# The US Model Workbook

**Ray C. Fair**

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# Contents

# Preface

This workbook can be used at a variety of levels. Chapter 1 contains introductory material. It presents the vocabulary of model building and covers the main issues that are involved in constructing and working with macroeconometric models. Chapter 2 is a review of the US model, and you should definitely look over this chapter before beginning to do the experiments. Some of the material in Chapter 2 is intermediate or advanced, but it can be easily skipped by introductory users.

The experiments begin in Chapter 3. The experiments in Chapter 3 are descriptive, and these can be very useful for introductory students. The experiments give students a feel for the data, especially for how variables change over time. All of Chapter 3 is introductory. Chapter 4 is also introductory; it contains descriptive experiments about the National Income and Product Accounts (NIPA) and the Flow of Funds Accounts (FFA).

The analysis begins in Chapter 5, where fiscal-policy effects are examined. This material is accessible to introductory students who have had the equivalent of the IS-LM model. (Although most introductory texts do not refer to the model that they are teaching as the"IS-LM" model, this is in fact the model that they are using.) The first two experiments pertain to changing government spending under two different assumptions about monetary policy. The rest of the experiments in this chapter pertain to changing other fiscal-policy variables, and this can be skipped by introductory users if desired.

Chapter 6 discusses monetary-policy effects, namely the effects of changing the short term interest rate, and again this material is accessible to those who have had the equivalent of the IS-LM model.

The first part of Chapter 7 discusses price shocks, and this material is accessible to those who have had the equivalent of the AS-AD model. The first two experiments concern changing the import price index, $PIM$, and these changes can be looked upon as shifts of the AS curve. Both of these experiments are good ways of showing how stagflation can arise. The second part of Chapter 7 examines wealth effects through stock market shocks, and this is intermediate material.

Chapter 8 is also intermediate material. It examines the effects on the economy of changing housing prices.

Chapters 9-13 are intermediate to advanced. Many of the experiments require changing coefficients in the equations and examining how the properties of the model differ for these changes. At the intermediate level this is an excellent way of getting students to have a deeper understanding of macroeconomic issues. The suggestions in Chapter 13 about imposing rational expectations on the model and making major changes to the model are for advanced users.

To summarize, the following is recommended for introductory users:

1. Chapter 1 - read carefully
2. Chapter 2 - look over and then use for reference purposes
3. Chapter 3 - do all the experiments
4. Chapter 4 - do all the experiments
5. Chapter 5 - do at least the first two experiments
6. Chapter 6 - do the experiment
7. Chapter 7 - do the first two experiments

Everything in the workbook is accessible to intermediate users except perhaps for Sections 13.3 and 13.4.

The latest version of the US model is dated January 30, 2016. It has been estimated through 2016:1. The estimates of this version are presented in *The US Model Appendix A: January 30, 2016*. A complete discussion of the version of the US model dated November 11, 2013, is in *Macroeconometric Modeling*. The current version differs from the November 11, 2013, version in the updated estimates, in the addition of the lagged value of housing wealth to the $IHH$ equation, equation 4, and in the dropping of the real wage and lagged wealth variables from the $L2$ equation, equation 6.

*Macroeconometric Modeling* should be read by those contemplating using the model for research. This reference may also be of interest to teachers who would like a deeper understanding of the model than can be obtained by reading Chapter 2 of this workbook. There are a number of experiments in *Macroeconometric Modeling* that may be of interest to discuss with advanced students.

# Chapter 1

# Introduction to Macroeconometric Models

## 1.1 Macroeconometric Models

A macroeconometric model like the US model is a set of equations designed to explain the economy or some part of the economy. There are two types of equations: *stochastic*, or *behavioral*, and *identities*. Stochastic equations are estimated from the historical data. Identities are equations that hold by definition; they are always true.

There are two types of variables in macroeconometric models: *endogenous* and *exogenous*. Endogenous variables are explained by the equations, either the stochastic equations or the identities. Exogenous variables are not explained within the model. They are taken as given from the point of view of the model. For example, suppose you are trying to explain consumption of individuals in the United States. Consumption would be an endogenous variable-a variable you are trying to explain. One possible exogenous variable is the income tax rate. The income tax rate is set by the government, and if you are not interested in explaining government behavior, you would take the tax rate as exogenous.

