AN EFFICIENT SOFTWARE METHOD FOR ECONOMETRIC SIMULATION

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PREFACE

If a person has knowledge of linear algebra, introductory mathematical statistics, and introductory economic theory, he can rather easily understand most econometric theories. Although it may be easy to understand econometric theories, it is quite difficult to establish a new theory or method for estimation or simulation. Is it easy to apply econometric theories to a problem? Is it possible to estimate the best equation for each left-hand side endogenous variable in a simultaneous equations system and find the best simultaneous equations model in only a few runs of the computer? Usually, one has to run the computer many times before finding the best equations for all Ieft-hand side endogenous variables and the best simultaneous equations model among many model candidates for a simultaneous equations system. If a system is large, it is necessary to spend tremendous amounts of time, labour, and resources such as output paper and electricity, for applied econometric research. Hence, for such research, it is of great importance to develop a time-, labour-, and resource-saving as well as cost-reducing software method. Even in other scientific fields, such a software method should be considered.

One of the reasons why one has to spend much time, labor, and resources for applied econometric research is that economic theory cannot always tell exactly which explanatory variables are crucially important for each left-hand side endogenous variables, what time lag structure is suitable for the explanatory variables, what kind of functional form must be assumed by an equation to be estimated, and so on. The second reason is that an explanatory variable may have strong multicollinearity relationship with another exlanatory variable, the assumption of normal distribution does not hold, and so on. The last reason seems trivial but disapponits the researcher often. It is that a human being makes many mistakes in entering the variable notation of the left-hand side endogenous variables together with their predetermined variables and right-hand side endogenous variables into the computer. How many mistakes are made when 200 equations are entered and estimated? Quite a few are possible. Consequently, applied econometric research is not as easy as a theorist thinks, especially for a large-scale system.

A contribution could be made to applied econometric research through the creation of efficient software methods for estimation and simulation. It appears that although software or programming for econometrics is definitely needed for applied econometric research, its efficiency has not been seriously considered by economists and econometricians. Nowadays, labor and resources are not cheap and in the near future they will be quite expensive. Therefore, time-, labour-, and resource-saving as well as cost-reducing software methods for estimation and simulation are needed. To cope with this requirement, I have tried to develop an efficient software package for economics. The result is the Econometric Program Package OEPP. It has been designed to shorten a research period, improve the quality of research, save labor and resources, and eventually reduce research expenditures. Of course, as long as good ideas are developed, I want to improve OEPP.

Computer work for econometic simulation is time-consuming. The method to automatically generate simultaneous equations model candidates in the permutational-equation-selection method and find the best simultaneous equations model among them will be described in this article.

I am very grateful to the International Institute for Applied Systems Analysis for giving me the opportunity to issue this article.

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INTRODUCTION

It is often heard that econometric models do not predict well. One of the reasons is due to aggregation. To avoid this defect, applied econometricians have started making large-scale simultaneous equations models in which some degree of disaggregation is taken into consideration. The rapid technical progress in the field of electronic computers, especially from the viewpoint of the hardware, has made it possible. Then, applied econometricians have to spend more and more time on finding the best equations for all left-hand side endogenous variables in their large-scale simultaneous equations models. The labor and resources utilized for the computer work concerned with the estimation and econometric simulation become larger and larger. More and more research funds are required. To cope with the inefficiency and difficulty concerned with estimation, the author proposed a time-, labor-, and resource-saving as well as cost-reducing software method for the estimation of a large-scale simultaneous equations model [9] and made the Econometric Program Package OEPP* which can handle this method [8]. Accordingly, it has become much quicker, easier, and cheaper than before to find the best equation for each left-hand side endogenous variable under the condition that a functional form of an equation and an estimation method are specified by a researcher.

*OEPP stands for Onishi Econometric Program Package designed for data management, input-output analysis, econometric estimation, and econometric simulation, developed by the author, at the Institute of Socio-Economic Planning, the University of Tsukuba, Japan, 1979. It consists of about 15,000 steps in Fortran.

The inefficiency and difficulty concerned with econometric simulation still remains. That is how to find the grand best equation among many kinds of best equations for a left-hand side endogenous variable. This difficulty is related to model evaluation.

The purpose of this article is to show a software method which helps a researcher to find the practically best simultaneous equations model among many possible simultaneous equations model candidates. This method has been already adopted in OEPP and been proven to be quite effective in shortening a research period, saving labor and resources, and improving the quality of econometric research.

INVERSE TRANSFORMATIONS, LEFT-HAND SIDE ORIGINAL AND TRANSFORMED ENDOGENOUS VARIABLES

Before describing the meaning of inverse transformation as used in this article and in OEPP, we would like to introduce original and transformed variables. An original variable implies here a variable whose data are not generated by variable transformations but loaded directly by a researcher. On the other hand, a transformed variable implies a variable whose data are not loaded but generated through appropriate variable transformations which a package can allow.

Let us give a few examples. Suppose that variables A and BB have their own data loaded and variable EE does not have its own data loaded but the data of variable EE can be generated by the following variable transformation:*

EE=A/BB . (1)

Then, variables A and BB are called original variables, while variable EE is called a transformed variable. If variable A is a left-hand side endogenous variable, it is here called a left-hand side original endogenous variable. On the other hand, if variable EE is a left-hand side endogenous variable, it is here called a left-hand side transformed endogenous variable. In some situations, it happens that its real purpose is to derive the estimated values of original variable A in (1), although variable EE is estimated as a left-hand side transformed endogenous variable. In this case, original variable A appearing in the variable transformation expression (1) is called the left-hand side original endogenous variable corresponding to left-hand side transformed endogenous variable EE. Of course, it is possible that original variable BB instead of original variable A in (1) is a left-hand side original endogenous variable

*In OEPP, 32 kinds of variable transformations are available. A variable transformation must be expressed as a lump such as (1) but not as EE =A/B, EE= A/B, EE = A/B, EE=A / B, and so on. The expression can not be separated with a space(s). Refer to the next footnote.

corresponding to left-hand side transformed endogenous variable EE. Therefore, some rule or signal is needed to notify the computer of what is the left-hand side original endogenous variable corresponding to a left-hand side transformed endogenous variable.*

The term inverse transformation is here used in a different way from the meaning of inverse transformation in mathematics. It implies obtaining the estimated (or ex post forecasted or ex ante forecasted) values of the left-hand side original endogenous variable (or the original explained variable) from the estimated (or ex post forecasted or ex ante forecasted) values of a left-hand side transformed endogenous variable (or a transformed explained variable) and the data of exogenous or predetermined endogenous variabels used for the variable transformations, if any.

For instance, variable EE is estimated with OLS by a constant term and variables CCC, D(-2), and FF. Let us use functional style F(...) and denote a constant term by $C, so that we can write

EE=F($C,CCC,D(-2),FF) , (2)

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*In OEPP, complicated variable transformations are made step by step at present in order to allow both transformations and inverse transformations for time series, cross-sectional, and pooling data. The first original variable in the first step of variable transformation is always regarded as the left-hand side original endogenous variable (or the original explained variable). For instance, if variable LABB is generated by LOG(A/BB), the first step of variable transformation takes the expression "$1=A/BB" and the second or last step takes the expression "LABB=LOG($1)#", where "$1" is the variable notation of a variable temporarily generated and "#" tells the computer the last step of variable transformations and a user can put in place of "$1" any variable notation which is not used as the variable notation of the original and transformed variables. These two steps generate the data of variable LABB based on time series, cross-sectional, or pooling data. If variable LABB is a left-hand side transformed endogenous variable, variable A becomes the left-hand side original endogenous variable. Thus, the estimated values of left-hand side original endogenous variable A are automatically obtained and compared with the corresponding data (or observations). If variable BB is regarded as the left-hand side original endogenous variable, the following three steps are required: "$1=1/BB" , "$2=$1*A" , and "LABB=LOG($2)#".

which is loaded.* Then, the following equation is obtained:

$$EE=a_0+a_1CCC+a_2D(-2)+a_3FF \tag{3}$$

which is equivalent to

$$A/BB=a_0+a_1CCC+a_2D(-2)+a_3FF \tag{4}$$

where a_0, a_1, a_2, and a_3 are estimated coefficients. If a researcher wants to have the estimated values of variable A through (4), the following modification is needed:

$$A=(a_0+a_1CCC+A_2D(-2)+a_3FF)*BB \quad . \tag{5}$$

Of course, (5) implies: (a) for time series data,

$$A(t)=(a_0+a_1CCC(t)+a_2D(t-2)+a_3FF(t))*BB(t) \qquad \text{for all } t \quad , \tag{6}$$

and (b) for pooling data

$$A_i(t)=(a_0+a_1CCC_i(t)+a_2D_i(t-2)+a_3FF_i(t))*BB_i(t) \qquad \text{for all } t \text{ and } i \quad , \tag{7}$$

where t and i stand for the t-th observation time and the i-th area (or region or country), respectively.

