SIMULTANEOUS EQUATION MODEL (SEM) IN EVIEWS: Creating and Simulating with SEM

Dealing with simultaneous equation in Eviews

ADESETE, AHMED ADEFEMI
SIMULTANEOUS EQUATION MODEL (SEM)

Single equation model assumes regression of a dependent variable on explanatory variable(s) and this directly means a one way causation between the dependent variable and explanatory variable(s). But, what if the explanatory variables are not truly exogenous? This invariably means a two way causation between the dependent variables and exogenous variables in which one equation cannot be treated in isolation as single equation model. In other words, this indicates a system of equations whereby each equation cannot be treated separately as a single equation mainly because of the joint dependence of the endogenous(Y) and exogenous variables(X) or predetermined variables. This is a type of model referred to as simultaneous equation model (SEM).

There are three major models that has to be understood when dealing with simultaneous equation:

(1) Structural models

(2) Reduced form models

(1) Structural models

This shows a complete system of equations which describe the structure of relationship between economic variables. Structural models expresses endogenous variables as a function of other endogenous variables, predetermined variables (stand-alone variables) and random variables.

Endogenous variables = f(Other endogenous variables, predetermined variables, random variable)

Let take the below simple model as example:

\[ C_t = b_0 + b_1 Y_t + u_t \quad \text{(1)} \]
\[ I_t = c_0 + c_1 Y_t + c_2 Y_{t-1} + u_2 \] \quad \text{-------(2)}

\[ Y_t = C_t + I_t + G_t \] \quad \text{-------(3)}

Equation (1) \text{---------Consumption function}

Equation (2) \text{--------Investment function}

Equation (3) \text{--------definitional(Income) function}

Endogenous variables----\( C_t, I_t, Y_t \)

Predetermined variables---\( G_t, Y_{t-1} \)

Random variables----------\( u_1, u_2, u_3 \)

Structural parameters-------\( b_1, c_1, c_2 \)

\textbf{Note}: Structural parameters examines the direct effect of explanatory variables on the dependent variables. The system of equations above shows each equation with its own structural parameters. Equation 1 determines the direct effect of Income at time \( t \) on consumption at time \( t \). Equation 2 determines the direct effect of income at time \( t \) and income at time \( t-1 \) on investment at time \( t \). However, structural parameters \( b_1, c_1, c_2 \) helps studies these direct effects by the magnitude, size and sign of these parameters. \textbf{But what if we want to determine the effect of consumption on investment or the effect of investment on consumption? Then this brings us to examining the indirect effect of consumption on investment which is cannot be accomplished with the structural equation.}

(2) Reduced form model

The reduced form model is usually derived from the structural model. It expresses endogenous variables as a function of predetermined variables only. There are basically two ways of obtaining and defining the reduced form model:
(i) **Direct estimation of the reduced form coefficients:** This is done by expressing endogenous variables directly as a function of the predetermined variables. The reduced form coefficients maybe estimated using the method of least-squares-no-restriction method (LSNR). The endogenous variables are expressed as a function of the predetermined variables and ordinary least square is applied (OLS) to the reduced form equations. This method directly helps estimates the reduced form coefficients ($\pi$).

Reduced form for the example above:

\[
C_t = \pi_{11}Y_{t-1} + \pi_{12}G_t + v_1
\]
\[
I_t = \pi_{21}Y_{t-1} + \pi_{22}G_t + v_2
\]
\[
Y_t = \pi_{31}Y_{t-1} + \pi_{32}G_t + v_3
\]

(ii) **Indirect estimation of the reduced form coefficients:** Since there seem to be a definite relationship between the reduced form coefficients and the structural parameters, the reduced form coefficients can be estimated by substituting the estimates of the structural parameters in the specified system of equations. That is, solving the structural system of endogenous variables in terms of the predetermined variables, the structural parameters and the random variables.

*See end of article for workings of the reduced form model*

**Note:** The Reduced form model determines the total effect, direct effect and indirect effect of a change in the predetermined variables on the dependent variables, after accounting for the interdependencies among the jointly dependent variables. The reduced form coefficients are also very useful to policy makers in forecasting (simulating) and policy analysis.

**Total effect = Direct effect + Indirect effect**
(3) Recursive models: This is a type of model in which its first equation includes only predetermined variables in the right side, the second equation includes the predetermined variables and the endogenous variable of the first equation, the third equation includes the predetermined variables and the endogenous variables in the first and second equation etc.

Example:

\[ C_t = a_0 + a_1 G_t + a_2 Y_{t-1} + u_1 \quad \text{(1)} \]

\[ I_t = b_0 + b_1 G_t + b_2 Y_{t-1} + b_3 C_t + u_2 \quad \text{(2)} \]

- \( C_t, I_t \) ------- endogenous variables
- \( G_t, Y_{t-1} \) ---- predetermined variables
- \( u_1, u_2 \) ------ Random errors

**Assumptions of the Simultaneous equation model (SEM)**

1. Rank of matrix \( X \) of exogenous variables must be equal to \( k \) (column of sub-matrix of \( X \)) both in finite samples and in limit as \( T \) tends towards infinity.
2. Error terms are assumed to be serially independent and identically distributed.
3. The number of unknowns in the system of equation should not exceed the number of equation. This assumption is very important for identification condition.

**IDENTIFICATION CONDITION**

Identification condition is very important so as to be able to obtain unique estimates of a simultaneous equation model. A model is said to be identified if it is possible to obtain the true estimates of the of the model parameters after obtaining an infinite number of observation from it. In other words, a model is identified, if it is in a unique statistical form, enabling unique values of its parameters to be subsequently obtained from the sample data.

