,n) = \min_{u(n)} E\{(x'(n)C'Q(n)Cx(n) - 2\,y_d'(n)\,Q(n)Cx(n)$$

$$+ y_d'(n)\,Q(n)\,y_d(n)$$

$$+ 2\left[x'(n)C'Q(n)N - y_d'(n)Q(n)N\right]u(n)$$

$$+u'(n)N'Q(n)Nu(n))/x(n)\} \qquad (A1.9)$$

solving the minimization problem for (A1.9) we obtain:

$$u^*(n) = -\left[N'Q(n)N\right]^{-1}\left[N'Q(n)\ Cx(n) - N'Q(n)\ y_d(n)\right] \qquad (A1.10)$$

therefore:

$$V(x,n) = x'(n)\left[\,2C'Q(n)\ N\ (N'Q(n)N)^{-1}N'Q(n)\right]y_d(n)$$

$$+ X'(n)\left[\,C'Q(n)C'Q(n)N\left[N'Q(n)N\right]^{-1}\ N'Q(n)C\right]x(n)$$

$$- 2x'(n)\ C'Q(n)\ y_d(n)$$

$$+ y_d'(n)\left[\,Q(n)\ +Q(n)\ N\ \left[N'Q(n)N\right]^{-1}\ N'Q(n)\right]y_d(n)$$

$$(A1.11)$$

rewriting (A1.11)

$$V(x,n) = X'(n)\ P(n)x(n) + X'(n)\ f(n) + g(n) \qquad (A1.12)$$

where:

$$P(n) = C'Q(n)C - C'Q(n)\ N\left[N'Q(n)N\right]^{-1}\ N'Q(n)C \qquad (A1.13)$$

$$f(n) = 2\{C'Q(n)\ N\ \left[N'Q(n)N\right]^{-1}\ N'Q(n) - C'Q(n)\}$$

$$y_d(n) \qquad (A1.14)$$

$$g(n) = y_d'(n)\ \left[Q(n) + Q(n)\ N\ \left[N'Q(n)\ N\right]^{-1}\ N'Q(n)\right]$$

$$y_d(n) \qquad (A1.15)$$

We will now show that the solution of the functional equation (A1.4) with the initial condition given by (A1.12) is given by the following function:

$$V(x,t) = x'(t)\ P(t)\ X(t) + X'(t)\ f(t) + g(t) \qquad (A1.16)$$

for $t = n$ is true by construction (see equation A1.12)

proceeding by induction:

$$V(x,t+1) = X'(t+1)\ P(t+1) + X'f(t+1) + g(t+1) \qquad (A1.17)$$

therefore:

$$\begin{aligned} E\{V(x,t+1)/x\} = & \left[Ax(t) + Bu(t) + Dv(t)\right]'\ P(t+1) \\ & \left[Ax(t) + Bu(t) + Dv(t)\right] \\ & + tr\left[\Xi\ P(t+1)\right] + \left[Ax(t) + Bu(t) + Dv(t)\right]' \\ & \quad f\ (t+1) \\ & + g(t+1) \end{aligned} \qquad (A1.18)$$

replacing (A1.17) and (A1.18) into the functional:

$$\begin{aligned} V(x,t) = \min_{u(t)} & \{\left[y(t) - y_d(t)\right]'\ Q(t)\ \left[y(t) - y_d(t)\right] \\ & + \left[u(t) - u_d(t)\right]'\ R(t)\ \left[u(t) - u_d(t)\right] \\ & + \left[Ax(t) + Bu(t) + Dv(t)\right]'\ P(t+1)\left[Ax(t) + \right. \\ & \quad \left. Bu(t) + Dv(t)\right] \\ & + tr\left[\Xi\ P(t+1)\right] + \left[Ax(t) + Bu(t) + Dv/t\right]' \\ & \quad f(t+1) \\ & + g(t+1)\} \end{aligned} \qquad (A1.19)$$

replacing in (A1.19) the value of $y(t)$:

$$\begin{aligned} V(x,t) = \min_{u(t)} & \{\left[Cx(t) + Nu(t) - y_d(t)\right]'\ Q(t)\ \left[Cx(t) \right. \\ & \left. + Nu(t) - y_d(t)\right] \\ & + \left[u(t) - u_d(t)\right]'\ R(t)\ \left[u(t) - u_d(t)\right] \\ & + \left[Ax(t) + Bu(t) + Dv(t)\right]'\ P(t+1)\left[Ax(t) + \right. \\ & \quad \left. Bu(t) + Dv(t)\right] \end{aligned}$$