In this case, variable EE is called a left-hand side transformed endogenous variable, while variable A is called the left-hand side original endogenous variable corresponding to left-hand side transformed endogenous variable EE.

Let us give another example. Variable LGG is defined by the following variable transformation:

$$LGG=LOG(GG) \tag{8}$$

where LOG implies a natural logarithm. If variable LGG is a

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*(2) is an equation-loading format in OEPP. Variable D(-2) implies variable D with time lag number 2.

left-hand side transformed endogenous variable, variable GG becomes the left-hand side original endogenous variable corresponding to left-hand side transformed endogenous variable LGG. Since this variable transformation is made by only one variable, GG, it is clear that variable GG becomes the left-hand side original endogenous variable, if variable LGG is estimated.

The function of making automatically inverse transformations from all left-hand side transformed endogenous variables to the corresponding left-hand side original endogenous variables is quite useful (a) to make simulation tests immediately after the estimation of a simultaneous equations system and (b) to automatically and continuously make various kinds of simulations for all possible simultaneous equations model candidates.

TRIAL EQUATIONS AND TRIAL SIMULTANEOUS EQUATIONS MODELS

If a functional form of an equation, an estimation method, and a type of variable transformation for a left-hand side transformed endogenous variable related to a left-hand side original endogenous variable at hand, if necessary, are specified, then we could find the best equation with repect to the left-hand side original endogenous variable. This implies that we can have many kinds of equations related to a left-hand side original endogenous variable each of which is the best under the respective condition. For instance, nominal wage rate is treated as a left-hand side original endogenous variable and estimated in the following three ways with OLS: (a) nominal wage rate is estimated in a linear form, (b) logarithm of nominal wage rate is estimated in a loglinear form, and (c) real wage rate, i.e., nominal wage rate deflated by price index is estimated in a linear form where the price index is exogenous or predetermined.

Usually, a researcher tries to find the grand best equation for a left-hand side original endogenous variable among these equations without referring to model evaluation. The equations related to a left-hand side original endogenous variable, each of which is the best under the respective condition, can be regarded as equation candidates for the left-hand side original endogenous variable and are here called trial equations concerned with the left-hand side original endogenous variable.

Suppose that a simultaneous equations system consists of K equations and identities and the k-th left-hand side original endogenous variable which corresponds to the k-th equation or identity in the system possesses K_k kinds of trial equations (or equation candidates), where $1 \leq k \leq K$ and $K_k \geq 1$ for all k and $K_k = 1$ if the k-th left-hand side original endogenous variable is determined by an identity. By selecting, in the permutational manner, a trial equation from a set of the trial equations related to each of K left-hand side original endogenous variables, we can have $\prod_{k=1}^{K} K_k$ sets of simultaneous equations models each of which consists of K trial equations and identities.* These simultaneous equations models are here called <u>trial simultaneous equations models</u>. The components of trial equations in each trial simultaneous equations model are listed below, where the j-th trial equation related to the k-th left-hand side original endogenous variable is expressed by "k-j".

THE COMPOSITION OF TRIAL EQUATIONS (AND IDENTITIES) IN ALL POSSIBLE TRIAL SIMULTANEOUS EQUATIONS MODELS GENERATED BY THE PERMUTATIONAL-TRIAL-EQUATION-SELECTION METHOD

1st Trial Sim.Eq.Mo.	2nd Trial Sim.Eq.Mo.		K_1-th Trial Sim.Eq.Mo.
1 - 1	1 - 2	.	1 - K_1
2 - 1	2 - 1	.	2 - 1
3 - 1	3 - 1	.	3 - 1
.	.	.	.
.	.	.	.
.	.	.	.
K - 1	K - 1	.	K - 1

(K_1+1)-th Trial Sim.Eq.Mo.	(K_1+2)-th Trial Sim.Eq.Mo.		$2K_1$-th Trial Sim.Eq.Mo.
1 - 1	1 - 2	.	1 - K_1
2 - 2	2 - 2	.	2 - 2
3 - 1	3 - 1	.	3 - 1
.	.	.	.
.	.	.	.
.	.	.	.
K - 1	K - 1	.	K - 1

. . . .

. . . .

*OEPP is designed to be able to make various kinds of basic and sophisticated simulations for about 10 million trial simultaneous equations models each of which consists of at most 9,999 (trial) equations and identities, if the parameters representing the number of left-hand side original endogenous variables and the maximum number of trial equations related to one left-hand side original endogenous variable are set at 9,999 and 999 respectively.

$(K_1 . K_2 - K_1 + 1)$-th Tr.Sim.Eq.Mo.	$(K_1 . K_2 - K_1 + 2)$-th Tr. Sim.Eq.Mo.		$K_1 . K_2$-th Tr.Sim.Eq.Mo.
1 - 1	1 - 2	.	1 - K_1
2 - K_2	2 - K_2	.	2 - K_2
3 - 1	3 - 1	.	3 - 1
.	.	.	.
.	.	.	.
.	.	.	.
K - 1	K - 1	.	K - 1

. . . .

. . . .

$(\Pi K_k - K_1 + 1)$-th Tr.Sim.Eq.Mo.	$(\Pi K_k - K_1 + 2)$-th Tr.Sim.Eq.Mo.		(ΠK_k)-th Tr.Sim.Eq.Mo.
1 - 1	1 - 2	.	1 - K_1
2 - K_2	2 - K_2	.	2 - K_2
3 - K_3	3 - K_3	.	3 - K_3
.	.	.	.
.	.	.	.
.	.	.	.
K - K_K	K - K_K	.	K - K_K

where k-j implies the j-th trial equation (or equation candidate) related to the k-th left-hand side original endogenous variable in the simultaneous equations system, and there are K_k trial equations related to the k-th left-hand side original endogenous variable, where $K_k \geqq 1$ for $1 \leqq k \leqq K$ and $K_k = 1$ if the k-th left-hand side original endogenous variable is determined by an identity.

Among $\prod\limits_k K_k$ sets of trial simultaneous equations models, we would like to find the best one through the final test. If we can find the best trial simultaneous equations model, we can apply various kinds of sophisticated simulation tests to the best model. The automatic derivation of all trial simultaneous equations models and the continuous application of the final test to each of all the models help to reduce a research period, save labor and resources, and at the same time, improve the quality of research.

