

GUIDE TO THE MACROECONOMIC MODEL

PROF. RAJEEV DHAWAN

Director of Economic Forecasting Center, GSU

&

PROF. LARRY J. KIMBELL

Professor Emeritus, UCLA

Spring 2008

Table of Contents

- Section 1: A Model Simulation Approach to Macroeconomics
- Section 2: Classification of Equations
- Section 3: Glossary of Variables
- Section 4: Listing of Equations in the Integrated Macro Model
- Section 5: Flow Diagram of the Integrated Macro Model
- Section 6: Policy Experiments with the Integrated Macro Model
- Section 7: Guidelines to Use the Model

Section 1:

A FLOW DIAGRAM AND MODEL SIMULATION APPROACH TO MACROECONOMICS

Outline of the Flow Diagram and Model Simulation Approach to Macroeconomics:

1. State macroeconomic theory as a complete set of algebraic equations.
2. Estimate/postulate numerical values of all parameters.
3. Assume initial conditions for the history of all lagged variables.
4. Assume “base case” values over future time periods for all exogenous variables.
5. Solve the model under base case assumptions.
6. Change some of the exogenous variable assumptions.
7. Solve the model again under alternative assumptions.
8. Compare model solutions between the *Base Case* and the alternative policy *Simulation*.

Advantages of the Model Simulation Approach:

1. Integrates short run and long run analysis into one coherent story of the dynamic reactions of an economy to macroeconomic policy.
2. Traces the complete logic of the model, step-by-step, instead of trying to condense model into a two-dimensional diagram, such as IS-LM diagram.
3. Extends to real-world macroeconomic policy issues.
4. Same process applies to realistic models of actual economies, such as U.S. forecasting models, or OECD models of major countries.

Section 2: CLASSIFICATION AND LISTING OF EQUATIONS

A. List of variables defined by exact **accounting identities** (always true): real GDP, tax revenues, disposable income, net exports, price level

Example: Disposable Income (Y) = Gross Domestic Product (GDP) – Taxes (T)

Accounting Identities have the following properties:

- As conditional forecasting equations, they are PERFECT
- Don't have parameters to be fitted
- No error term
- No theoretical disputes about their truth, only about their relevance

B. List of variables defined by **behavioral equations** (commonly fitted by regression analysis of historical data): consumption, real interest rate, investment, exchange rate, exports, imports, inflation

*Example: Consumption (C) = α_0 * Disposable income (YDP)*

(Where α_0 = marginal propensity to consume = 0.9215686)

Behavioral Equations have the following properties:

- Estimated parameter values change as behavior changes
- Source of all conditional forecasting errors
- Theoretical disputes concerning these equations, e.g., are consumers myopic or forward looking?

Section 3. GLOSSARY OF VARIABLES

Variable	Meaning	Units
C	Consumption	Billions of \$
EX	Exports	Billions of \$
EXCH	Real Exchange Rate	Index
G	Government Purchases	Billions of \$
GDP	Gross Domestic Product	Billions of \$
GDP@FULL	GDP @ Full Employment	Billions of \$
GDP@ROW	GDP in Rest of the World	Billions of \$
I	Investment	Billions of \$
IM	Imports	Billions of \$
M	Money supply	Billions of \$
NETEX	Net Exports	Billions of \$
P	Price Level	Index
P%	Inflation	Percent
P@ROW	Price Level, Rest of the World	Index
R	Real Interest Rate	Percent
R@ROW	Real Interest Rate, Rest of the World	Percent
T	Tax Revenues	Billions of \$
TAX%	Tax Rate	Fraction
YDP	Disposable Income	Billions of \$

Definitions:

$GDP_N = GDP \times P$	Nominal GDP	\$ Billions
$EXCH_N = EXCH \times (P/P@ROW)$	Nominal Exchange Rate	Index
$R_N = R + P\%$	Nominal Interest Rate	Percent