However, for identification of the entire SEM, the model must be complete and each
equation in the model must be identified. A model is complete if it contains at least as many independent equations as endogenous variables. **For identification, two conditions must be met** which is the **order condition** and the **rank condition**. Identification condition can also be determined with the structural model or reduced form model.

**Determination Of Identification Condition From Structural Model**

There are two major conditions which must be fulfilled for a particular equation to be identified.

(1) The Order Condition

This is considered as a necessary but not sufficient condition. According to the order condition, for an equation to be identified in a system of equation, the total number of variables (both endogenous and exogenous) excluded from the equation must be equal to or greater than the number of endogenous variables in the system of equation less than one.

If the variables excluded is equal to the number of endogenous variables less one, then we say the equation is **exactly identified** while if the excluded variables is greater than the number of endogenous variables less one, then we say the equation is **over-identified**. Otherwise, if the excluded variables is less than the number of endogenous variables, we say the equation is **under-identified**.

Mathematically,

\[ K - M \geq G - 1 \]

\( K \) ------- Number of variables in the model (both endogenous and exogenous)

\( M \) ------- Number of variables included in the considered equation

\( G \) ------- Total number of equations (endogenous variables)
Example

\[ C_t = b_0 + b_1 Y_t + u_1 \]  \hspace{1cm} (1)

\[ I_t = c_0 + c_1 Y_t + c_2 Y_{t-1} + u_2 \]  \hspace{1cm} (2)

\[ Y_t = C_t + I_t + G_t \]  \hspace{1cm} (3)

For equation 1,

\[ K = 5 \ (C_t, Y_t, I_t, Y_{t-1}, G_t) \]

\[ M = 2(C_t, Y_t) \]

\[ G = 3(C_t, I_t, Y_t) \]

5 - 2 = 3 , 3 - 1 = 2

3 > 2 (Equation 1 is over-identified)

For equation 2,

\[ K = 5 \ (C_t, Y_t, I_t, Y_{t-1}, G_t) \]

\[ M = 3(I_t, Y_t, Y_{t+1}) \]

\[ G = 3(C_t, I_t, Y_t) \]

5 - 3 = 2 , 3 - 1 = 2

2 = 2 (Equation 2 is exactly identified)

For equation 3,

\[ K = 5 \ (C_t, Y_t, I_t, Y_{t-1}, G_t) \]

\[ M = 4 (Y_t, C_t, I_t, G_t) \]

\[ G = 3 \ (C_t, I_t, Y_t) \]

5 - 4 = 1 , 3 - 1 = 2

1 < 2 (Equation 3 is under-identified)

(2) The Rank Condition
The rank condition states that in a SEM, any particular equation is identified, if and only if it is possible to construct at least one non-zero determinant of order(G -1) from the coefficients of the variables excluded from that particular equation but contained in other equations of the simultaneous equation model(SEM).

Steps for tracing the identification condition of an equation under the rank condition

Step 1: Sort and write down the parameters(coefficients of variables in the structural equation) of the structural equation.

Using the previous example:

\[ C_t = b_0 + b_1Y_t + u_1 \] \hspace{1cm} (1)
\[ I_t = c_0 + c_1Y_t + c_2Y_{t-1} + u_2 \] \hspace{1cm} (2)
\[ Y_t = C_t + I_t + G_t \] \hspace{1cm} (3)

Sorting and rearranging the three equations

\[ -C_t + 0(I_t) + 0(G_t) + b_1Y_t + 0(Y_{t-1}) + u_1 = 0 \] \hspace{1cm} (4)
\[ 0(C_t) - I_t + 0(G_t) + c_1Y_t + c_2(Y_{t-1}) + u_2 = 0 \] \hspace{1cm} (5)
\[ C_t + I_t + G_t - Y_t + 0(Y_{t-1}) + 0(u_1) = 0 \] \hspace{1cm} (6)

Taking the coefficients of each variable to form the table

<table>
<thead>
<tr>
<th>Equations</th>
<th>Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( C_t )</td>
</tr>
<tr>
<td>Equation 4</td>
<td>-1</td>
</tr>
<tr>
<td>Equation 5</td>
<td>0</td>
</tr>
<tr>
<td>Equation 6</td>
<td>1</td>
</tr>
</tbody>
</table>
Step 2: Strike out rows and of equation being examined for the identification. Let take equation 1 for an example to check if it is identified or not.

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<td>0</td>
</tr>
<tr>
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<td>1</td>
</tr>
</tbody>
</table>

Step 3: Strike out column in which non-zero coefficient appears for the equation being examined.

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<td>Equation 5</td>
<td>0</td>
</tr>
<tr>
<td>Equation 6</td>
<td>1</td>
</tr>
</tbody>
</table>

Step 4: Form a matrix of the unstriked numbers.

Matrix A =
\[
\begin{pmatrix}
-1 & 0 & c_2 \\
1 & 1 & 0
\end{pmatrix}
\]

Step 5: Form a matrix of order \((G - 1)\) from matrix A.

Recall, \( G = \) Total number of equations( endogenous variables)

\( G = 3, \ G - 1 = 3 - 1 = 2 \)

According to this example, we would form a matrix of order 2 (2 X 2 matrix)

Matrix \( A_1 = \)
\[
\begin{pmatrix}
-1 & 0 \\
1 & 1
\end{pmatrix}
\]

Matrix \( A_2 = \)
\[
\begin{pmatrix}
-1 & c_2 \\
1 & 0
\end{pmatrix}
\]
Matrix $A_3 = \begin{vmatrix} 0 & c_2 \\ 1 & 0 \end{vmatrix}$

Note: we have been able to form three (2 X 2) matrix from matrix $A$.