EXAMPLE

Suppose that a simultaneous equations system consists of five original endogenous variables and the first four original endogenous variables are determined by their respective behavioral equations but the last original endogenous variable is determined by an identity. Furthermore, the first original endogenous variable has only one trial equation, the second original endogenous variable has two trial equations, the third original endogenous variable has only one trial equation, and the fourth original endogenous variable has three trial equations, where each trial equation is the best in each specified condition. It is recognized that $K_1=1$, $K_2=2$, $K_3=1$, $K_4=3$, and $K_5=1$. Then, if we denote the j-th trial equation of the k-th left-hand side original endogenous variable by k-j, we have 1-1; 2-1, 2-2; 3-1; 4-1, 4-2, 4-3; 5-1. By selecting, in the permutational manner, a trial equation for each left-hand side original endogenous variable, we can derive the following six trial simultaneous equations models:

1st Trial Sim.Eq.Mo.	2nd Trial Sim.Eq.Mo.	3rd Trial Sim.Eq.Mo.
1 - 1	1 - 1	1 - 1
2 - 1	2 - 2	2 - 1
3 - 1	3 - 1	3 - 1
4 - 1	4 - 1	4 - 2
5 - 1	5 - 1	5 - 1

4th Trial Sim.Eq.Mo.	5th Trial Sim.Eq.Mo.	6th Trial Sim.Eq.Mo.
1 - 1	1 - 1	1 - 1
2 - 2	2 - 1	2 - 2
3 - 1	3 - 1	3 - 1
4 - 2	4 - 3	4 - 3
5 - 1	5 - 1	5 - 1

Each of the six trial simultaneous equations models is automatically and continuously put on total test, final test, final test with ex post forecasting, final test with ex ante forecasting, final test with ex post and ex ante forecasting, total test and, at the same time, final test, total test and final test with ex post forecasting, total test and final test with ex ante forecasting, or total test and final test with ex post and ex ante forecasting, depending on the researcher's purpose and the order he makes. The left-hand side endogenous variable of trial equation k-j can be some transformed variable of the k-th left-hand side original endogeous variable.

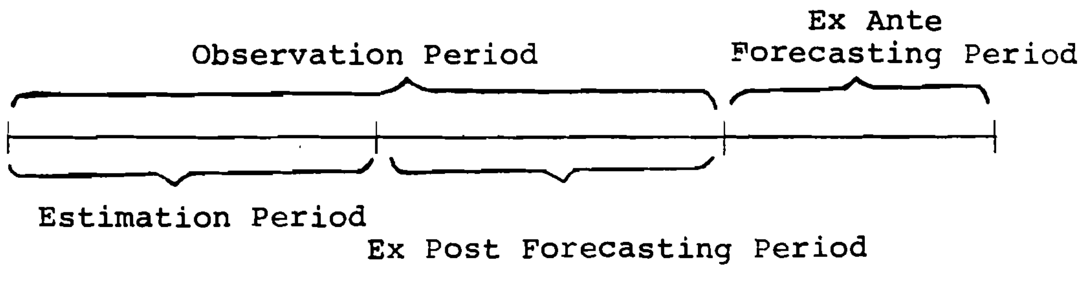
Instead of entering each of the above six trial simultaneous equations models into the computer and checking the simulation performances, (a) to add the information about model evaluation criteria to the file used for estimation and use that file or (b) to enter all trial equations in order and criterion values for model evaluation shortens a research period, saves labor and resources, and reduces research expenditures.

EX POST FORECASTING, EX ANTE FORECASTING, AND BASIC SIMULATIONS

The definitions of total test and final test are seen in many standard econometrics books. It is not necessary to explain total and final test here. However, the term ex post forecasting is often used with different meanings, so that to avoid any ambiguity, it is better to define ex post forecasting.

First of all, an observation period is defined as a time period during which there exist the observations of all endogenous and exogenous variables in a simultaneous equations system. Furthermore, an ex ante forecasting period is defined as a time period during which only the observations (or values predicted outside the model) of all exogenous variables are available but those of endogenous variables are unavailable and must be determined in the model. It is usual to use the data or observations of the entire observation period for estimation of all trial equations. However, it is possible to use the data covering part of an observation period for the estimation and regard the remaining observation period as a type of ex ante forecasting period. This type of ex ante forecasting period is here called an ex post forecasting period.

Observation Period, Estimation Period, Ex Post Forecasting Period, and Ex Ante Forecasting Period



We would like to call the final test during an ex post forecasting period ex post forecasting, and the final test during an ex ante forecasting period ex ante forecasting. Consequently, it is possible to compare the forecasted values with the observations of all the endogenous variables during the ex post forecasting period but it is impossible to do so during the ex ante forecasting period.

The following basic simulations are available to each of all trial simultaneous equations models:

Basic Simulations Available In OEPP

(a) Total Test

(b) Final Test

(c) Final Test with Ex Post Forecasting

(d) Final Test with Ex Ante Forecasting

(e) Final Test with Ex Post and Ex Ante Forecasting

(f) Total Test and Final Test at the Same Time

(g) Total Test and Final Test with Ex Post Forecasting at the Same Time

(h) Total Test and Final Test with Ex Ante Forecasting at the Same Time

(i) Total Test and Final Test with Ex Post and Ex Ante Forecasting at the Same Time

CHOICE OF THE BEST TRIAL SIMULTANEOUS EQUATIONS MODEL

Since some left-hand side original endogenous variables have more than one trial equation, each of which is the best equation in the respective condition, it would be better to let the computer find the best trial simultaneous equations model of all, derivable by selecting, in the permutational manner, a trial equation from those related to a left-hand side original endogenous variable. What is the best trial simultaneous equations model? What criteria are needed to find it? So far, a complete set of criteria for model evaluation has not been developed. However, several model evaluation criteria which are independent of each other and equally important have been proposed [1]. Hence, we need a grand model evaluation function which is a function of criterion variables and can provide a scalar value for comparison when evaluation values for the criterion variables are given. Unfortunatley, we do not know whether or not such a function exists and which functional form it assumes, even if it exists. And also we do not know whether or not there is a ranking in the proposed model evaluation criteria.

Therefore, OEPP makes some plausible compromise not from the theoretical point of view but from the practical point of view. The compromise is reflected on the definition of the best trial simultaneous equations model. Let us introduce the model evaluation criteria adopted in OEPP and then define the best trial simultaneous equations model.

The following criteria can be applied which are given in order below:

(a) Gauss-Seidel Method Convergence Criterion

(b) Root-Mean-Square Percentage Error Criterion

(c) Residual Percentage or Relative Error Criterion

(d) Turning Point Error Percentage Criterion

(e-1) Fixed Theil's Inequality Coefficient Criterion

(e-2) Partially Upgrading Theil's Inequality Coefficient Criterion

(e-3) Globally Upgrading Theil's Inequality Coefficient Criterion

where (a) is always required to be applied but the remaining criteria are optional and (e-1) to (e-3) are explained later.

Now we are in a position to state the model evaluation procedure adopted in OEPP. We would like to define the <u>practically best</u> trial simultaneous equations model as follows:

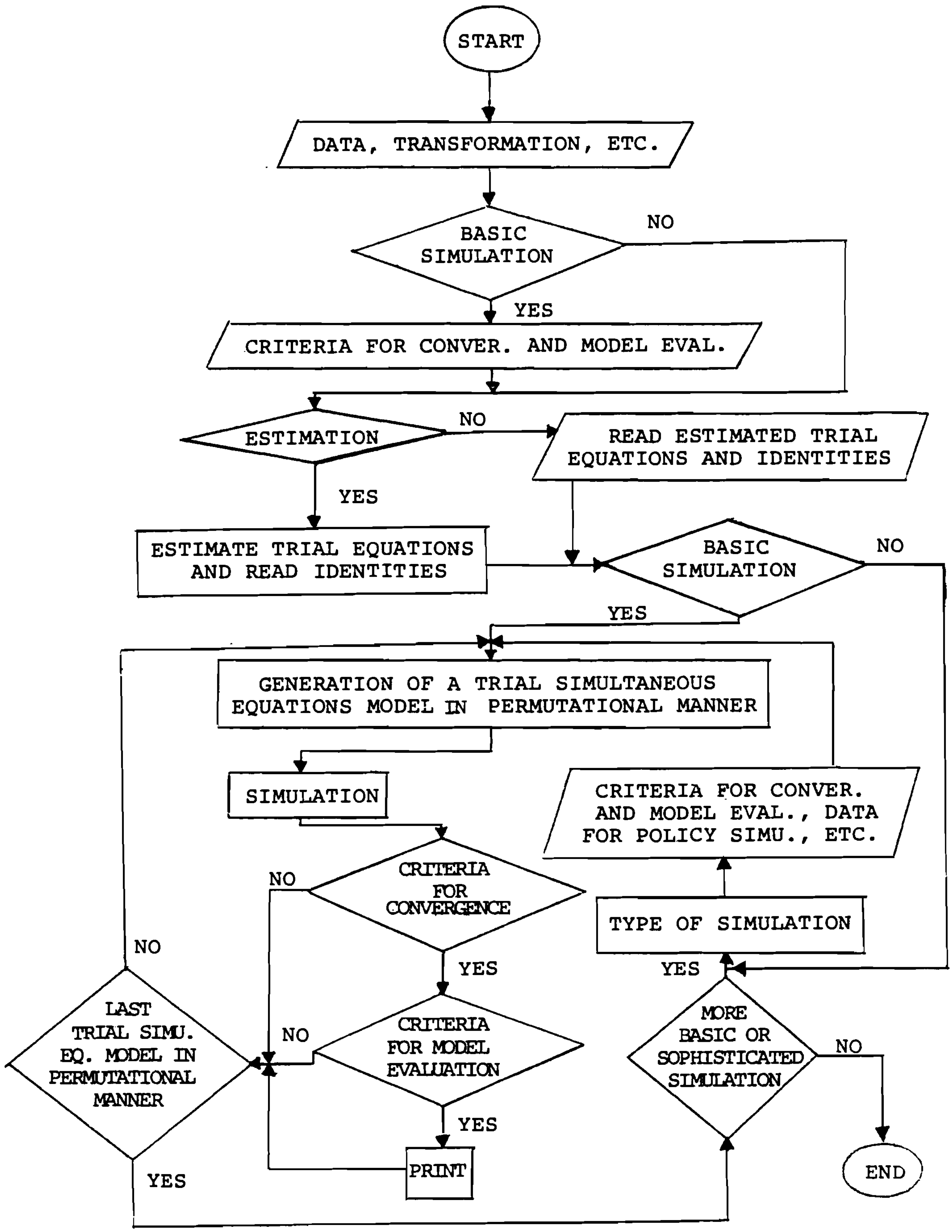
in case (A) where a researcher does not have any criterion in addition to the model evaluation criteria (a) to (e-2) mentioned above,

a trial simultaneous equations model which satisfies criteria (a) and (e-3) and all of the criteria selected from (b), (c), and (d) by him;

in case (B) where a researcher has his own criterion (or criteria) in addition to the model evaluation criteria (a) to (e-2) mentioned above,

a trial simultaneous equations model which satisfies criterion (a) and all of the criteria selected from (b), (c), (d), (e-1), and (e-2) by him and further satisfies his own criterion (or criteria).

FIGURE 1. FLOW CHART OF PERMUTATIONAL-TRIAL-EQUATION-SELECTION METHOD FOR BASIC AND/OR SOPHISTICATED SIMULATION



Needless to say, OEPP cannot apply a researcher's own criterion (or criteria) but can help the researcher to find the best trial simultaneous equations model by reducing the number of best trial simultaneous equations model candidates. The criterion values for (a) to (e-3) are also specified by the researcher. The Gauss-Seidel method convergence criterion is applied to the process in which the equilibrium values of all left-hand side original endogenous variables are searched, while the root-mean-square percentage error criterion, residual percentage criterion, turning point error percentage criterion, and Theil's inequality coefficient criterion are applied to the equilibrium values of all left-hand side original endogenous variables in a trial simultaneous equations model.

One must keep in mind that the best trial simultaneous equations model does not necessarily mean the theoretically best model but the practically best in the condition that case (A) or case (B) mentioned above is accepted as a suitable model evaluation procedure. From here on, we would like to refer only to case (A).

The same file used for estimation of all trial equations can be used for a basic simulation with two additional cards or lines which give the information about a code number of basic simulation, simulation period, criterion values, and a code number for printing tables and/or graphs for the simulation performance and observations. It is possible to make various simulations for all trial simultaneous equations models (a) immediately after estimation and (b) without estimation if the coefficients of all trial equations are stored in a file, tape, or as a set of cards. Needless to say, the coefficients of all trial equations can be stored in a file specified by a researcher, when estimation is made. Therefore, a researcher does not need to enter all estimated trial equations into the computer.

GAUSS-SEIDEL METHOD CONVERGENCE CRITERION

The Gauss-Seidel method is utilized in OEPP to find the equilibrium values of all original endogenous variables in a trial simultaneous equations model. Accordingly, nonlinear trial equations can be handled.

We regard the following case as a convergence case: the absolute value of the relative difference defined in (9) between the j-th and (j+1)-th iteration step is equal to or less than a (Gauss-Seidel method) convergence criterion value, denoted by $\hat{c}$, specified by the researcher with respect to all areas, observation times and original endogenous variables if j is less than the maximum iteration number allowed by him.

$$\left| \left(EY_{ik}^{j}(t) - EY_{ik}^{j+1}(t)\right) / EY_{ik}^{j}(t) \right| \leq \hat{c}$$

$$\text{for } 1 \leq i \leq I \;, \quad 1 \leq j \leq J \;, \quad 1 \leq k \leq K \;, \quad \text{and}$$

$$1 \leq t \leq T \;, \qquad (9)$$

where I, J, K, and T stand for the number of areas (or regions), the maximum number of iteration allowed by the researcher, the number of original endogenous variables and the number of observation times, respectively.

Usually, the smaller a convergence criterion value, the more costly a simulation would be, but the better the observations would be tracked. Of course, the maximum number of iterations allowed by the researcher is used to stop the iteration when divergence occurs in the Gauss-Seidel method.

ROOT-MEAN-SQUARE PERCENTAGE ERROR CRITERION

The first criterion to evaluate the performance of the final test for a trial simultaneous equations model is the root-mean-square percentage error criterion which is, of course, optional. The evaluation value, r_k, concerned with the root-mean-square percentage error is given by the following formula:

$$r_k = \sqrt{\frac{1}{T \cdot I} \sum_{t=1}^{T} \sum_{i=1}^{I} \left\{ \frac{Y_{ik}(t) - EY_{ik}(t)}{Y_{ik}(t)} \right\}^2} \quad \text{for } 1 \leqq k \leqq K \qquad (10)$$

where $Y_{ik}(t)$ and $EY_{ik}(t)$ stand for the observation and simulated value of the k-th left-hand side original endogenous variable in the i-th area at the t-th observation time, respectively, and T and I stand for the number of observation times and the number of areas, respectively.

If a researcher specifies root-mean-square percentage error criterion value $\hat{r}$, a trial simultaneous equations model which yields $r_k \leqq \hat{r}$ for all k is judged to be satisfactory. However, if at least one of the evaluation values r_k exceeds the criterion value $\hat{r}$, such a trial simultaneous equations model is considered to be unsatisfactory and the simulation performance of the model is not printed in the printout.

RESIDUAL PERCENTAGE CRITERION OR RELATIVE ERROR CRITERION

This criterion is to check whether or not the deviation of a value simulated by final test from the corresponding observation is within a magnitude tolerable by a researcher. The evaluation value , v_{ikt}, of residual percentage criterion is given as follows:

$$v_{ikt} = |100*(Y_{ik}(t) - EY_{ik}(t))/Y_{ik}(t)| \quad \text{for} \quad 1 \leqq i \leqq I, \quad 1 \leqq k \leqq K, \quad \text{and } 1 \leqq t \leqq T \tag{11}$$

where $Y_{ik}(t)$ and $EY_{ik}(t)$ stand for the observation and simulated value of the k-th left-hand side original endogenous variable in the i-th area at the t-th observation time, respectively, and I, K, and T stand for the numbers of areas, left-hand side original endogenous variables, and observation times, respectively.