Section 4: LISTING OF 12 EQUATIONS IN THE MODEL

7 Exogenous Variables

- 3 Policy Variables: M, G, TAX%
3 Rest-of-World Variables: P@ROW, R@ROW, GDP@ROW
1 Other Variable: GDP@FULL

12 Endogenous Variables*

One GDP Accounting Identity:

1. $GDP = C + I + G + NETEX$

Three Consumption Related Equations:

2. $T = TAX_{\%} \times GDP$
3. $YDP = GDP - T$
4. $C = \alpha_0 \times YDP$

Two Interest Rate and Investment Equations:

5. $R = \alpha_1 \times \left\{ \frac{GDP \times P}{M} \right\}^{\alpha_2}$
6. $I = \alpha_3 \times GDP \times R^{\alpha_4}$

Four Exchange Rate, Export, Import and Net Export Equations:

7. $EXCH = \left\{ \left(\frac{P @ ROW}{P} \right) \times (\alpha_5 + [\alpha_6 \times R] + [\alpha_7 \times R @ ROW]) \right\}$
8. $EX = \alpha_8 \times \left\{ \frac{EXCH \times P}{P @ ROW} \right\}^{\alpha_9} \times (GDP @ ROW)^{\alpha_{10}}$
9. $IM = \alpha_{11} \times \left\{ \frac{EXCH \times P}{P @ ROW} \right\}^{\alpha_{12}} \times (GDP)^{\alpha_{13}}$
10. $NETEX = EX - IM$

Two Price Inflation Equations:

11. $P_{\%} = \{(\alpha_{14} \times P_{\%t-1}) + (\alpha_{15} \times [GDP - GDP @ FULL])\}$
12. $P = P_{t-1} \times \left\{ \left(\frac{P_{\%t-1}}{100} \right) + 1 \right\}$

Note:

-
- This model has 12 equations and 12 unknown variables which are GDP, C, I, EX, IM, NETEX, R, P, YDP, T, EXCH, P%.
 - α_i , $i = 0, 1, 2, 3, \dots, 15$, are numerically fixed parameters
 - X_{t-1} means variable X lagged by one year

Section 6: POLICY EXPERIMENTS WITH THE INTEGRATED MACRO MODEL

Introduction

The **Macroeconomic Model** simulates the working of the US Economy using explicit equations to model consumption, investment, exports, imports, exchange rate, price level and inflation rate. The exogenous factors in the model, apart from GDP potential, are domestic policy variables, which are money supply, government spending and tax policy, as well as rest-of-the-world (ROW) factors such as foreign interest rate, foreign price level and ROW GDP potential.

Policy Experiments are comparisons of simulated time paths of all endogenous variables to changes in the values of some of the exogenous variables representing macroeconomic policy, such as government spending, taxes, or money growth.

Three policy experiments are discussed in this Guide:

1. **An Inflation Policy Experiment:** Simulated response to an increase in the growth of money supply from zero to a chosen rate of inflation (1 to 20 percent range).
2. **A Fiscal-Stimulus Policy Experiment:** Simulated response to an increase in real government spending by \$50 billion increments without any change in taxes.
3. **A Neutral-Budget Policy Experiment:** Simulated response to two coordinated fiscal policy changes:
 - a. An increase in real government spending, (the same as in the second experiment).
 - b. An increase in tax rates high enough to “crowd out” an exactly offsetting amount of consumption.

Econ 101 Rule

This rule states that *“Given the values of exogenous variables for a given economy, if the values of inflation ($P\%$) = 0.00% and nominal exchange rate ($EXCH_N$) = 1.00, then the economy is in equilibrium or steady state in such a way that actual GDP is exactly equal to potential GDP”*. This also implies that the values of the Endogenous variables will also be constant for the subsequent years. This follows from the fact, that P and $P\%$ from today become the exogenous variables for subsequent years’ endogenous value calculations as seen from equations 11 and 12.

BASE CASE:

The *Base Case* that these experimental results or *simulations* are compared with is the state of the economy where for the given values of exogenous variables, the ECON 101 rule applies and the values of endogenous variables solved in the first year remain constant for all subsequent years. This means that GDP will be equal to its potential value for all the years in the base case. Inflation will be zero, and the nominal exchange value will be at one for all the years in a base case.