$$+ \operatorname{tr}[\Xi\ P(t+1)] + [Ax(t) + Bu(t) + Dv(t)]'\ f(t+1) + g(t+1)\} \tag{A1.20}$$

multiplying out equation (A1.20):

$$\begin{aligned}
V(x,t) = \min_{u(t)} \{ & X'(t)\ C'Q(t)\ X(t) + X'(t)\ C'Q(t)\ Nu(t) - X'(t)\ C'Q(t)\ y_d(t) \\
& + u'(t)\ N'Q(t)\ C\ x(t) + u'(t)\ N'Q(t)\ Nu(t) \\
& - u'(t)\ N'Q(t)\ y_d(t) - y_d'Q(t)\ Cx(t) - y_d'(t)\ Q(t)\ Nu(t) \\
& + y_d'(t)\ Q(t)\ y_d(t) + u'(t)\ R(t)\ u_d(t) \\
& - u_d'(t)\ R(t)\ u(t) + u_d'(t)\ R(t)\ u_d(t) \\
& + X'(t)\ A'P(t+1)\ Ax(t) + X'(t)A'\ P(t+1)\ Bu(t) \\
& + X'(t)\ A'P(t+1)\ Dv(t) + u'(t)\ B'\ P(t+1)\ Ax(t) \\
& + u'(t)\ B'P(t+1)\ Bu(t) + u'(t)\ B'\ P(t+1)\ Dv(t) \\
& + v'(t)\ D'P(t+1)\ Ax(t) + v'(t)\ D'P(t+1)\ Bu(t) \\
& + v'(t)\ D'P(t+1)\ Dv(t) + v'(t)\ D'P(t+1)\ Ax(t) \\
& + v'(t)\ D'P(t+1)\ Bu(t) + v'(t)\ D'P(t+1)\ Dv(t) + \\
& + \operatorname{tr}\ \Xi\ P(t+1) \\
& + x'(t)\ A'f(t+1) + u'(t)\ B'f(t+1) + v'(t)\ D'f(t+1) + g(t+1)\}
\end{aligned} \tag{A1.21}$$

Let us define a new equation for the terms containing $u(t)$ in equation (A1.21)

$$\begin{aligned}
L \stackrel{\Delta}{=}\ & X'C'QNu + u'N'QCX + u'N'QNu - u'N'Qy_d \\
& - y_d'\ QNu + u'Ru - u'Ru_d - u_d'\ Ru
\end{aligned}$$

$$+ X'A'P(t+1)\ Bu + u'B'P(t+1)\ Ax + u'B'P(t+1)\ Bu$$

$$+ u'B'P(t+1)\ Dv + u'B'f(t+1) + v'D'P(t+1)\ Bu \qquad (A1.22)$$

Grouping terms in (A1.22)

$$L = 2u'N'QCx - 2u'N'Qy_d - 2u'Ru_d + u'B'P(t+1)Ax$$

$$+ u'B'P(t+1)\ Ax + 2u'B'P(t+1)Dv + u'B'f(t+1)$$

$$+ u'\left[N'QN + R + B'\ P(t+1)\ B\right] u \qquad (A1.23)$$

and:

$$\frac{\partial L}{\partial L} = 2N'QCx + B'P(t+1)\ Ax + B'P(t+1)\ Ax + 2\left[N'QN+R+B'P(t+1)B\right] u$$

$$- 2N'Qy_d - 2Ru_d + B'P(t+1)Dv + B'f(t+1) \qquad (A1.24)$$

$$\frac{\partial L}{\partial u} = 0 \quad \text{implies}$$

$$u^*(t) = -\left[N'Q(t)N + R + B'P(t+1)B\right]^{-1} \{\left[N'Q(t)C + B'P(t+1)A\right] x(t)$$

$$- N'Q(t)y_d(t) - Ru_d(t) + B'P(t+1)Dv(t) + \tfrac{1}{2}\ B'f(t+1)\} \qquad (A1.25)$$

Rewriting (A1.25)

$$u^*(t) = - G(t)\ x(t) + h(t) \qquad (A1.26)$$

where:

$$G(t) = M(t)\left[N'Q(t)C + B'P(t+1)A\right] \qquad (A1.27)$$

$$M(t) = \left[N'Q(t)N + R(t) + B'P(t+1)B\right]^{-1} \qquad (A1.28)$$

$$h(t) = M(t)\{N'Q(t)y_d(t) + R(t)u_d(t) - B'P(t+1)\ Dv(t)$$

$$- \tfrac{1}{2}\ B'f(t+1)\} \qquad (A1.29)$$

replacing (A1.26) into (A.122)