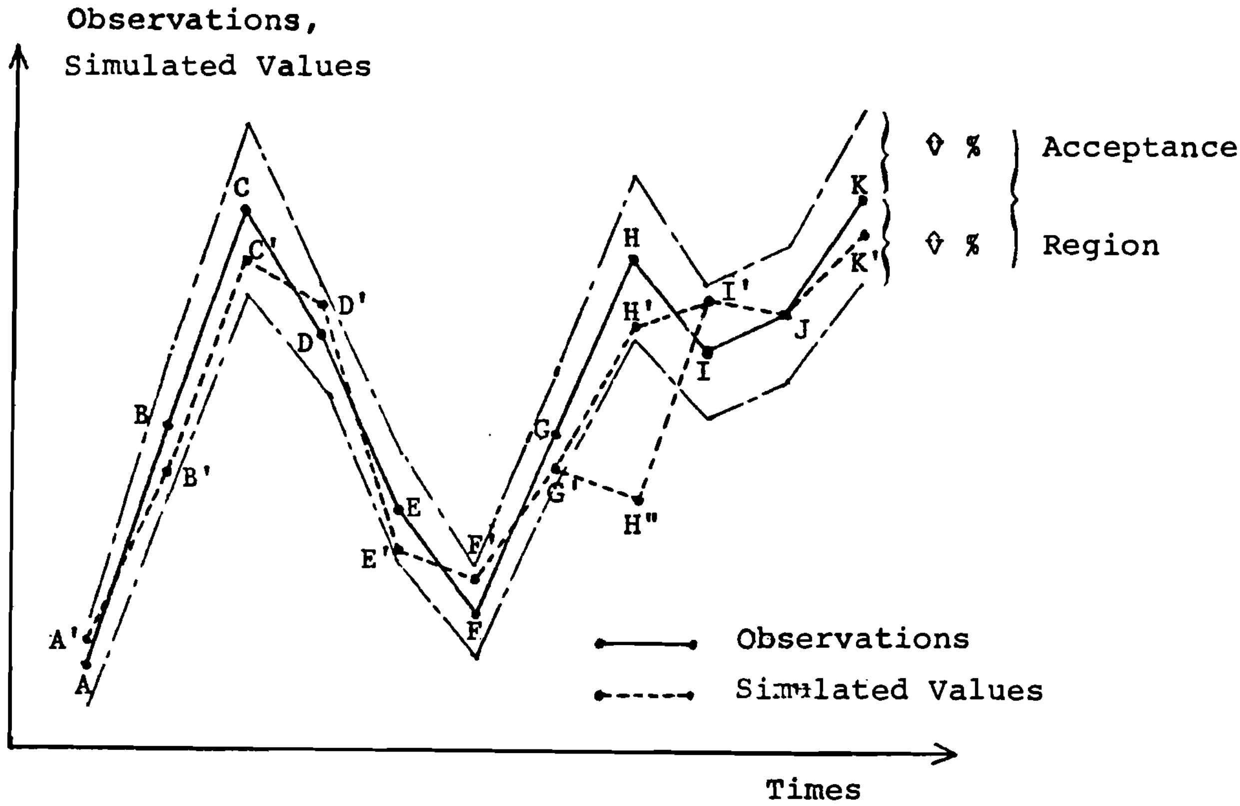
If all evaluation values of residual percentage with respect to areas, left-hand side original endogenous variables, and observation times fall short of residual percentage criterion value $\hat{v}$ specified by a researcher, this criterion is cleared by a trial simultaneous equations model in question. However, if at least one of the residual percentages of some left-hand side original endogenous variable in an area at an observation time exceeds the criterion value $\hat{v}$, such a model is judged to be unsatisfactory.

The magnitude of an acceptance region depends on the magnitude of observation. For given $\hat{v}$, the acceptance region of the k-th left-hand side original endogenous variable in the i-th area at the t-th observation time is given as

$$Y_{ik}(t)(1 - \hat{v}/100) \leqq EY_{ik}(t) \leqq Y_{ik}(t)(1 + \hat{v}/100) \tag{12}$$

Figure 2 shows the acceptance region for given $\hat{v}$ in the case of time series data (I=1). The observations of a left-hand side original endogenous variable are represented by A,B,...,I,J,and K, while the simulated values are represented by A',B',...,I',J,and K'. If all values simulated by the final test are within the acceptance region, such a trial simultaneous equations model is considered to be satisfactory from the viewpoint of the residual percentage criterion. In the figure, simulated values A',B',...H',I',J,and K' clear this criterion. However, if the simulated value corresponding to observation H is represented by H" which is outside

Figure 2. Residual Percentages (or Relative Errors) and Turning Points of Observations and Simulated Values of a LHS Endogenous Original Variable



the acceptance region, such a trial simultaneous equations model is considered to be unsatisfactory.

TURNING POINT ERROR PERCENTAGE CRITERION

It is very important to well track changes in an economy by a trial simultaneous equations model, especially from the viewpoint of economic policies. This criterion is concerned with how many turning points of the observations cannot be well tracked by the values simulated by the final test of a trial simultaneous equations model. Turning points assume Λ-shape or V-shape.

Let us denote by K_1^k and L_2^k the numbers of Λ-shape and V-shape turning points observed and by L_3^k and L_4^k the numbers of Λ-shape and V-shape turning points not well tracked by the simulated values of the k-th left-hand side original endogenous variable. Then, we introduce a turning point error percentage w_k to evaluate the performance of the final test as follows:

$$w_k = 100*(L_3^k + L_4^k)/(L_1^k + L_2^k), \quad \text{if } L_1^k + L_2^k \neq 0 \qquad (13)$$

$$\text{for } 1 \leqq k \leqq K$$

where K stands for the number of left-hand side original endogenous variables in a model.

Unless the evaluation values $w_1, w_2, \ldots, w_K$ concerned with all left-hand side original endogenous variables in a trial simultaneous equations model at hand exceed turning point error percentage criterion value $\hat{w}$ specified by a researcher, such a model is judged to be satisfactory. On the other hand, if the evaluation value of at least one left-hand side original endogenous variable exceeds criterion value $\hat{w}$, such a trial simultaneous equations model is judged to be unsatisfactory, even if the model satisfies the root-mean-square percentage error criterion and the residual percentage criterion.

Researchers of economic policy, especially, may be interested in the respective turning point error percentage of Λ-shape and V-shape turning points. In this case, the following two Λ-shape and V-shape turning point error percentages can be introduced:

$$w_k^h = 100 * L_3^k / L_1^k \text{ if } L_1^k \neq 0 \quad \text{for} \quad 1 \leqq k \leqq K \tag{14}$$

$$w_k^t = 100 * L_4^k / L_2^k \text{ if } L_2^k \neq 0 \quad \text{for} \quad 1 \leqq k \leqq K \tag{15}$$

Then, a researcher can specify his tolerable Λ-shape and V-shape turning point error percentage criterion values, $\hat{w}^k$ and $\hat{w}^t$. If (a) $w_k^h \leqq \hat{w}^h$ and $w_k^t \leqq \hat{w}^t$ for all k in the case of $L_1^k > 0$ and $L_2^k > 0$, (b) $w_k^h \leqq \hat{w}^h$ for all k in the case of $L_1^k > 0$ and $L_2^k = 0$, and (c) $w_k^t \leqq \hat{w}^t$ for all k in the case of $L_1^k = 0$ and $L_2^k > 0$, it is judged that such a trial simultaneous equations model satisfies the turning point error percentage criterion.

OEPP is not designed to deal with this case. However, it is quite easy to change the programming from (13) to (14) and (15).