1. An Inflation Policy Experiment

In this experiment:

- The rate of growth of the money supply is increased from 0% in the historical past to a chosen number (between 1-20%) to see what a money supply shock would do to the economy.
- Inflation follows the money growth path, slightly over-shooting on the way down.
- Real GDP shoots above the Base Case values (and also the potential GDP), so there is a boom in the economy in the short run. In the long run, once prices adjust, the economy is back to potential GDP, although the vibration shock is still obvious.
- The real disposable income increases and so does the real consumption.
- The real interest rate becomes cyclic. At first it drops and pulls down the real exchange rate, which increases real exports and real imports, keeping the real net exports almost constant.
- In the short run, lower money growth raises the unemployment rate. However, once inflation is brought under control, the unemployment rate returns to the natural rate of unemployment.
- In the long run, all real variables return to their Base Case values and the only lasting effects are lower money growth, which leads to less inflation.

2. Fiscal Stimulus Policy Experiment

In this experiment real government spending is increased in steps of \$50 billion higher than in the Base Case Simulation. The tax rate is held constant (tax revenues vary, of course, with real GDP). A deficit-financed war provides the historical context for large increases in government spending. Fortunately, wars do not often last as long as the 26 year simulation period, from 2008 to 2033. We simulate the response long enough for almost all dynamic reactions to be complete.

Long Run Responses

Examine the simulated response in Table 2 and compare then with the Base Case in Table 1 for the last several years, from 2028 to 2033. A shock to the large, open economy model sets in motion a damped oscillation toward a very long run steady state. After 26 years, these

oscillations are small but not entirely gone. We will “round off” and make an educated guess about where the model settles. Highlights of the reactions and their rationale include:

- Government spending is higher by assumption.
- Taxes return to Base Case values, since real GDP does as well.
- Real GDP, or output, returns to Base Case values (**government spending does not affect long run real GDP**).
- Disposable income and consumption are therefore unaffected as well.
- The (nominal) money supply is unchanged, by assumption.
- Higher government spending “crowds out” private investment and net exports by raising the price level to a sustained higher level for a transitional period.
- With the same real GDP and money supply but a higher price level, the real interest rate rises, crowding out private investment.
- A higher real interest rate raises the real exchange rate, lowering real exports and raising real imports. Net exports therefore drops for both reasons.
- With the same real GDP, and by assumption the same potential GDP, employment is the same and the unemployment rate returns to its natural rate.

Short Run Responses

The real government spending shock causes transition effects that are quite different from the Long Run results, which mainly show “crowding out” effects. Highlights include:

- Higher government spending adds directly to real GDP, by the national income accounting identity. Since prices do not adjust completely in the first year, the full adjustment is delayed and the economy goes into a damped oscillation toward the long run steady state.
- Higher real GDP, with constant tax rates, raises real disposable income, which raises consumption. This “multiplier process” reinforces the boom induced by direct government spending.
- The booming economy raises the demand for money and forces the real interest rate higher. A higher real interest rate lowers real investment.
- Higher real interest rates also raise the exchange rate relative to the domestic price level and the rest-of-the-world price level. That is, the real exchange rate rises. This

lowers real exports and raises real Imports, causing net exports to drop for both the reasons.

- The booming government and consumption sectors add more employment than losses due to lower investment and net exports, so temporarily the unemployment rate drops.

Transition from Short Run to Long Run

The economic adjustment from the short run to the long run involves inertia in the price level, which is gradually adjusting each year. This imparts a pendulum-like swing to the economy, so it “over-shoots” the steady state and moves from boom to bust. Unemployment, for example, rises above the natural rate and real GDP drops below potential GDP.

3. Neutral-Budget Policy Experiment

In this experiment real government spending is increased by the same one-step increase imposed in the first experiment. However, instead of running a deficit, the government raises the tax rate high enough to crowd out the exact amount of increase in government spending by reducing consumption.