### Specification

It is easiest to consider what a macroeconometric model is like by considering a simple example. The following is a simple multiplier model. $C_t$ is consumption, $I_t$ is investment, $Y_t$ is total income or GDP, $G_t$ is government spending, and $r_t$ is the interest rate. The $t$ subscripts refer to period $t$.

$$C_t = \alpha_1 + \alpha_2 Y_t + e_t, \tag{1}$$

$$I_t = \beta_1 + \beta_2 r_t + u_t, \tag{2}$$

$$Y_t = C_t + I_t + G_t, \tag{3}$$

Equation (1) is the consumption function, equation (2) is the investment function, and equation (3) is the income identity. Equations (1) and (2) are stochastic equations, and equation (3) is an identity. The endogenous variables are $C_t$, $I_t$, and $Y_t$; they are explained by the model. $r_t$ and $G_t$ are exogenous variables; they are not explained.

The specification of stochastic equations is based on theory. Before we write down equations (1) and (2), we need to specify what factors we think affect consumption and investment in the economy. We decide these factors by using theories of consumption and investment. The theory behind equation (1) is simply that households decide how much to consume on the basis of their current income. The theory behind equation (2) is that firms decide how much to invest on the basis of the current interest rate. In equation (1) consumption is a function of income, and in equation (2) investment is a function of the interest rate. The theories behind these equations are obviously much too simple to be of much practical use, but they are useful for illustration. In practice it is important that we specify our equations on the basis of a plausible theory. For example, we could certainly specify that consumption was a function of the number of sunny days in period $t$, but this would not be sensible. There is no serious theory of household behavior behind this specification.

$e_t$ and $u_t$ are error terms. The error term in an equation encompasses all the other variables that have not been accounted for that help explain the endogenous variable. For example, in equation (1) the only variable that we have explicitly stated affects consumption is income. There are, of course, many other factors that are likely to affect consumption, such as the interest rate and wealth. There are many reasons that not all variables can be included in an equation. In some cases data on a relevant variable may not exist, and in other cases a relevant variable may not be known to the investigator. We summarize the effects of all of the left out variables by adding an error term to the equation. Thus, the error term $e_t$ in equation (1) captures all the factors that affect consumption other than current income. Likewise, the error term $u_t$ in equation (2) captures all the factors that affect investment other than the interest rate.

Now, suppose that we were perfectly correct in specifying that consumption is solely a function of income. That is, contrary to above discussion, suppose there were no other factors that have any influence on consumption except income. Then the error term, $e_t$, would equal zero. Although this is unrealistic, it is clear that one hopes that consumption in each period is mostly explained by income. This would mean that the other factors explaining consumption do not have a large effect, and so the error term for each period would be small. This means that the variance of the error term would be small. The smaller the variance, the more has been explained by the

explanatory variables in the equation. The variance of an error term is an estimate of how much of the left hand side variable has not been explained. In macroeconomics, the variances are never zero; there are always factors that affect variables that are not captured by the stochastic equations.

Equation (3), the income identity, is true regardless of the theories one has for consumption and investment. Income is always equal to consumption plus investment plus government spending (we are ignoring exports and imports here).

## Estimation

Once stochastic equations have been specified (written down), they must be estimated if they are to be used in a model. Theories do not tell us the size of coefficients like $\alpha_1$, $\alpha_2$, $\beta_1$, and $\beta_2$. These coefficients must be estimated using historical data. Given the data and the specification of the equations, the estimation techniques choose the values of the coefficients that best"fit" the data in some sense.

Consider the consumption equation above. One way to think of the best fit of this equation is to graph the observations on consumption and income, with consumption on the vertical axis and income on the horizontal axis. You can then think of the best fit as trying to find the equation of the line that is"closest to" the data points, where $\alpha_2$ would be the slope of the line and $\alpha_1$ would be the intercept. The *ordinary least squares* technique picks the line that minimizes the sum of the squared deviations of each observation to the line.