FIXED, PARTIALLY UPGRADING, OR GLOBALLY UPGRADING THEIL'S INEQUALITY COEFFICIENT CRITERION

Theil proposed two kinds of ineqaulity coefficients [12], [13]. In 1958, he introduced the following inequality coefficient formula:*

$$u_k = \frac{\sqrt{\sum_{t=1}^{T} \sum_{i=1}^{I} (EY_{ik}(t) - Y_{ik}(t))^2}}{\sqrt{\sum_{t=1}^{T} \sum_{i=1}^{I} EY_{ik}(t)^2} + \sqrt{\sum_{t=1}^{T} \sum_{i=1}^{I} Y_{ik}(t)^2}} \quad \text{for } 1 \leqq k \leqq K \tag{16}$$

where $Y_{ik}(t)$ and $EY_{ik}(t)$ stand for the observation and simulated value of the k-th left hand side original endogenous variable in the i-th area at the t-th observation time, respectively, and T and I stand for the number of observation times and the number of areas, respectively.

Later he proposed another inequality coefficient formula as follows:*

$$u_k = \sqrt{\frac{\sum_{t=2}^{T} \sum_{i=1}^{I} (Y_{ik}(t) - EY_{ik}(t))^2}{\sum_{t=2}^{T} \sum_{i=1}^{I} (Y_{ik}(t) - Y_{ik}(t-1))^2}} \quad \text{for } 1 \leqq k \leqq K \tag{17}$$

Let us call the coefficients calculated by (16) and (17) the first and second kind of Theil's inequality coefficients, respectively. We would like to adopt the second kind of Theil's inequality coefficient, i.e., (17). If a researcher specifies Theil's inequality coefficient criterion value $\hat{u}$, any trial simultaneous equations model in which all left-hand side original endogenous variables obtain the Theil's inequality coefficients equal to or less than $\hat{u}$ is judged to be satisfactory and its simulation performance is printed in the output, because the Theil's inequality coefficient criterion is the last criterion applicable in OEPP. On the other hand, if at least one of the left-hand side original endogenous variables achieves its Theil's inequality coefficient greater than $\hat{u}$, such a trial simultaneous equations model is judged to be unsatisfactory, although the model passes all the criteria mentioned above. As is well known, $u_k = 0$ for all k implies a perfect simulation,

*(16) and (17) are introduced for the case of time series, cross-sectioned, or pooling data.

The case in which Theil's inequality coefficient criterion value $\hat{u}$ is always applied for all trial simultaneous equations models is here called "fixed Theil's inequality coefficient criterion". In this case, a researcher has to find the best trial simultaneous equations model by himself by comparing Theil's inequality coefficients with each other and/or with his own model evaluation criterion (or criteria).

We have defined the best trial simultaneous equations model as the one which satisfies all (or some) above applied criteria and possesses the minimum model's inequality coefficient, where model's inequality coefficient implies the maximum among the Theil's inequality coefficients of all left-hand side original endogenous variables in a model in question. Therefore, we have to make the computer find the best among many model candidates.

Suppose that a trial simultaneous equations model which satisfied all (or some) above applied criteria clears first the Theil's inequality coefficient criterion with Theil's inequality coefficients of all left-hand side original endogenous variable u_1^1, $u_2^1, \ldots,$ $u_k^1, \ldots,$ u_K^1 with $\hat{u} \geqq u_k^1$ for all k and the simulation performance of this mdel is printed. Only when $\hat{u} > u_k^1$ for all k, we replace the initial Theil's inequality coefficient criterion value $\hat{u}$ with the model's inequality coefficient u^1, where

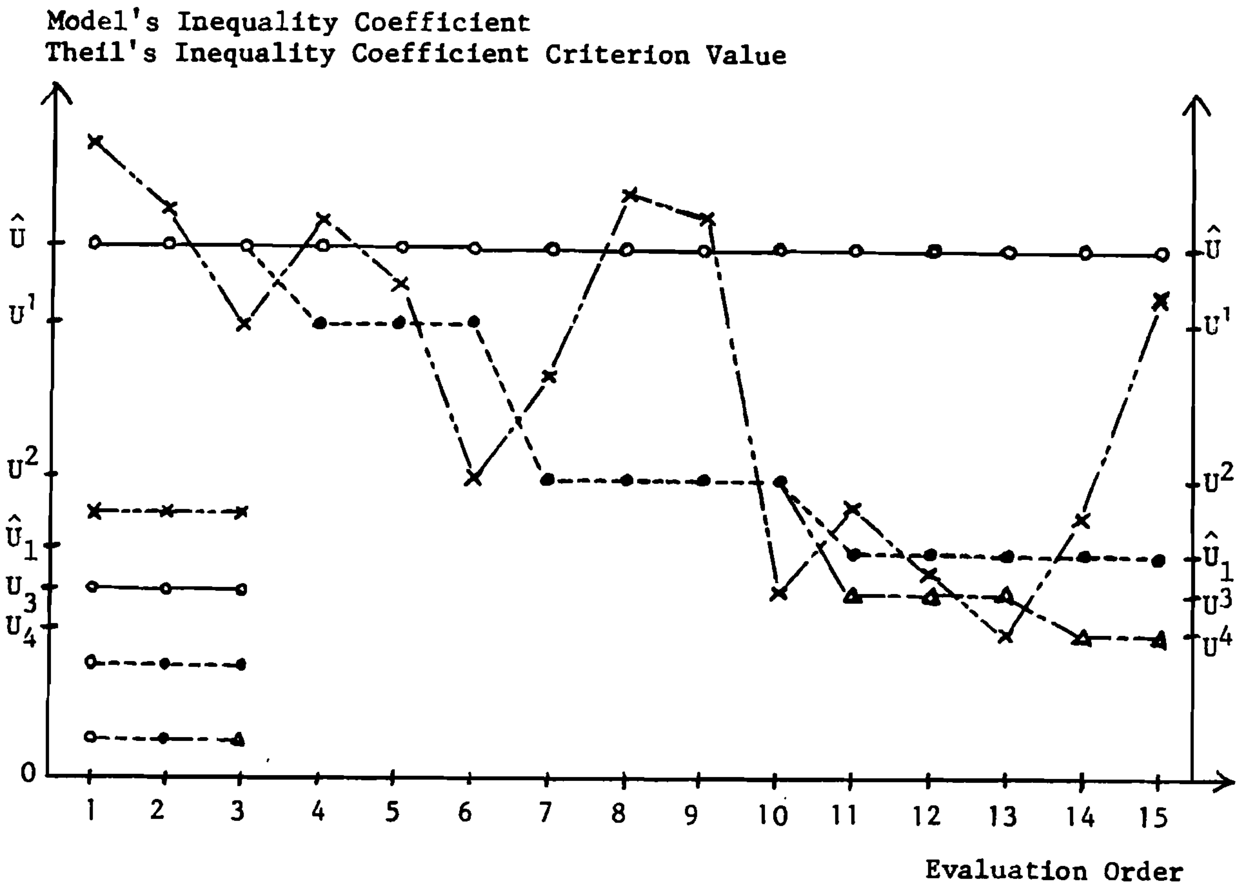
$$u^1 = \max(u_1^1, u_2^1, \ldots, u_k^1, \ldots u_K^1) \tag{18}$$

Since $u^1 < \hat{u}$, more severe Theil's inequality coefficient criterion value is applied to the remaining trial simultaneous equations models, if any. Then, if one of the remaining models which satisfies all (or some) above applied criteria meets first the current Theil's inequality coefficient criterion with the Theil's inequality coefficients of all left-hand side original endogenous variables $u_1^2, u_2^2, \ldots, u_k^2, \ldots, u_K^2$, then the simulation performance of this model is printed in the output. Only when $u^1 > u_k^2$ for all k, we replace u^1 with u^2, where

$$u^2 = \max(u_1^2, u_2^2, \ldots, u_k^2, \ldots, u_K^2) \quad . \tag{19}$$

Of course, $u^1 > u^2$. Then, new Theil's inequality coefficient criterion value u^2 is utilized for the remaining trial simultaneous equations models, if any. This process is repeated as many times as necessary. Consequently, the trial simultaneous equations model whose simulation performance is printed in the output last can be regarded as the best trial simultaneous equations model in the sense defined above.