Step 6: Find the determinant of matrices $A_1$, $A_2$, $A_3$ and use their determinant to make the decision if equation 1 is identified or not.

Decision criterion: Any particular equation is identified, if and only if it is possible to construct at least one non-zero determinant of order $(G - 1)$ from the coefficients of the variables excluded from that particular equation.

Determinant of matrix $A_1 = (-1 \times 1) - (0 \times 1)$

$= -1 - 0 = -1$

Determinant of matrix $A_2 = (-1 \times 0) - (c_2 \times 1)$

$= 0 - c_2 = -c_2$

Determinant of matrix $A_3 = (0 \times 0) - (c_2 \times 1)$

$= 0 - c_2 = -c_2$

Decision: Irrespective of what $c_2$ takes as value (that is if $c_2$ is greater than zero, less than zero or equal to zero), equation 1 is identified according to the rank condition because at least one of the determinant of matrices $A_1$, $A_2$, $A_3$ of order $(G - 1)$ is a non-zero value (Determinant of matrix $A_1$ is $-1$ which is non-zero).

The Order and rank condition ascertains that equation 1 is identified. Same step can also be followed for equation 2, equation 3 and any subsequent question on SEM.
Determination Of Identification Condition From Reduced form Model

The order and rank condition are the important factors also to be considered when using the reduced form model to determine the identification condition of an equation in a SEM.

(1) The Order condition.

The steps taken here is the same with the steps taken when using the order condition for the structural model. The only difference is that, the considered model is the reduced form system of equations.

Mathematically,

\[ K - M \geq G - 1 \]

(Excluded Variables) (Endogenous Variables less one)

K-------Number of variables in the model(both endogenous and exogenous)

M-------Number of variables included in the considered equation

G-------Total number of equations(endogenous variables)

Example: Let use the reduced form of the considered structural equation.

\[ C_t = \beta_{11}Y_{t-1} + \beta_{12}G_t + \nu_1 \] \hspace{1cm} (1)

\[ I_t = \beta_{21}Y_{t-1} + \beta_{22}G_t + \nu_2 \] \hspace{1cm} (2)

\[ Y_t = \beta_{31}Y_{t-1} + \beta_{32}G_t + \nu_3 \] \hspace{1cm} (3)

For equation 1,

\[ K = 5 \] , \[ M = 3 \] , \[ G = 3 \]

\[ 5 - 3 = 2 \] , \[ 3 - 1 = 2 \]

\[ K - M = G - 1 \] (2 = 2)

Equation 1 is exactly identified.
For equation 2,
\[ K = 5, M = 3, G = 3 \]
\[ 5 - 3 = 2, 3 - 1 = 2 \]
\[ K - M = G - 1 (2 = 2) \]

Equation 2 is exactly identified.

For equation 3,
\[ K = 5, M = 3, G = 3 \]
\[ 5 - 3 = 2, 3 - 1 = 2 \]
\[ K - M = G - 1 (2 = 2) \]

Equation 3 is exactly identified.

(2) The Rank condition

The steps taken for rank condition for reduced form model is slightly different from that of a structural model. The rank states that an equation \( G^* \) endogenous variables is identified, if and only if it is possible to construct at least one non-zero determinant of order \((G^* - 1)\) from the reduced form coefficients of the predetermined(exogenous) variables excluded from that particular equation.

Steps for tracing the identification condition of an equation under the rank condition

\[ C_t = \pi_{11} Y_{t-1} + \pi_{12} G_t + v_1 \]  \hspace{1cm} \text{(1)}

\[ I_t = \pi_{21} Y_{t-1} + \pi_{22} G_t + v_2 \]  \hspace{1cm} \text{(2)}

\[ Y_t = \pi_{31} Y_{t-1} + \pi_{32} G_t + v_3 \]  \hspace{1cm} \text{(3)}
Step 1: Write down the reduced form equation parameters (coefficients of variables in the reduced form equation) in a table as below.

<table>
<thead>
<tr>
<th>Equations</th>
<th>Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$Y_{t-1}$</td>
</tr>
<tr>
<td>$C_t$</td>
<td>$\pi_{11}$</td>
</tr>
<tr>
<td>$I_t$</td>
<td>$\pi_{21}$</td>
</tr>
<tr>
<td>$Y_t$</td>
<td>$\pi_{31}$</td>
</tr>
</tbody>
</table>

Step 2: **Strike out the rows corresponding to the endogenous variables excluded from the structural equation being considered for identifiability.**

**Structural equations**

- $C_t = b_0 + b_1 Y_t + u_1$  \(\text{--------- (4)}\)
- $I_t = c_0 + c_1 Y_t + c_2 Y_{t-1} + u_2$  \(\text{--------- (5)}\)
- $Y_t = C_t + I_t + G_t$  \(\text{--------- (6)}\)

Let check the identification condition for equation 1 and equation 2,

For equation 1,

Excluded endogenous variable in equation 4 = $I_t$

<table>
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</thead>
<tbody>
<tr>
<td></td>
<td>$Y_{t-1}$</td>
</tr>
<tr>
<td>$C_t$</td>
<td>$\pi_{11}$</td>
</tr>
<tr>
<td>$I_t$</td>
<td>$\pi_{21}$</td>
</tr>
<tr>
<td>$Y_t$</td>
<td>$\pi_{31}$</td>
</tr>
</tbody>
</table>
For equation 2,

**Excluded endogenous variable in equation 5 = C_t**

<table>
<thead>
<tr>
<th>Equations</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Y_{t-1}</td>
</tr>
<tr>
<td>C_t</td>
<td>π_{11}</td>
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<tr>
<td>I_t</td>
<td>π_{21}</td>
</tr>
<tr>
<td>Y_t</td>
<td>π_{31}</td>
</tr>
</tbody>
</table>

Step 3: Strike out the columns of included exogenous variables in the structural equation corresponding to the considered reduced form equation.