$$V(x,t) = x'(t)\ C'Q(t)\ x(t) + 2x'(t)\ C'Q(t)\ u^*(t) -$$
$$- 2x'(t)\ C'Q(t)\ y_d(t)$$
$$+ u^{*\prime}(t)\ N'Q(t)\ Nu^*(t) - 2y_d'(t)\ Q(t)\ Nu^*(t) +$$
$$+ y_d'(t)\ Q(t)\ y_d(t)$$
$$+ u^*(t)\ R(t)\ u^*(t) - 2u_d'(t)\ R(t)\ u^*(t) +$$
$$+ u_d'(t)\ R(t)\ u_d(t)$$
$$+ x'(t)\ A'P(t+1)\ Ax(t) + 2x'(t)\ A'P(t+1)\ Bu^*(t) +$$
$$+ 2x'(t)\ A'P(t+1)\ Dv(t)$$
$$+ u^{*\prime}(t)\ B'P(t+1)\ Bu^*(t) + 2v'(t)\ D'P(t+1)\ Bu^*(t) +$$
$$+ v'(t)\ D'P(t+1)\ Dv(t)$$
$$+ \mathrm{tr}\ \Xi\ P(t+1) + x'(t)\ A'f(t+1) + u^{*\prime}(t)\ B'f(t+1) + g(t+1)$$
$$+ v'(t)\ D'f(t+1) \qquad \text{(A1.30)}$$

then:

$$V(x,t) = x'(t)\ C'Q(t)\ Cx(t) + 2x'(t)\ C'Q(t)\ N\ \{-G(t)x(t)+h(t)\}$$
$$- 2x'(t)\ C'Q(t)\ y_d(t) + \{-G(t)x(t)+h(t)\}'\ N'Q(t)N$$
$$\{-G(t)x(t)+h(t)\}$$
$$- 2y_d'(t)\ Q(t)\ N\{-G(t)x(t) + h(t)\} + y_d'(t)\ Q(t)\ y_d(t)$$
$$+\{-G(t)x(t) + h(t)\}'\ \left[R(t) + B'P(t+1)\ B\right]\ \{-G(t)x(t) +$$
$$+ h(t)\}$$
$$- 2u_d'(t)R(t)\ \{-G(t)x(t) + h(t)\} + u_d'(t)\ R(t)\ u_d(t)$$
$$+ x'(t)\ A'P(t+1)\ Ax(t) + 2x'(t)\ A'P(t+1)\ B\ \{-G(t)x(t) +$$
$$h(t)\}$$

$$+ 2x'A'P(t+1)\ Dv(t) + 2v'(t)\ D'P(t+1)\ B\{-G(t)x(t) + h(t)\}$$
$$+ v'(t)D'P(t+1)Dv(t) + tr\Xi P(t+1) + x'(t)A'f(t+1)$$
$$+ \{-G(t)x(t) + h(t)\}'\ B'f(t+1) + v'(t)D'f(t+1) + g(t+1) \qquad (A1.31)$$

Grouping terms in (A1.31):

$$V(x,t) = x'(t)\{C'Q(t)C + A'P(t+1)A - 2G'(t)\ M^{-1}(t)\ G(t) + G'(t)\ M^{-1}(t)\ G(t)\}\ x(t)$$
$$+ x'(t)\ \{-2G'(t)\ M^{-1}(t)\ h(t) + 2G'(t)\left[N'Q(t)\ y_d(t) + R(t)\ u_d(t) - B'P(t+1)\ Dv(t)\right.$$
$$\left. - \tfrac{1}{2}\ B'f(t+1)\right] + 2h'(t)\ M^{-1}(t)\ G(t) - 2C'Q(t)\ y_d(t) + 2A'P(t+1)\ Dv(t) + A'f(t+1)\} + h'(t)\ M^{-1}(t)\ h(t)$$
$$- 2h'(t)\ \{N'Q(t)y_d(t) + Ru_d(t) - B'P(t+1)\ Dv(t) - \tfrac{1}{2}B'f(t+1)\}$$
$$+ y_d'(t)\ Q(t)\ y_d(t) + u_d'(t)\ R(t)\ u_d(t) + v'(t)\ D'P(t+1)\ Dv(t) + v'(t)\ D'f(t+1) + tr\ \Xi\ P(t+1) + g\ (t+1) \qquad (A1.34)$$