A common estimation technique in macroeconometrics is *two-stage least squares*, which is the technique used to estimate the US model. This technique is similar to the ordinary least squares technique except that it adjusts for certain statistical problems that arise when there are endogenous variables among the explanatory (right hand side) variables. In our current example, one would estimate the four coefficients $\alpha_1$, $\alpha_2$, $\beta_1$, and $\beta_2$.

## Solution

Once a model has been specified and estimated, it is ready to be solved. By "solving" a model, we mean solving for the values of the endogenous variables given values for the exogenous variables. Remember that exogenous variables are not explained within the model. Say that we are in period $t-1$ and we want to use the model to forecast consumption, investment, and income for period $t$. We must first choose values of government spending and the interest rate for period $t$. Since $t$ is in the future, we do not know for certain what government spending and the interest rate will be in period $t$, and so we must make our best guesses based on available information. (For example, we might use projected government budgets.) In other words, our model

forecasts what consumption, investment, and income will be in period $t$ if the values we chose for government spending and the interest rate in period $t$ are correct. We must also choose values for the error terms for period $t$, which in most cases are taken to be zero. Given the exogenous variable values, the values of the error terms, and the coefficient estimates, equations (1), (2), and (3) are three equations in three unknowns, the three unknowns being the three endogenous variables, $C_t$, $I_t$, and $Y_t$. Thus, the model can be solved to find the three unknowns.

A model like equations (1)-(3) is called *simultaneous*. Income is an explanatory variable in the consumption function, and consumption is a variable in the income identity. One cannot calculate consumption from equation (1) unless income is known, and one cannot calculate income from equation (3) unless consumption is known. We thus say that consumption and income are"simultaneously" determined. (Investment in this model is not simultaneously determined because it can be calculated once the value for the exogenous variable $r_t$ has been chosen.)

The above model, even though it is simultaneous, is easy to solve by simply substituting equations (1) and (2) into (3) and solving the resulting equation for $Y_t$. Once $Y_t$ is solved, $C_t$ can then be solved. In general, however, models are not this simple, and in practice models are usually solved numerically using the *Gauss-Seidel* technique. The steps of the Gauss-Seidel technique are as follows:

1. Guess a set of values for the endogenous variables.

2. Using this set of values for the right hand side variables, solve all the equations for the left hand side variables.

3. Step 2 yields a new set of values of the endogenous variables. Replace the initial set with this new set, and solve for the left hand side variables again.

4. Keep replacing the previous set of values with the new set until the differences between the new set and the previous set are within the required degree of accuracy. When the required accuracy has been reached,"convergence" has been attained, and the model is solved. The right hand side values are consistent with the computed left hand side values.

If a variable computed by an equation is used on the right hand side of an equation that follows, usually the newly computed value is used rather than the value from the previous iteration. It is not necessary to do this, but it usually speeds convergence. The usual procedure for the above model would be to guess a value for $Y_t$, compute $C_t$ from equation (1) and $I_t$ from equation (2), and use the computed values to solve for $Y_t$ in equation (3). This new value of $Y_t$ would then be used for the next pass through the model.

### Testing

Once a model has been specified and estimated, it is ready to be tested. Testing alternative models is not easy, and this is one of the reasons there is so much disagreement in macroeconomics. The testing of models is discussed extensively in *Macroeconometric Modeling*, and the interested reader is referred to this material.

One obvious and popular way to test a model is to see how close its predicted values are to the actual values. Say that you want to know how well the model explained output and inflation in the 1970s. Given the actual values of the exogenous variables over this period, the model can be solved for the endogenous variables. The solution values of the endogenous variables are the predicted values. If the predicted values of output and inflation are close to the actual values, then we can say that the model did a good job in explaining output and inflation in the 1970s; otherwise not.

The solution of a model over a historical period, where the actual values of the exogenous variables are known, is called an *ex post* simulation. In this case, we do not have to guess values of the exogenous variables because all of these variables are known. One can thus use ex post simulations to test a model in the sense of examining how well it predicts historical episodes.

### Forecasting

Once a model has been specified and estimated, it can be used to forecast the future. Forecasts into the future require that one first choose future values of the exogenous variables, as we described in the **Solution** section above. Given values of the exogenous variables, we can solve for the values of the endogenous variables. The solution of a model for a future period, where"guessed" values of the exogenous variables are used, is called an *ex ante* simulation.