**For equation 1,**

Note: No exogenous variable is in equation 4 which is the structural equation for equation 1.

**For equation 2,**

**Included exogenous variable in equation 5 = Y_{t-1}**

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<tr>
<td></td>
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<tr>
<td>C_t</td>
<td>π_{11}</td>
</tr>
<tr>
<td>I_t</td>
<td>π_{21}</td>
</tr>
<tr>
<td>Y_t</td>
<td>π_{31}</td>
</tr>
</tbody>
</table>

Step 4: Form a matrix of \(G^*\) order from the unstriked values.

\(G^* = \text{Number of endogenous variables remaining after striking values on rows and columns.}\)

Decision criterion: An equation of \(G^*\) endogenous variables is identified, if and only if it is possible to construct at least one non-zero determinant of order \((G^* - 1)\) from the reduced form coefficients of the predetermined (exogenous) variables excluded from...
that particular equation

For equation 1,

\[ G^* = 2(C_t, Y_t), \quad G^* - 1 = 1(2 - 1 = 1) \]

Matrix \( A = \begin{bmatrix} \pi_{11} & \pi_{12} \\ \pi_{31} & \pi_{32} \end{bmatrix} \)

Note: It is possible to form four matrices (\( \pi_{11}, \pi_{12}, \pi_{31}, \pi_{32} \)) of order 1 X 1 (\( G^* - 1 \)). Thus, if at least one determinant of the matrices is non-zero, then we say equation 1 is identified but if all determinant of the matrices is zero, then we say equation one is not identified.

For equation 2,

\[ G^* = 2(I_t, Y_t), \quad G^* - 1 = 1(2 - 1 = 1) \]

Matrix \( B = \begin{bmatrix} \pi_{22} \\ \pi_{32} \end{bmatrix} \)

Note: It is possible to form two matrices (\( \pi_{22}, \pi_{32} \)) of order 1 X 1 (\( G^* - 1 \)). Thus, if at least one determinant of the matrices is non-zero, then we say equation 1 is identified but if all determinant of the matrices is zero, then we say equation two is not identified.
SIMULATING METHODS

Simulating simply means forecasting with the aid of some given data (information) either within or out of the sample of data given. There are two instances of simulation which are in-sample and out-of-sample simulation. The basic methods used in simulating are:

(1) **Naive Method**: The forecast for next period (say period T+1) will be equal to the current period’s (period T) value.

For example:

\[ Y_{T+1} = Y_T \]

\[ Y_{T+2} = Y_{T+1} \]

\[ Y_{T+n} = Y_{T+n-1} \]

(2) **Simple Average Method**: The forecast for next period will be equal to the average of all past sum of values of the observations.

For example:

\[ Y_{T+1} = \frac{1}{T} \sum_{t=1}^{T} Y_t \]

\[ Y_{T+n} = \frac{1}{T+n-1} \sum_{t=1}^{T+n-1} Y_t \]

(3) **Simple Moving Average Method**: The forecast for next period will be equal to the mean of a specified number of the most recent observations, with each observation receiving the same weight.

For example:
(4) **Weighted Moving Average Method**: The forecast for next period will be equal to a weighted average of a specified number of the most recent observations.

For example:

\[
Y_{T+1} = \frac{Y_T + Y_{T-1} + Y_{T-2}}{3}
\]

(5) **Trend projection method**: This involves regressing the variable under consideration on a time trend.

That is: \( Y = a + bTrend \)

The trend term can also be non-linear depending on the behaviour of the series being examined.
METHOD OF SOLVING SIMULTANEOUS EQUATION MODEL

(1) The reduced form or Indirect least squares method (ILS)

(2) Method of instrumental variables (IV)

(3) Two-stage least squares method (TSLS)

(4) Limited information maximum likelihood (LIML)

(5) The mixed estimation method

(6) Three stage least squares method (3SLS)

(7) Full information maximum likelihood (FIML)

The first five methods are considered to be single equation methods because it estimates one equation at a time. The last two methods are called the system equations method because it estimates all equations simultaneously at the same time. It should however be noted that if an equation is exactly identified, it is appropriate to use the indirect least squares method while if an equation is over-identified, it is appropriate to use the two stage least squares method, three stage least squares method or the maximum likelihoods method.
SIMULTANEOUS MODEL IN EVIEWS

STEP ONE: Get the data set ready in Microsoft excel. Here we would be using data for consumption expenditure, investment expenditure, government expenditure and gross domestic product proxy to Income ranging from 1981-2015. See end of article for data used.

STEP TWO: Navigate to the eviews package installed on your device and open the package.
STEP THREE

Create a new workfile by clicking **File/New/Workfile** on the **toolbar** of the **Main window** of Eviews.

Then a workfile range appears which looks like this:
Input the data range and workfile desired name

- Click on **OK** after the date has been set and workfile name has been specified and this would take us to the workfile environment which includes constant **C** and **resid**.
STEP FOUR

Now, the workfile environment is ready which specifies that there are 44 observations, let us load our data into eviews. There are different methods of doing this, we can use the drag and drop method, import method or the copy and paste method. Let try the copy and paste method.