Figure 3: Fixed, Partially Upgrading, and Globally Upgrading Theil's Ineqaulity Coefficient Criteria in the Case Where It Is Assumed That 15 Trial Simultaneous Equations Models Have Already Satisfied the Previous Applied Model Evaluation Criteria.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fixed			$\bar{P}$		$\bar{P}$	$\bar{P}$	$\bar{P}$			$\bar{P}$	$\bar{P}$	$\bar{P}$	$\bar{P}$	$\bar{P}$	$\bar{P}$
P.U.			P			P				$\bar{P}$		$\bar{P}$	$\bar{P}$		
G.U.			P			P				P			$\hat{P}$		

where 1,2,3,...,15 imply the numbers of trial simultaneous equations models which are assumed to have already satisfied the previous applied model evaluation criteria. Fixed, P.U., and G.U. stand for fixed, partially upgrading, and globally upgrading Theil's inequality coefficient criterion, P implies the printing of the simulation performance of the trial simultaneous equations model indicated by a number on the horizontal axis which was temporarily best and should be ignored, $\bar{P}$ implies the printing of the simulation performance of trial simultaneous equations model, which is a candidate for the best trial simultaneous equations model, and $\hat{P}$ implies the printing of the simulation performance of the best trial simultaneous equations model in the sense defined in this article and in OEPP.

This case is here called "globally upgrading Theil's inequality coefficient criterion".

Sometimes, a researcher wants to apply his own criterion (or criteria), which may be subjective, in addition to the criteria adopted in OEPP. In this case, he can specify the lowest bound, denoted by $\hat{u}_l$, allowing the replacement of Theil's inequality coefficient criterion value, where $\hat{u} > \hat{u}_l > 0$. If the i-th replacement yields $\hat{u} > u^1 > \ldots > u^{i-1} > u_l \geq u^i > 0$, the replacement automatically stops so that not so many trial simultaneous equations models pass all (or some) above applied criteria and meet the Theil's inequality coefficient criterion characterized by criterion value $\hat{u}_l$. Then, the researcher has to apply his own criterion (or criteria) to these trial simultaneous equations models and find the best among them by himself. This case is here called "partially upgrading Theil's inequality coefficient criterion".

Figure 3 explains in detail fixed, partially upgrading, and globally upgrading Theil's inequality coefficient criteria. It should be noticed that upgrading implies that the Theil's inequality coefficient criterion value becomes smaller or closer to zero.

MODEL EVALUATION CONCERNED WITH CRUCIALLY IMPORTANT ENDOGENOUS VARIABLES

This is a method in which all trial simultaneous equations models are evaluated only with the evaluation values of some crucially important original endogenous variables. Hence, the evaluation values of other endogenous variables are ignored whether or not they satisfy the criterion values. This implies that $1 \leq k \leq K$ in (10), (11), (13), and (17) is replaced with $k \varepsilon \{k_1, k_2, \ldots, k_m\}$, where k_j implies the k_j-th original endogenous variable which is regarded as one of the crucially important original endogenous variables. In this case, the researcher has to notify the computer of the variable notation of crucially important original endogenous variables.

SPECIFIED TRIAL SIMULTANEOUS EQUATIONS MODELS

It may be convenient if not all but some specified trial simultaneous equations models can be put on simulation. For instance, it is time-saving if the researcher can use, for sophisticated simulations of the best trial simultaneous equations model, the same file (the same data deck) used for final test of all trial simultaneous equations models by adding to the file a few lines (or to the data deck a few cards) indicating the trial equation numbers of the best trial simultaneous equations model. In this case, the indication of the k-j implying the j-th trial equation of the k-th left-hand side original endogenous variable implies the adoption of trial eqaution k-j. On the other hand, if any trial equations related to the k-th left-hand side original endogenous variable are not indicated, it is implied that all trial equations related to the k-th left-hand side original endogenous variable must be adopted.

For instance, if "2-1; 4-3" is indicated in the above example where $K_1=1$, $K_2=2$, $K_3=1$, $K_4=3$, and $K_5=1$, the trial simultaneous equations model consisting of 1-1; 2-1; 3-1; 4-3; 5-1 is focussed on and the remaining five trial simultaneous equations models are ignored. If "4-2" is indicated, two trial simultaneous equations models consisting of 1-1; 2-1; 3-1; 4-2; 5-1 and 1-1; 2-2; 3-1; 4-2; 5-1 are selected and put on simulations.

SELECTION OF APPROPRIATE CRITERION VALUES

The criterion values for model evaluation may be obtained from empirical studies, but generally speaking, it is quite difficult to specify the appropriate criterion values. Therefore, OEPP allows a researcher to specify the number ,N, of trial simultaneous equations models, usually N=1 or 2, which are put on test run without using any criterion, so that the first N trial simultaneous equations models give their respective evaluation values of the criteria and other information such as Theil's inequality coefficients of the first kind, root-mean-square errors, simple correlation coefficients with intercepts, Durbin-Watson statistics, and means of observations and simulated values. Usually, a researcher can find appropriate criterion values from the test run and use them for all trial simultaneous equations models.

SOPHISTICATED SIMULATIONS

It is suggested that after finding the best trial simultaneous equations model, a researcher apply sohpisticated or advanced simulations for the model. Sophisticated simulations are classified below. It is possible to apply all of the sophisticated simulations for the model in a run of the computer.

Ex ante forecasting policy simulation with targets is quite interesting. Policy variables can assume several alternative policies or strategies which are reflected on their ex-ante-forecasting-data vectors. There are fifteen kinds of functions of the time trend variable by which the ex ante forecasting data of policy variables can be generated if the code number of a function, the variable notation of policy variable, the initial value of the time trend variable, and the necessary coefficients are specified by a researcher. Then, ex ante forecasting policy simulation with or without targets is continuously made for each of all possible sets of policy variables' ex ante forecasting data which are obtained by selecting, in the permutational manner, a vector of ex ante forecasting data for a policy variable.

Brief explanation about the sophisticated simulations adopted in OEPP may help researchers to use OEPP.

SOPHISTICATED SIMULATIONS AVAILABLE IN OEPP

(a) Initial Value Test

(b) Impact Test

(c) Fixation Test

(d) Variation Test

(e) Exogenization Test

(f) Ex Ante Forecasting Policy Simulation with/without Targets

(g) Simulation of Macroeconomic Model Related to $(I-A)^{-1}Y$ Type Input-Output Analysis

(h) Simulation of Macroeconomic Model Related to $(I-A)^{-1}(Y-M)$ Type Input-Output Analysis

(i) Simulation of Macroeconomic Model Related to $(I+m-A)^{-1}Y$ Type Input-Output Analysis

(j) Simulation of Macroeconomic Model Related to $\{I-(I-m)-A\}^{-1}\{(I-m)Y+E\}$ Type Input-Output Analysis

(k) Simulation of Macroeconomic Model Related to $(I-A^c)^{-1}Y^c$ and $A^n(I-A^c)^{-1}Y^c+Y^n$ Type Input-Output Analysis

(l) Ex Ante Forecasting Policy Simulation of Macroeconomic Model Related to $(I-A)^{-1}Y$ Type Input-Output Analysis

(m) Ex Ante Forecasting Policy Simulation of Macroeconomic Model Related to $(I-A)^{-1}(Y-M)$ Type Input-Output Analysis

(n) Ex Ante Forecasting Policy Simulation of Macroeconomic Model Related to $(I-M-A)^{-1}Y$ Type Input-Output Analysis

(o) Ex Ante Forecasting Policy Simulation of Macroeconomic Model Related to $\{I-(I-m)A\}^{-1}\{(I-m)Y+E\}$ Type Input-Output Analysis

(p) Ex Ante Forecasting Policy Simulation of Macroeconomic Model Related to $(I-A^c)^{-1}Y^c$ and $A^n(I-A^c)^{-1}Y^c+Y^n$ Type Input-Output Analysis

where multiplier effect can be measured, if required, and I, A, Y, M, m, E, A^c, Y^c, A^n and Y^n stand for identity matrix, input-output coefficient matrix, final demand vector, import vector, import coefficient matrix, export vector, competitive goods input-output coefficient matrix, competitive goods final demand vector, non-competitive goods input-output coefficient matrix, and non-competitive goods final demand vector, respectively.