### Analyzing Properties of Models

Perhaps the most important use of a model is to try to learn about the properties of the economy by examining the properties of the model. If a model is an adequate representation of the economy, then its properties should be a good approximation to the actual properties of the economy. One may thus be able to use a model to get a good idea of the likely effects on the economy of various monetary and fiscal policy changes.

In the simple model above there are two basic questions that can be asked about its properties. One is how income changes when government spending changes, and the other is how income changes when the interest rate changes. In general one asks the question of how the endogenous variables change when one or more exogenous

variables change. Remember, in our simple model above the only exogenous variables are government spending and the interest rate.

The Gauss-Seidel technique can be used to analyze a model's properties. Consider the question of how $Y_t$ changes when $G_t$ changes in the above model. In other words, one would like to know how income in the economy is affected when the government changes the amount that it spends. One first solves the model for a particular value of $G_t$ (and $r_t$), perhaps the historical value of $G_t$ if the value for period $t$ is known. Let $Y_t^*$ be the solution value of $Y_t$. Now change the value of $G_t$ (but not $r_t$) and solve the model for this new value. Let $Y_t^{**}$ be this new solution value. Then $Y_t^{**} - Y_t^*$ is the change in income that has resulted from the change in government spending. (The change in $Y$ divided by the change in $G$ is sometimes called the"multiplier," hence the name of the model.) Similarly, one can examine how income changes when the interest rate changes by 1) solving the model for a given value of $r_t$, 2) solving the model for a new value of $r_t$, and 3) comparing the predicted values from the two solutions. You can begin to see how all sorts of proposed policies can be analyzed as to their likely effects if you have a good macroeconometric model.

Most of the experiments in this workbook are concerned with examining the properties of the US model. You will be comparing one set of solution values with another. If you understand these properties and if the model is an adequate approximation of the economy, then you will have a good understanding of how the economy works.

## Further Complications

Actual models are obviously more complicated than equations (1)–(3) above. For one thing, *lagged endogenous variables* usually appear as explanatory variables in a model. The value of consumption in period $t-1$, denoted $C_{t-1}$, is a lagged endogenous variable since it is the lagged value of $C_t$, which is an endogenous variable. If $C_{t-1}$ appeared as an explanatory variable in equation (1), then the model would include a lagged endogenous variable.

When lagged endogenous variables are included in a model, the model is said to be dynamic. An important feature of a dynamic model is that the predicted values in one period affect the predicted values in future periods. What happens today affects what happens tomorrow, and the model is dynamic in this sense. Again, in the case of consumption, the idea is that how much you decide to consume this year will affect how much you decide to consume next year.

Also, most models in practice are *nonlinear*, contrary to the above model, where, for example, consumption is a linear function of income in equation (1). In particular, most models include ratios of variables and logarithms of variables. Equation (1), for

example, might be specified in log terms:

$$\log C_t = \alpha_1 + \alpha_2 \log Y_t + e_t, \qquad (1)'$$

Nonlinear models are difficult or impossible to solve analytically, but they can usually be solved numerically using the Gauss-Seidel technique. The same kinds of experiments can thus be performed for nonlinear models as for linear models. As long as a model can be solved numerically, it does not really matter whether it is nonlinear or not for purposes of forecasting and policy analysis.

The error terms in many stochastic equations in macroeconomics appear to be correlated with their past values. In particular, many error terms appear to be *first order serially* correlated. If $e_t$ is first order serially correlated, this means that:

$$e_t = \rho e_{t-1} + v_t,$$

where $\rho$ is the first order serial correlation coefficient and $v_t$ is an error term that is not serially correlated. In the estimation of an equation one can treat $\rho$ as a coefficient to be estimated and estimate it along with the other coefficients in the equation. This is done for a number of the stochastic equations in the US model.

## 1.2 Data

It is important in macroeconomics to have a good understanding of the data. Macroeconomic data are available at many different intervals. Data on variables like interest rates and stock prices are available daily; data on variables like the money supply are available weekly; data on variables like unemployment, retail sales, and industrial production are available monthly; and variables from the NIPA and FFA are available quarterly. It is always possible, of course, to create monthly variables from weekly or daily variables, quarterly variables from monthly variables, and so on.