Since the marginal propensity to consume (α_0) in the model is 92.5%, this requires a tax rate high enough to raise revenues equivalent to the increase in government spending. If real GDP is to be kept constant, the real disposable income is lowered by the increase in government spending. Consumption, as targeted and savings also drops due to the shift. The following equation calculates the needed increase in the tax rate:

$$NewTax\% = OldTax\% \times \left\{ \frac{\Delta G}{\alpha_0} \right\} \times \left\{ \frac{1}{GDP @ FULL} \right\}$$

Since the higher injection of real government spending into real GDP is exactly offset by induced lower consumption, there are no effects on the real interest rate, investment, or net exports.

Section 7: GUIDELINES TO USE THE MODEL

Instructions to Start Using the Simulations Model:

- a) First, whenever you open the worksheet for the **first time** on your system, click on **TOOLS** from the menu bar, click on **OPTIONS**, then choose the **CALCULATIONS TAB**. Check the box in front of **Iterations** and **specify 100** in the maximum iterations box (default is 100) and click **OK**. Note the model sits in the Calculations worksheet where all the steps are done. The Graphs and Print sheet are then updated when an experiment in the calculation sheet is undertaken. The **BASE CASE** is the steady state of the model when inflation, money growth, fiscal changes are all zero. After any changes in the values or growth rate of these variables we get the new solution referred to as **SIM** (short for simulation experiment). To solve the model for new values of endogenous variables after making any changes in the values of fiscal or monetary variables one needs to do the following two steps. Pressing the **CALCULATE BUTTON (STEP #1)** on the Calculations Worksheet runs the simulation of all the endogenous variables in the economy for years 2007-2032. If at any point during the calculations process, you wish to stop it press the **ESCAPE** key and select **End of Operation**. The process will resume from the beginning when you press the Calculate Button again.

- b) Pressing the **GRAPHS BUTTON (STEP #2)**, on the Calculations Worksheet copies all the values of Endogenous and Exogenous Variables from the Calculations Worksheet and pastes them on a new worksheet called Values. It also creates related graphs in a new worksheet called GRAPHS. There are 17 graphs, which you can see by either scrolling down or by clicking the box with the graph name at the top of the sheet, which brings that graph to the top. To view another graph, close the window of the existing graph and press the button for the respective graph you want. Note: The graphs of the Base Case don't necessarily appear correct to the human eye as it shows some gyrations even though the values of the economic variables are constant over 30 years. This "optical illusion" happens because of small variations in decimal values (a result of numerical accuracy in Excel) and appears to be a cycle or trend in the GRAPHS Worksheet. When closely observed (look at the scale of the Y axis), these values are for practical purpose constant.

- c) To print the results of your experiment press the **PRINT** Button on the Calculations Worksheet or the Print Results Worksheet.

- d) To **reset** the whole model, press the **BASE CASE** Button on the Calculations Worksheet, and then press the **CALCULATE** button once to run the whole model simulation to return to the original base case where you started.

Instructions to Start Using the One-Year Model:

1. The one-year model gives you the ability to create a new economy by changing the values of some exogenous and parameter values.
2. Columns B, C, D represent the base case values for an economy having GDP = \$7,000 billion. Also, this economy is stable because the Econ 101 rule is incorporated with inflation = 0% and nominal exchange rate = 1.00