(a) INITIAL VALUE TEST

There are two kinds of initial value test. One of them is the test in which the initial simulation time is changed from the initial estimation time to a specified time and the initial values of lagged variables and non-lagged exogenous variables are the observations used for estimation. In this case, just indication of an arbitrary initial simulation time within the estimation period handles this kind of initial value test. The second is the test in which the initial simulation time is the same as the initial estimation time but the initial values are not the observations used for estimation but arbitrary values entered by a researcher. For this case, the notation of variables whose initial values are replaced, observation times, area numbers, and values must be loaded into the computer.

(b) IMPACT TEST

An impact test is a simulation test in which a researcher wants to replace the observation of some exogenous variable at a certain observation time with an artificial value to see its impact on the economy at hand through the final test. If more than one exogenous variable is focussed on, the composite effect of the impact test could be seen on the economy.

For example, suppose that rainfall precipitation which is exogenous in a model at hand is focussed on. A researcher may want to replace the rainfall precipitation of some observation time with an artificial rainfall precipitation to see what impact would have occurred on the agricultural production through the final test.

(c) FIXATION TEST

A fixation test is a simulation test in which a researcher wants to replace all of the observations of some exogenous variable during a certain observation period with an artificial value to see what would have happened through the final test. Of course, it is possible to see the composite effect of some exogenous variables on the economy at hand, if more than one exogenous variable is used for a fixation test.

For example, suppose that government workers' wage rates are determined not by the market mechanism but by the central government. A researcher may want to replace the government workers' wage rate of a certain observation period with an artificial wage rate in order to see whether or not the fixed wage rate would have brought about any reduction of inflation.

(d) VARIATION TEST

A variation test is a simulation test in which a researcher wants to replace the observations of some exogenous variable during a certain observation period with some values which are directly loaded or generated with a function of the time trend variable specified by him and then to see what would have occurred in this circumstance through the final test. If more than one exogenous variable is focussed upon, the composite effect of these exogenous variables can be seen on the economy at hand.

For example, suppose that the international petroleum price is focussed upon. A researcher may want to know what would have occurred in his country's economy if a certain observation period's international petroleum prices are 10% greater than the observed prices.

(e) EXOGENIZATION TEST

An exogenization test is used to see what would happen to the simulation performance of a model if an original endogenous variable(s) is treated as exogenous. The exogenization test therefore reduces the size of the model. Of course, a researcher still has to enter the notation of an original endogenous variable(s) which is to be treated as exogenous into the computer.

For instance, suppose that an interest rate is endogenous in a model. The researcher can see whether or not the simulation performances of other endogenous variables can be improved if the interest rate is treated as exogenous.

(f) EX ANTE FORECASTING POLICY SIMULATION WITH/WITHOUT TARGETS

Ex ante forecasting policy simulation adopted in OEPP is related to ex ante forecasting and is quite useful for policy makers to shorten the time spent on reaching the final policy decision and to save labor and resources. Ex ante forecasting policy simulation is a simulation in which each of some policy variables possess a number of vectors of ex ante forecasting data and the final test with ex ante forecasting is repeatedly made for each of all possible configurations of ex ante forecasting data which are generated by selecting, in the permutational manner, a vector from the vectors of ex ante forecasting data belonging to a policy variable which is one of the policy variables in question.

Suppose that there are J kinds of policy variables for $J \geq 1$ and the j-th policy variable possesses J_j vectors (or kinds or policy strategies) of ex ante forecasting data for $j = 1,2,\ldots, J$ and $J_j \geq 1$ for all j. Consequently, there exist $\prod_{j=1}^{J} J_j$ sets (or matrices) of ex ante forecasting data. The final test with ex ante forecasting is repeatedly made for each of $\Pi\ J_j$ sets with respect to the best trial simultaneous equations model (or with respect to each of all possible trial simultaneous equations models).

In most cases, a policy (or policy mix) which best satisfies the policy goal(s) is adopted. A policy goal is a target. If a set of ex ante forecasting data assumed by the policy variables in question cannot achieve a specified target, the policy (or policy mix) based on this set of ex ante forecasting data will be of no value, so that the result of this policy (or policy mix) need not be printed. Maximum 10% price rise, maximum 5% unemployment rate, and maximum one-million-US-dollar reduction of foreign reserves are examples of policy targets. Targeted ex ante forecasting policy simulation requires variable notation of targeted variables, targeted ex ante forecasting times, and maximum values, minimum values, or ranges of upper and lower bounds of the targets.

(g-k) SIMULATION OF MACROECONOMIC MODEL* RELATED TO INPUT-OUTPUT ANALYSIS

This is a simulation of a macroeconomic model in which all components of the final demand are generated for each of all sectors in the economy in question and a type of input-output analysis is made. The equilibrium induced production quantities of all the sectors, which are, of course, consistent with the equilibrium values of endogenous variables and the data of exogenous variables in the macroeconomic model, are derived. Fixed input-output technical coefficients are assumed during the entire simulation period. Needless to say, a set of the equilibrium induced production quantities of all sectors are calculated for each of the simulation times.

15(l-p) It is apparent that these simulations are the combination of (f) with (g) to (k).

CONCLUSION

Many packages are available for econometric estimation, but all of them cannot handle econometric simulation. Most packages available for economic simulation require a researcher to enter a different simultaneous equations model into the computer and make the final test for it by each run of the computer. It takes more time to enter all possible trial simultaneous equations models (or model candidates) into the computer, make the final test for them, and judge which trial simultaneous equations model is the best. Therefore, in order to reduce the number of all possible trial simultaneous equations models, a researcher usually singles out one trial equation from the trial equations related to each left-hand side original endogenous variable not by model evaluation but by his subjective judgement. This may lead him to have a simultaneous equations model which is not the best. Such a simultaneous equations model may not predict well.

I would like to propose a software method in which a trial equation (or an equation candidate) is automatically selected, in the permutational manner, from a set of trial equations related to each left-hand side original endogenous variable and the computer automatically finds the practically best trial simultaneous equations model from the view point of the model evaluation criteria applied by a researcher. The method is quite useful to shorten a research period, improve the quality of research, save labor and resources, and eventually reduce

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*A national single-sectoral macroeconomic model is focussed on at present, but a national multi-sectoral macroeconomic mdoel is planned to be handled in a later version of OEPP. Therefore, a set of portions for allocation of a value of, for instance, consumption into all the sectors is needed to be loaded for the present version of OEPP.

cost. A researcher can be released, to some extent, from heavy computer work and therefore is able to spend more time on his essential work such as finding deeply underlying causal relationships between economic activities, proper functional forms assumed by trial equations, and so on.

Nowadays, computers can process the data and necessary information such as variables for equations to be estimated quickly, once they are loaded. However, it still takes more time to enter the data and necessary information into the computer, get the output, and judge whether or not the outcome is satisfactory. A software method in which time, labor, and the resources can be saved for this type of input-output computer work is needed because labor and resources are not cheap at present and will be quite expensive in the near future.

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There are many other computer program packages in Japan and in other countries which can deal with input-output analysis, econometric estimation, and econometric simulation. Most of the packages are offered as software services but cannot be brought.