The US model is a quarterly model; all the variables are quarterly. An important point should be kept in mind when dealing with quarterly variables. In most cases quarterly variables are quoted at *seasonally adjusted annual rates*. For example, in the NIPA real GDP for the fourth quarter of 1994 is listed as $9003.2 billion, but this does not mean that the U.S. economy produced $9003.2 billion worth of output in the fourth quarter. First, the figure is seasonally adjusted, which means that it is adjusted to account for the fact that on average more output is produced in the fourth quarter than it is in the other three quarters. The number before seasonal adjustment is higher than the seasonally adjusted number. Seasonally adjusting the data smooths out the ups and downs that occur because of seasonal factors.

Second, the figure of $9003.2 billion is also quoted at an annual rate, which means that it is four times larger than the amount of output actually produced (ignoring

seasonal adjustment). Being quoted at an annual rate means that if the rate of output continued at the rate produced in the quarter for the whole year, the amount of output produced would be $9003.2 billion. For variables that are quoted at annual rates, it is not the case that the yearly amount is the sum of the four published quarterly amounts. The yearly amount is one fourth of this sum, since all the quarterly amounts are multiplied by four.

In the US model all variables are seasonally adjusted when appropriate and all flow variables are at *quarterly* rates. If you want to examine the flow variables at annual rates, just multiply by four.

It is also important to understand how growth rates are computed. Consider a variable $Y_t$. The *change* in $Y$ from period $t-1$ to period $t$ is $Y_t - Y_{t-1}$. The *percentage change* in $Y$ from $t-1$ to $t$ is $(Y_t - Y_{t-1})/Y_{t-1}$, which is the change in $Y$ divided by $Y_{t-1}$. If, for example, $Y_{t-1}$ is 100 and $Y_t$ is 101, the change is 1 and the percentage change is .01. The percentage change is usually quoted in percentage points, which in the present example means that .01 would be multiplied by 100 to make it 1.0 percent.

The percentage change in a variable is also called the *growth rate* of the variable, except that in most cases growth rates are given at annual rates. In the present example, the growth rate of $Y$ at an annual rate in percentage points is

$$\mathrm{GrowthRate(annualrate)} = 100[(\mathrm{Y_t}/\mathrm{Y_{t-1}})^4 - 1]$$

If $Y_{t-1}$ is 100 and $Y_t$ is 101, the growth rate is 4.06 percent. Note that this growth rate is slightly larger than four times the quarterly growth rate of 1.0 percent. The above formula "compounds" the growth rate, which makes it slightly larger than 4 percent. The growth rate at an annual rate is the rate that the economy would grow in a year if it continued to grow at the same rate in the next three quarters as it did in the current quarter.

# Chapter 2

# A Review of the US Model

## 2.1 History

The US model consists 25 stochastic equations and slightly over 100 identities. There are about 150 exogenous variables and many lagged endogenous variables. The stochastic equations are estimated by two-stage least squares. The data base for the model begins in the first quarter of 1952.

Work began on the theoretical basis of the model in 1972. The theoretical work stressed three ideas: 1) basing macroeconomics on solid microeconomic foundations, 2) allowing for the possibility of disequilibrium in some markets, and 3) accounting for all balance sheet and flow of funds constraints. The stress on microeconomic foundations for macroeconomics has come to dominate macro theory, and this work in the early 1970s is consistent with the current emphasis. The introduction of disequilibrium possibilities in some markets provides an explanation of business cycles that is consistent with maximizing behavior. The model explains disequilibrium on the basis of non rational expectations. Agents must form expectations of the future values of various variables before solving their multiperiod maximization problems. It is assumed that no agent knows the complete model, and so expectations are not rational. Firms, for example, make their price and wage decisions based on expectations that are not rational, which can cause disequilibrium in the goods and labor markets.

The theoretical model was used to guide the specification of the econometric model. This work was done in 1974 and 1975, and by 1976 the model was essentially in the form that it is in today. The explanatory variables in the econometric model were chosen to be consistent with the assumption of maximizing behavior, and an attempt was made to model the effects of disequilibrium. Balance sheet and flow of funds constraints were accounted for: the NIPA and FFA data are completely integrated

in the model. This latter feature greatly helps in considering alternative monetary policies, and it allows one to consider carefully"crowding out" questions.