- Navigate to the Microsoft excel file in which the data is located and open it
- Copy the data
- After the data has been copied, go and paste it in the eviews work environment
### Excel 97-2003 Clipboard Read - Step 1 of 2

- **Header lines**: 1
- **Header type**: Names only
- **Column info**: Click in preview to select column for editing
- **Names**: Year
- **Description**: 
- **Data type**: Number

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<tr>
<th>Year</th>
<th>Y</th>
<th>C</th>
<th>G</th>
<th>J</th>
</tr>
</thead>
<tbody>
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<td>5.87E+10</td>
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<tr>
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<td>1.16E+10</td>
</tr>
</tbody>
</table>

- **Read series by row (transpose incoming data)**

Click Next

### Excel 97-2003 Read - Step 2 of 2

**Import method**: Dated read

**Basic structure**: Dated - specified by date series

**Frequency Conversion**:

<table>
<thead>
<tr>
<th>YEAR</th>
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<td>1.18E+11</td>
<td>8.46E+10</td>
<td>1.12E+11</td>
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<td>1987</td>
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<tr>
<td>1988</td>
<td>1.09E+11</td>
<td>6.18E+10</td>
<td>8.68E+10</td>
<td>1.16E+10</td>
</tr>
</tbody>
</table>

Click Next
The workfile environment should appear like this:

STEP FIVE: Navigate to **Object/New object** in the main menu

**Note:** We are estimating the reduced form equations for the structural model specified as example previously. Order condition and rank condition has confirmed the reduced form equations are identified. So we are using Indirect Least Squares (ILS) method to estimate the structural model by applying OLS on the reduced form model.
STEP SIX: Click on **Object** and navigate to **System**.

Click **OK** and you would have a display like this:
STEP SEVEN: Now you can **specify all your equations** in the empty space. Let look at the equations being considered for this article.

**STRUCTURAL EQUATIONS**

\[ C_t = b_0 + b_1 Y_t + u_1 \]
\[ I_t = c_0 + c_1 Y_t + c_2 Y_{t-1} + u_2 \]
\[ Y_t = C_t + I_t + G_t \]

**REDUCED FORM EQUATIONS**

\[ C_t = \nu_{11} Y_{t-1} + \nu_{12} G_t + v_1 \]
\[ I_t = \nu_{21} Y_{t-1} + \nu_{22} G_t + v_2 \]
\[ Y_t = \nu_{31} Y_{t-1} + \nu_{32} G_t + v_3 \]

Note: The reduced form equation is being considered for estimation in this article. The reduced form equations has also been proven to be identified which validates the use of indirect least squares method. After the reduced form has been estimated with ordinary least squares method, the reduced form equations coefficients would be used to estimate the structural form model.

\[ C_t \] ► CONS
\[ I_t \] ► INV

The equation would be specified as thus:

\[ \log(CONS) = C(1) + C(2) \cdot \log(Y(-1)) + C(3) \cdot \log(G) \]
\[ \log(INV) = C(4) + C(5) \cdot \log(Y(-1)) + C(6) \cdot \log(G) \]
\[ \log(Y) = C(7) + C(8) \cdot \log(Y(-1)) + C(9) \cdot \log(G) \]
STEP EIGHT: Click **Estimate** in the Menu options and this would appear:
Click on OK, you should now have the estimation result

![Estimation Result Table]

Determinant residual covariance 8.01E-08

Equation: \( \text{LOG(CONS)} = C(1) + C(2) \times \text{LOG(Y(-1))} + C(3) \times \text{LOG(G)} \)

Observations: 34

\[ R^2 = 0.996032 \quad \text{Mean dependent var} = 25.55266 \]

\[ \text{Adjusted } R^2 = 0.996063 \quad \text{S.D. dependent var} = 0.573340 \]

\[ \text{S.E. of regression} = 0.036074 \quad \text{Sum squared resid} = 0.040119 \]

\[ \text{Durbin-Watson stat} = 1.593898 \]

Equation: \( \text{LOG(NW)} = C(4) + C(5) \times \text{LOG(Y(-1))} + C(6) \times \text{LOG(G)} \)

Observations: 34

\[ R^2 = 0.754959 \quad \text{Mean dependent var} = 23.91218 \]

\[ \text{Adjusted } R^2 = 0.739149 \quad \text{S.D. dependent var} = 0.572814 \]

\[ \text{S.E. of regression} = 0.292557 \quad \text{Sum squared resid} = 2.653269 \]

\[ \text{Durbin-Watson stat} = 0.516988 \]

Equation: \( \text{LOG(Y)} = C(7) + C(8) \times \text{LOG(Y(-1))} + C(9) \times \text{LOG(G)} \)

Observations: 34

\[ R^2 = 0.991631 \quad \text{Mean dependent var} = 25.95734 \]

\[ \text{Adjusted } R^2 = 0.991091 \quad \text{S.D. dependent var} = 0.494376 \]

\[ \text{S.E. of regression} = 0.046003 \quad \text{Sum squared resid} = 0.067501 \]

\[ \text{Durbin-Watson stat} = 1.291271 \]

Relating this to the specified reduced form equation:

Note: Constants \( n_{10} \), \( n_{20} \), \( n_{30} \) were excluded from the equations for simplicity.

\[ C_t = n_{10} + n_{11} Y_{t-1} + n_{12} G_t + v_1 \]

\[ I_t = n_{20} + n_{21} Y_{t-1} + n_{22} G_t + v_2 \]
\[ Y_t = \pi_{30} + \pi_{31} Y_{t-1} + \pi_{32} G_t + v_3 \]

\[ \text{Log(CONS)} = C(1) + C(2) \times \text{Log(Y(-1))} + C(3) \times \text{Log(G)} \]

\[ \text{Log(INV)} = C(4) + C(5) \times \text{Log(Y(-1))} + C(6) \times \text{Log(G)} \]

\[ \text{Log(Y)} = C(7) + C(8) \times \text{Log(Y(-1))} + C(9) \times \text{Log(G)} \]