3. Columns F and G represent the set of exogenous and parameter values that need to be changed (depending on the experiment) to create the required values of endogenous values for the new economy.
4. Pressing the **BASE CASE** Button on top of this spreadsheet in cells B1-C1 brings the all the endogenous, exogenous and parameter values to the base case economy of GDP = \$ 7,000 billion. It will undo all the changes made so far to the exogenous and parameter values.
5. Pressing the **FEED GDP** Button in the cells I12-J14 computes the values for exogenous values for the selected endogenous and parameter values to create a new economy.
6. The "PRINT COPY" Button helps you to print a copy of the solved results for the desired new economy.
7. Pressing the **COPY EXOGENOUS & PARAMETER VALUES FOR SIMULATION** button in the cells F5-G8 copies the values of the final computed economy required for simulation. The values of the new set of exogenous and parameter values are copied and pasted in the spreadsheet called "Calculations". This helps in doing a simulation of the economy for next 26 years using the new set of values for a different economy.
8. **After Copying the Exogenous & Parameter Values always run the simulations once before doing any experiments with the new economy.** Pressing the "Calculate" Button in the Calculations Worksheet does this.
9. After this simulation is done press the "**COPY STEADY STATE VALUES**" button in cell no. A144 on Calculations Worksheet.
10. Now, you are all set to do the experiments. Use the "Instructions to start using the model" for doing the experiments.

Experiments:

1. **Constant money supply growth experiments: There are three steps involved to do this experiment. In Step A choose the growth rate of money supply from the drop-down menu. In Step B click whether this is a positive (i.e. a loose monetary policy) or a negative growth rate from the two choices given. Choices in Step C result in following 3 experiments:**
 - a) If you click on **Mon. Policy Change For All Years:** This experiment increases the money supply by a constant growth % selected in the drop down menu every year, starting in the year 2008.
 - b) If you click on **Monetary Policy Stops in 2012:** This experiment increases the money supply by a constant growth % selected in the drop down menu for four years starting in 2008 and ending in 2012 when the money supply growth rate drops to 0%. (**Note:** the four-year growth spurt is timed to coincide with one Chairman of FOMC term).
 - c) If you click on **Monetary Policy Stops Slowly by 2015:** This experiment increases the money supply by a constant growth % selected in the drop-down menu for four years starting in 2008. From 2012 onwards, the growth rate of the money supply is brought down to 0% by 2015 in equal increments

2. Deficit Financing Experiments: There are three steps involved to do this experiment. In Step A choose the government spending value from the drop-down menu. In Step B click whether this is a positive or a negative change in government spending. Choices in Step C result in following 2 experiments:

- a) If you click on **Govt. Spending Stays at New Levels Until 2033:** This experiment increases government spending by a constant amount selected in the drop-down menu for four years starting in 2008 and ending in 2012. From 2013 until 2033, the value of government spending is equal to the value in 2012, the last year of the increase (**Note:** The four year growth spurt is timed to coincide with one Presidential term).
- b) If you click on **Govt. Spending is Restored to Original Level by 2016:** This experiment increases Government Spending by a constant amount selected in the drop down menu for four years from 2008 to 2012 and then is reduced in equal increments by 2016 to its historical value in 2007. (**Note:** The four-year growth spurt and subsequent reduction in four years is timed to coincide with two Presidential terms).

3. Neutral or Balanced Budget Experiment

- a) In this experiment, select the increase in government spending by a constant amount in 2008. This one-time increase is maintained for the rest of the simulation period until 2033. The model then will calculate the required increase in the tax rate needed to offset the increase in government spending making for a **NEUTRAL BUDGET experiment**.

4. Stop-Go Experiment

- a) In this experiment, the money supply growth is increasing every year for first three years and drops to zero in the fourth year. It starts increasing again in the fifth year, goes on increasing for the next five years, and then drops to zero in the tenth year. It starts increasing again in the eleventh year, goes on increasing for seven years then drops to zero and remains at zero after the eighteenth year. (Note: The factor by which the money supply growth can be changed is in the adjoining box).

TECHNICAL DETAILS

Pressing the **CALCULATE BUTTON (STEP #1)**, on the Calculations Worksheet runs the simulation of all the endogenous variables in the economy for years 2005-2030. This click of a button does 130,000 calculations to come-up with the simulation numbers! If you need to increase the accuracy of the model, you will have to change the Excel Solver iterations. To change the # of iterations: click on **TOOLS** from the menu bar, and then click **OPTIONS**, and choose the **Calculations Tab** there. Check the box in front of **Iterations** and specify the number of iterations (say 200) in the maximum iterations box (default is 100) and click **OK**.