## 2.2 Tables of Variables and Equations

An attempt has been made in this workbook to have nothing in the model be a "black box," including the collection of the data. This has been done by putting the complete listing of the model and the data collection in *The US Model Appendix A: January 30, 2016*. The hope is that with a careful reading of the tables in Appendix A, you can answer why the model has the particular properties that it has. You should use these tables for reference purposes.

Table A.1 presents the six sectors in the US model: household (h), firm (f), financial (b), foreign (r), federal government (g), and state and local government (s). In order to account for the flow of funds among these sectors and for their balance-sheet constraints, the U.S. Flow of Funds Accounts (FFA) and the U.S. National Income and Product Accounts (NIPA) must be linked. Many of the identities in the US model are concerned with this linkage. Table A.1 shows how the six sectors in the US model are related to the sectors in the FFA. The notation on the right side of this table (H1, FA, etc.) is used in Table A.5 in the description of the FFA data.

Table A.2 lists all the variables in the US model in alphabetical order, and Table A.3 lists all the stochastic equations and identities. Table A.2 also lists which variables appear in which equations, which can be useful for tracing through how one variable be affects other variables in the model. The functional forms of the stochastic equations are given in Table A.3, but not the coefficient estimates. The coefficient estimates are presented in Table A.4, where within this table the coefficient estimates and tests for equation 1 are presented in Table A1, for equation 2 in Table A2, and so on. The tests for the equations, which are reported in Table A.4, are explained in *Macroeconometric Modeling*, and this discussion is not presented in this workbook.

The remaining tables provide more detailed information about the model. Tables A.5-A.7 show how the variables were constructed from the raw data. Table A.9 lists the first stage regressors per equation that were used for the two-stage least squares estimates.

## 2.3 The Structure of the Model

The model is divided into six sectors:

1. Household sector (h)
2. Firm sector (f)

3. Financial sector (b)
4. Federal government sector (g)
5. State and local government sector (s)
6. Foreign sector (r)

Each of these sectors will be discussed in turn.

## The Household Sector

In the multiplier model in Chapter 1, consumption is simply a function of current income, but this is obviously much too simple as a description of reality. As noted above, the stress in the model is on microeconomic foundations and possible disequilibrium effects. In the microeconomic story households maximize a multiperiod utility function. Households make two decisions each period. They decide how much to consume and how many hours to work. If households can work as many hours as they wish (no disequilibrium), then income, which is the wage rate times the number of hours worked, is not an appropriate explanatory variable in a consumption equation, because part of it (the number of hours worked) is itself a decision variable. If there is no disequilibrium, decisions about consumption and hours worked are made at the same time. Households do not earn income and then decide how much to consume. Consumption and hours worked are instead *determined jointly*, and hours worked should not be considered as helping to "explain" consumption if there is no disequilibrium. Both variables are "explained" by other variables.

The main variables that explain consumption and hours worked in the microeconomic story are the wage rate, the price level, the interest rate, tax rates, the initial value of wealth, and nonlabor income. The interest rate affects consumption because of the multiperiod nature of the maximization problem. This microeconomic story has to be modified if households are not allowed to work as many hours as they would like. If households want to work more hours than firms want to employ and if firms employ only the amount they want (which seems reasonable), then households are"constrained" from working their desired number of hours. These periods correspond to periods of"unemployment." The existence of binding labor constraints is likely to lead households to consume less than they otherwise would. Also, a binding labor constraint on a household means that income is a legitimate explanatory variable for consumption, since the number hours worked is no longer a decision variable. It is imposed from the outside by firms. As discussed below, an attempt has been made in the econometric work to handle possible disequilibrium effects within the context of the microeconomic story.

In the empirical work the expenditures of the household sector are disaggregated into four types: consumption of services ($CS$), consumption of nondurable goods ($CN$), consumption of durable goods ($CD$), and investment in housing ($IHH$). Four labor supply variables are used: the labor force of men 25–54 ($L1$), the labor force of women 25–54 ($L2$), the labor force of all others 16+ ($L3$), and the number of people holding more than one job, called"moonlighters" ($LM$). These eight variables are determined by eight estimated equations.