\( \pi_{10} = C(1) , \pi_{20} = C(4) , \pi_{30} = C(7) , \pi_{11} = C(2) , \pi_{12} = C(3) , \pi_{21} = C(5) , \pi_{22} = C(6) \)

\( \pi_{31} = C(8) , \pi_{32} = C(9) \)

Recall: From the working of the reduced form equations from the structural models:

\[ \pi_{12} = b_1(\pi_{32}) , \pi_{11} = b_1(\pi_{31}) , \pi_{10} = b_1(\pi_{30}) , c_1(\pi_{31}) + c_2 = \pi_{21} , c_1(\pi_{32}) = \pi_{22} , \]

\[ b_1 = \frac{n_{11} + n_{12}}{n_{31} + n_{32}} , c_1 = \pi_{22}/\pi_{32} , c_2 = \pi_{21} - c_1(\pi_{31}) , b_0 = \pi_{10} - b_1(\pi_{30}) , c_0 = \pi_{20} - c_1(\pi_{30}) \]

\( \pi_{10} = -2.525604 \), \( \pi_{11} = -0.231220 \), \( \pi_{12} = 1.319813 \), \( \pi_{20} = -1.990124 \), \( \pi_{21} = 0.377008 \)

\( \pi_{22} = 0.624855 \), \( \pi_{30} = -0.007419 \), \( \pi_{31} = 0.522939 \), \( \pi_{32} = 0.480758 \)

\[ b_1 = \frac{-0.231220 + 1.319813}{0.522939 + 0.480758} \]

\[ b_1 = 1.088593/1.003697 \]

\[ b_1 = 1.084583 \]

\[ b_0 = -2.525604 - (1.084583)(-0.007419) \]

\[ b_0 = -2.525604 + 0.008047 \]

\[ b_0 = -2.517557 \]

\[ c_1 = 0.624855/0.480758 \]

\[ c_1 = 1.299739 \]

\[ c_0 = \pi_{20} - c_1(\pi_{30}) \]

\[ c_0 = -1.990124 - 1.299739(-0.007419) \]

\[ c_0 = -1.990124 + 0.009643 \]
\[ c_0 = -1.980481 \]
\[ c_2 = 0.377008 - 1.299739(0.522939) \]
\[ c_2 = 0.377008 - 0.679684 \]
\[ c_2 = -0.302676 \]

STEP NINE: Respecifying the structural equations by substituting the estimated structural parameters in the structural equations.

\[ C_t = b_0 + b_1 Y_t + u_t \]
\[ I_t = c_0 + c_1 Y_t + c_2 Y_{t-1} + u_2 \]
\[ Y_t = C_t + I_t + G_t \]
\[ C_t = -2.517557 + 1.084583 Y_t \]
\[ I_t = -1.980481 + 1.299739 Y_t - 0.302676 Y_{t-1} \]
\[ Y_t = -2.536305 + 1.084583 Y_t + (-1.980481 + 1.299739 Y_t - 0.302676 Y_{t-1}) + G_t \]
\[ Y_t = -2.536305 - 1.980481 + 1.299739 Y_t + 1.084583 Y_t - 0.302676 Y_{t-1} + G_t \]
\[ Y_t = -4.516786 + 2.384322 Y_t - 0.302676 Y_{t-1} + G_t \]
\[ Y_t - 2.384322 Y_t = -4.516786 - 0.302676 Y_{t-1} + G_t \]
\[ -1.384322 Y_t = -4.516786 - 0.302676 Y_{t-1} + G_t \]
\[ Y_t = -4.516786/-1.384322 - (0.302676/-1.384322) Y_{t-1} + G_t/-1.384322 \]
\[ Y_t = 3.262814 + 0.218641 Y_{t-1} - 0.722375 G_t \]
STRUCTURAL EQUATIONS

\[ C_t = -2.517557 + 1.084583Y_t \]
\[ I_t = -1.980481 + 1.299739Y_t - 0.302676Y_{t-1} \]
\[ Y_t = 3.262814 + 0.218641Y_{t-1} - 0.722375G_t \]

REDUCED FORM EQUATIONS

\[ C_t = -2.525604 - 0.231220Y_{t-1} + 1.319813G_t \]
\[ I_t = -1.990124 + 0.377008Y_{t-1} + 0.624855G_t \]
\[ Y_t = -0.007419 + 0.522939Y_{t-1} + 0.480758G_t \]
SIMULATING WITH SIMULTANEOUS EQUATION WITH EVIEWS

Simulating mostly requires having at least one policy variable so as to be able forecast to help in policy recommendation. Recall we made use of data ranging from 1981-2015, what if we want to forecast what the values of our endogenous variables would be in 2020 if government expenditure is increased or decreased? **Simulating the endogenous variables requires using one of the simulation method to forecast the values of the exogenous variables.**

Using the weighted average method to forecast the values of $Y_{t-1}$ for 2016-2020 and assuming government expenditure increases or decreases by 10%.

**STEP 1:** Increase the sample size of the variables uploaded in Eviews by double clicking on the highlighted portion and changing the End date from 2015 to 2020.
STEP 2: Click OK

Click Yes

You would observe a change in data range

STEP 3: Generate series for the exogenous variable to be forecasted. The Trend projection method would be used in this article to forecast $Y_{t-1}$.

$Y_{t-1} = a + b(Trend)$

We would number the years from 1981-2020 to generate a trend variable. 1981-2020 generates a trend variable of 1-40.
<table>
<thead>
<tr>
<th>Years</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>1</td>
</tr>
<tr>
<td>1982</td>
<td>2</td>
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<tr>
<td>1983</td>
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<tr>
<td>1992</td>
<td>12</td>
</tr>
<tr>
<td>1993</td>
<td>13</td>
</tr>
</tbody>
</table>

Upload this trend variable to the eviews workfile, after $Y_{t-1}$ should be regressed on the Trend variable as below. Quick/Estimate equation
After clicking Estimate equation, the equation should be specified thus:

![Equation Estimation window](image)

Click OK.