Rewriting Equation (A1.35)

$$V(x,t) = x'(t)\ \{C'Q(t)\ C + A'P(t+1)\ A - G'(t)\ M^{-1}(t)\ G(t)\}x(t)$$
$$+ x'(t)\ \{2G'(t)\ M^{-1}(t)\ h(t) - 2C'Q(t)\ y_d(t) + 2A'P(t+1)\ Dv(t) + A'f(t+1)\} + \{y_d'(t)Q(t)y_d(t) - h'(t)M^{-1}(t)h(t) + u_d'(t)R(t)u_d(t) + v'(t)D'P(t+1)$$
$$Dv(t) + v'(t)D'f(t+1) + tr\ \Xi\ P(t+1) + g(t+1)\}$$
$$(A1.36)$$

or:

$$V(x,t) = x'(t)\ P(t)\ x(t) + x'f(t) + g(t) \qquad \text{(A1.37)}$$

and we have shown that the solution of the functional equation has the form given by equation (A1.37) where:

$$P(t) = C'Q(t)C + A'P(t+1)A - G'(t)M^{-1}(t)\ G(t) \qquad \text{(A1.38)}$$

with the initial condition given by:

$$P(n) = C'Q(n) - C'Q(n)\ N\left[N'Q(n)N\right]^{-1}\left[N'Q(n)C\right] \qquad \text{(A1.39)}$$

$$f(t) = 2G'(t)\ M^{-1}(t)\ h(t) - 2C'Q(t)\ y_d(t) + 2A'P(t+1)\ Dv(t) + A'f(t+1) \qquad \text{(A1.40)}$$

with the initial condition given by:

$$f(n) = 2C'Q(n)\ N\left[N'Q(n)N\right]^{-1} N'Q(n)y_d(n) - 2C'Q(n)\ y_d(n) \qquad \text{(A1.41)}$$

and:

$$g(t) = -\ h'(t)\ M^{-1}(t)\ h(t) + y_d'(t)\ Q(t)\ y_d(t) + u_d'(t)\ R(t)\ u_d(t) + v'(t)\ D'P(t+1)\ Dv(t) + v'(t)\ D'f(t+1) + \operatorname{tr} \Xi\ P\ (t+1) + g\ (t+1) \qquad \text{(A1.42)}$$

with the initial condition given by:

$$g(n) = y_d'(n)\ \{Q(n) + Q(n)\ N\left[N'Q(n)\ N\right]^{-1} N'Q(n)\}\ y_d(n) \qquad \text{(A1.43)}$$

<u>Note</u>: $\Xi = L'\ \Theta\ L$

$\Theta = E\ \{\xi\xi'\}$: covariance of the disturbance vector

Summary of Equations for the Finite Horizon Optimal Control Problem

o Optimal Control Law:

$$u^*(t) = -G(t)x(t) + h(t) \qquad t = 0,1,\ldots.N-1$$

where

G(t): Deterministic Control Gain Matrix

h(t): Deterministic Control Correction Vector

$$G(t) = M(t)\left[N'Q(t)C + B'P(t+1)A\right]$$

$$M(t) = \left[N'Q(t)\,N + R(t) + B'P(t+1)B\right]^{-1}$$

$$P(t) = A'P(t+1)A + C'Q(t)C - G'(t)\,M^{-1}(t)\,G(t)$$

Boundary Condition:

$$P(N) = C'Q(N)C - C'Q(N)\,N\left[N'Q(N)N\right]^{-1}NQ(N)C$$

$$h(t) = M(t)\,\{N'Q(t)\,y_d(t) + Ru_d(t) - B'P(t+1)\,Dv(t) - \tfrac{1}{2}\,B'f(t+1)\}$$

$$f(t) = 2G'(t)M^{-1}(t)h(t) - 2C'Q(t)\,y_d(t) + 2A'P(t+1)\,Dv(t) + A'f(t+1)$$

Boundary Condition:

$$f(N) = 2C'Q(N)N\left[N'Q(N)N\right]^{-1}N'Q(N)\,y_d(N) - 2C'Q(N)\,y_d(N)$$

o Optimal "Cost To Go"

$$V(x,t) = x'(t)P(t)x(t) + x'(t)f(t) + g(t)$$

where:

$$g(t) = -h'(t)M^{-1}(t)h(t) + y_d'(t)Q(t)y_d(t) + u_d'(t)\,R(t)\,u_d(t)$$

$$+ v'(t)D'P(t+1)Dv(t) + v'(t)D'f(t+1) + g(t+1)$$

$$+ \mathrm{tr}\ \Xi\ P(t+1)$$

Boundary Condition:

$$g(N) = - h'(n)\ N'Q(n)\ Nh(n) + y_d'(n)\ Q(n)\ y_d(n)$$

where:

$$\Xi = L'\ \Theta\ L$$

$$\Theta = E\ \{\xi\xi'\}$$