There are two main empirical approaches that can be taken regarding the use of wage, price, and income variables in the consumption equations. The first is to add the wage, price, nonlabor income, and labor constraint variables separately to the equations. These variables in the model are as follows. The after tax nominal wage rate is $WA$, the price deflator for total household expenditures is $PH$, and the before tax nonlabor income variable is $YNL$. The price deflators for the four expenditure categories are $PCS$, $PCN$, $PCD$, and $PIH$.

Regarding a labor constraint variable, let $Z$ denote a variable that takes on a value of zero when there is no binding labor constraint (periods of full employment) and values further and further below zero as the economy gets further and further from full employment. (In earlier versions of the US model there was such a variable.) Consider as an example the $CS$ equation. Under the first approach one might add $WA/PH$, $PCS/PH$, $YNL/PH$, and $Z$ to the equation. The justification for including $Z$ is the following. By construction, $Z$ is zero or nearly zero in tight labor markets. In this case the labor constraint is not binding and $Z$ has no effect or only a small effect in the equation. This is the "classical" case. As labor markets get looser, on the other hand, $Z$ falls and begins to have an effect in the equation. Loose labor markets, where $Z$ is large in absolute value, correspond to the "Keynesian" case. Since $Z$ is highly correlated with hours paid for in loose labor markets, having both $WA$ and $Z$ in the equation is similar to having a labor income variable in the equation in loose labor markets.

The second, more traditional, empirical approach is to replace the above four variables with real disposable personal income, $YD/PH$. This approach in effect assumes that labor markets are always loose and that the responses to changes in labor and nonlabor income are the same. One can test whether the data support $YD/PH$ over the other variables by including all the variables in the equation and examining their significance. The results of doing this in the four expenditure equations supports the use of $YD/PH$ over the other variables, and so the equations that are chosen for the model use $YD/PH$.

The dominance of $YD/PH$ does not necessarily mean that the classical case never holds in practice. What it does suggest is that trying to capture the classical case through the use of $Z$ does not work. An interesting question for future work is whether the classical case can be captured in some other way.

The first eight equations in Table A.4 in Appendix A are for the household sector. As noted above, there are four expenditure equations and four labor supply equations. These are the first eight equations in Table A.4.

## The Firm Sector

There are nine stochastic equations for the firm sector (equations 10 through 18 in Table A.4). The firm sector determines production given sales (i.e., inventory investment), nonresidential fixed investment, employment demand, the price level, and the wage rate, among other things.

In the multiplier model in Chapter 1 investment is only a function of the interest rate. There is no labor market, and so employment demand is not determined. Also, no distinction is made between production and sales, and so there is no inventory investment. (Inventory investment in a period is the difference between what firms produce and what they sell.) Finally, no mention is made as to how the price level is determined. A realistic model of the economy must obviously take into account more features of firm behavior.

Production in the model is a function of sales and of the lagged stock of inventories (equation 11). Production is assumed to be "smoothed" relative to sales.

The capital stock of the firm sector depends on the amount of excess capital on hand and on current and lagged values of output (equation 12). It also depends on two cost of capital variables: a real interest rate variable and a stock market variable. Nonresidential fixed investment is determined by an identity (equation 92). It is equal to the change in the capital stock plus depreciation. The demand for workers and hours depends on output and the amount of excess labor on hand (equations 13 and 14). (Excess labor is labor that the firm holds (pays for) that is not needed to produce the current level of output.)

The price level of the firm sector is determined by equation 10. It is a function of the lagged price level, the wage rate, the price of imports, the unemployment rate, and a time trend. The lagged price level is meant to pick up expectational effects, the unemployment rate is meant to pick up demand pressure effects, and the wage rate and import price variables are meant to pick up cost effects.

The nominal wage of the firm sector is determined by equation 16. The nominal wage rate is a function of the current and lagged value of the price level and a time trend. The equation is best thought of as a real wage equation, where the nominal wage rate adjusts to the price level with a lag. Equation 17 determines the demand for money of the firm sector. It is discussed later.