![View window](image)
To generate the estimated values of $Y_{t-1}$,

Navigate to Proc/Make model as shown below under the trend equation

Click on Make model, this would appear
Navigate and click on Solve, also change the highlighted from baseline to scenario 1, Specify the solution sample as 2016 2020 because that is the considered data range for simulation this would appear

It is also better to change the Solver from Broyden to Gauss-Seidel because it is the commonly used in macro-econometric literature to Solve models
After all this changes has been made, Click OK and a variable y_1 would be added to the variable list

Now generate the value of y for 2016-2020 from y_1.

Navigate to generate series as shown below:
If you open the y variable in the eviews workfile, you would observe values are already assigned to year 2016-2020

<table>
<thead>
<tr>
<th>Year</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>2016</td>
<td>4.85E+10</td>
</tr>
<tr>
<td>2017</td>
<td>4.06E+10</td>
</tr>
<tr>
<td>2018</td>
<td>5.06E+10</td>
</tr>
<tr>
<td>2019</td>
<td>5.17E+10</td>
</tr>
<tr>
<td>2020</td>
<td>5.27E+10</td>
</tr>
</tbody>
</table>

Recall: Government expenditure ($G_t$) is the policy variable.

Assume Government expenditure is increased by 10%, what would be the value of $C_t$, $I_t$ and $Y_t$. Would they increase or decrease?

Follow the same step in generating variables to generate values for $g$ in 2016-2020,

$$g = 1.10 \times g(-1)$$
Click OK and you would observe variables are generated for 2016-2020

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
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<tr>
<td>2019</td>
<td>5.70E+11</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>6.27E+11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

STEP 4: Substitute the generated values of G and Y_{t-1} to get the projected values of C_t, I_t, Y_t by solving the reduced form equations.

Open the saved estimated reduced form equation (the reduced form equation is saved with simulta)

Click **Proc** in the estimated reduced form equation and navigate to **Make model**.

**Proc/Make Model**
Click **Solve**

**Add new scenario 2 because scenario 1 has previously been used.** Click **Add/Delete Scenarios. Add/Delete Scenarios ➔ Create New Scenario**

**Scenario 2 would be created**
After clicking OK, you would observe new variables (cons_2, inv_2, y_2) are already included in the eviews workfile.

Now, let see what the new values of consumption expenditure, investment expenditure and income are from 2016-2020 compared to that of 2015.

<table>
<thead>
<tr>
<th>YEARS</th>
<th>C</th>
<th>I</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>3.16E+11</td>
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<td>6.94E+10</td>
</tr>
<tr>
<td>2016</td>
<td>5.6E+11</td>
<td>3.1E+10</td>
<td>1.81E+11</td>
</tr>
<tr>
<td>2017</td>
<td>5.08E+11</td>
<td>4.72E+10</td>
<td>3.13E+11</td>
</tr>
<tr>
<td>2018</td>
<td>5.08E+11</td>
<td>6.16E+10</td>
<td>4.37E+11</td>
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<tr>
<td>2019</td>
<td>5.34E+11</td>
<td>7.41E+10</td>
<td>5.44E+11</td>
</tr>
<tr>
<td>2020</td>
<td>5.75E+11</td>
<td>8.54E+10</td>
<td>6.39E+11</td>
</tr>
</tbody>
</table>
The table above which contains the simulated values of C, I and Y indicates that if there is a 10% increase in government expenditure, consumption expenditure would increase from 316 billion US dollar to 575 billion US dollar in 2020, Investment expenditure would increase from 69.4 billion US dollar to 85.4 billion US dollar in 2020, income would increase from 69.4 billion US dollar to 639 billion US dollar in 2020 (almost 9.2 times the value of income in 2015).

If there is a 10% decrease in Government expenditure, Same STEPS would be taken aside from the command for generating the new values of G.

\[ g = 0.9^*g(-1) \]

Solution sample = 2016 2020
If there is a 10% decrease in Government expenditure, consumption expenditure increased from 316 billion US dollar in 2015 to 430 billion US dollar in 2016, after which there was a decrease in consumption expenditure over the years even up to 2020, the projected consumption expenditure in 2020 is 176 billion US dollar almost half the value of consumption expenditure in 2015. There was a sharp decrease in Investment expenditure from year 2015 to 2016, after which investment expenditure started experiencing a slight increase from year 2016 to 2017, 2017 to 2018. Investment expenditure started decreasing again from year 2018 to 2020. However, the projected investment expenditure for 2020 is
36.4 billion US dollar. Income increased rapidly from year 2015 to 2016 which makes the income of 2015 almost thrice the income of 2016. Income kept increasing from year 2016 to year 2019, after which income decreased slightly from 297 billion US dollar to 288 billion US dollar. The projected income for 2020 is approximately 288 billion US dollar which is more than four times the value of income in 2015.

**Note:** Other simulation methods can also be used to obtain values of exogenous variables in any simultaneous equation model. Other instances can also be assumed for policy recommendation.

**WORKINGS FOR THE REDUCED FORM MODEL (EXAMPLE)**

\[ C_t = b_0 + b_1 Y_t + u_1 \]  \hspace{1cm} (1)

\[ I_t = c_0 + c_1 Y_t + c_2 Y_{t-1} + u_2 \]  \hspace{1cm} (2)

\[ Y_t = C_t + I_t + G_t \]  \hspace{1cm} (3)

Substitute equation 1 and 2 in equation 3

\[ Y_t = b_0 + b_1 Y_t + u_1 + c_0 + c_1 Y_t + c_2 Y_{t-1} + u_2 + G_t \]

\[ Y_t - b_1 Y_t - c_1 Y_t = (b_0 + c_0) + c_2 Y_{t-1} + G_t + (u_1 + u_2) \]

\[ Y_t(1 - b_1 - c_1) = (b_0 + c_0) + c_2 Y_{t-1} + G_t + (u_1 + u_2) \]

Divide both sides by \((1 - b_1 - c_1)\)

\[ Y_t = \frac{b_0 + c_0}{1 - b_1 - c_1} + \frac{c_2}{1 - b_1 - c_1} Y_{t-1} + \frac{1}{1 - b_1 - c_1} G_t + \frac{u_1 + u_2}{1 - b_1 - c_1} \]

Let \( \Pi_{30} = \frac{b_0 + c_0}{1 - b_1 - c_1} \), \( \Pi_{31} = \frac{c_2}{1 - b_1 - c_1} \), \( \Pi_{32} = \frac{1}{1 - b_1 - c_1} \), \( V_3 = \frac{u_1 + u_2}{1 - b_1 - c_1} \)

\[ Y_t = \Pi_{30} + \Pi_{31} Y_{t-1} + \Pi_{32} G_t + V_3 \]  \hspace{1cm} (4)

Substitute Equation 4 in equation 2 and 3
Substituting equation 4 in equation 2

\[ C_t = b_0 + b_1 (n_{30} + n_{31} Y_{t-1} + n_{32} G_t + v_3) + u_1 \]

\[ C_t = (b_0 + b_1(n_{30})) + b_1(n_{31})y_{t-1} + b_1(n_{32})G_t + (b_1 v_3 + u_1) \]

\[ n_{10} = (b_0 + b_1(n_{30})) , \quad n_{11} = b_1(n_{31}) , \quad n_{12} = b_1(n_{32}) , \quad v_1 = (b_1 v_3 + u_1) \]

\[ C_t = n_{10} + n_{11} Y_{t-1} + n_{12} G_t + v_1 \]

Substituting equation 4 in equation 3

\[ I_t = c_0 + c_1(n_{30} + n_{31} Y_{t-1} + n_{32} G_t + v_3) + c_2 Y_{t-1} + u_2 \]

\[ I_t = (c_0 + c_1(n_{30})) + c_1(n_{31})Y_{t-1} + c_1(n_{32})G_t + c_1v_3 + c_2 Y_{t-1} + u_2 \]

\[ I_t = (c_0 + c_1(n_{30})) + c_1(n_{31})Y_{t-1} + c_2 Y_{t-1} + c_1(n_{32})G_t + (c_1v_3 + u_2) \]

\[ I_t = (c_0 + c_1(n_{30})) + (c_1(n_{31}) + c_2) Y_{t-1} + (c_1v_3 + u_2) \]

Let: \[ n_{20} = (c_0 + c_1(n_{30})) , \quad n_{21} = (c_1(n_{31}) + c_2) , \quad n_{22} = c_1(n_{32})G_t , \quad v_2 = (c_1v_3 + u_2) \]

\[ I_t = n_{20} + n_{21} Y_{t-1} + n_{22} G_t + v_2 \]

The reduced form equations:

\[ C_t = n_{10} + n_{11} Y_{t-1} + n_{12} G_t + v_1 \]

\[ I_t = n_{20} + n_{21} Y_{t-1} + n_{22} G_t + v_2 \]

\[ Y_t = n_{30} + n_{31} Y_{t-1} + n_{32} G_t + v_3 \]

Solving for the coefficients of the structural equations.

Recall:

\[ n_{10} = (b_0 + b_1(n_{30})) , \quad n_{11} = b_1(n_{31}) , \quad n_{12} = b_1(n_{32}) , \quad v_1 = (b_1 v_3 + u_1) \]
\[ n_{20} = (c_0 + c_1(n_{30})) , \quad n_{21} = (c_1(n_{31}) + c_2) , \quad n_{22} = c_1(n_{32})G_1 , \quad \nu_2 = (c_1\nu_3 + u_2) \]

\[ b_0 = n_{10} - b_1(n_{30}) , \]

\[ n_{11} + n_{12} = b_1(n_{31}) + b_1(n_{32}) \]

\[ n_{11} + n_{12} = b_1(n_{31} + n_{32}) \]

\[ b_1 = \frac{n_{11} + n_{12}}{n_{31} + n_{32}} \]

\[ c_0 = n_{20} - c_1(n_{30}) \]

\[ c_1 = \frac{n_{22}}{n_{32}} \]

\[ c_2 = n_{21} - c_1(n_{31}) \]

**References**

Afees A. Salisu. A guide to simulation with Eviews 7.0, Centre for Econometric and Allied Research(CEAR)


<table>
<thead>
<tr>
<th>Year</th>
<th>Y</th>
<th>C</th>
<th>G</th>
<th>I</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>1.25E+11</td>
<td>1.01E+11</td>
<td>1.35E+11</td>
<td>5.87E+10</td>
<td>1</td>
</tr>
<tr>
<td>1982</td>
<td>1.24E+11</td>
<td>9.55E+10</td>
<td>1.26E+11</td>
<td>4.55E+10</td>
<td>2</td>
</tr>
<tr>
<td>1983</td>
<td>1.17E+11</td>
<td>8.4E+10</td>
<td>1.12E+11</td>
<td>2.99E+10</td>
<td>3</td>
</tr>
<tr>
<td>1984</td>
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