The other stochastic equations for the firm sector are fairly minor. The level of overtime hours is a nonlinear function of total hours (equation 15). The level of dividends paid is a function of after tax profits (equation 18).

## The Financial Sector

The multiplier model in Chapter 1 is the IS part of the IS-LM model. The LM part of this model is as follows:

$$M_t^d/P_t = d_1 + d_2 Y_t + d_3 r_t + w_t, \tag{4}$$

$$M_t^s = M_t, \tag{5}$$

$$M_t^d = M_t^s, \tag{6}$$

where $M_t^d$ is the quantity of money demanded, $M_t^s$ is the quantity of money supplied, and $P_t$ is the price level. In equation (4) the demand for real money balances is a function of income and the interest rate. Equation (5) states that the supply of money is equal to $M_t$, which is assumed to be the policy variable of the monetary authority. Equation (6) is the equilibrium condition in the money market; the money market is assumed to clear—the quantity of money demanded equals the quantity of money supplied. The three endogenous variables in equations (4)-(6) are $M_t^d$, $M_t^d$, and $r_t$. The exogenous variables to this block of equations are $M_t$, $Y_t$, and $P_t$.

When equations (4)-(6) are added to equations (1)-(3) in Chapter 1, $Y_t$, which is exogenous in the LM model, becomes endogenous and $r_t$, which is exogenous in the IS model, becomes endogenous. The exogenous variables in this expanded model, the overall IS-LM model, are $G_t$, $M_t$, and $P_t$.

The demand for money equations in the model are consistent with equation (4) of the LM model. The main demand for money equation is for the firm sector—equation 17. In this equation the demand for money is a function of the interest rate and a transactions variable. There is also a separate demand for currency equation—equation 26—which is similar to equation 17.

An important difference between the present model and the LM model is that the present model accounts for all the flows of funds among the sectors and all balance sheet constraints. This allows the main"tool" of the monetary authority in the model to be open market operations, which is the main tool used in practice.

The other equations of the financial sector consist two term structure equations and an equation explaining the change in stock prices. The bond rate in the first term structure equation is a function of current and lagged values of the bill rate (equation 23). The same is true for the mortgage rate in the second term structure equation (equation 24). In the stock price equation, the change in stock prices is a function of the change in the bond rate and the change in after tax profits (equation 25).

## The Foreign Sector

There is one stochastic equation in the foreign sector, which explains the level of imports (equation 27). The level of imports depends on consumption plus fixed in-

vestment and on the domestic price level relative to the price of imports. If the price of imports rises relative to the domestic price level, imports are predicted to fall, other things being equal, as people substitute domestic goods for imported goods. Otherwise, the level of imports is just run off of total consumption and fixed investment.

### The State and Local Government Sector

There is one stochastic equation in the state and local government sector, an equation explaining unemployment insurance benefits (equation 28). The level of unemployment insurance benefits is a function of the level of unemployment and the nominal wage rate. The inclusion of the nominal wage rate is designed to pick up effects of increases in wages and prices on legislated benefits per unemployed worker.

### The Federal Government Sector

There are two stochastic equations in the federal government sector. The first explains the interest payments of the federal government (equation 29), and the second explains the three month Treasury bill rate (equation 30). The federal government sector is meant to include the Federal Reserve as well as the fiscal branch of the government.

Equation 29 for the federal government sector is similar to equation 19 for the firm sector. It explains the level of interest payments of the government sector.

The bill rate is determined by an "interest rate reaction function," where the Fed is assumed to"lean against the wind" in setting its interest rate targets. That is, the Fed is assumed to allow the bill rate to rise in response to increases in inflation and lagged money supply growth and to decreases in the unemployment rate. There is a dummy variable multiplying the money supply variable in the equation. This variable takes on a value of one between 1979:4 and 1982:3 and zero otherwise. It is designed to pick up the change in Fed operating policy between October 1979 and October 1982 when the Fed switched from targeting interest rates to targeting the money supply.

When the interest rate reaction function (equation 30) is included in the model, monetary policy is endogenous. In other words, Fed behavior is explained within the model. How the Fed behaves is determined by what is going on in the economy. There are, however, three other assumptions that can be made about monetary policy. These are 1) the bill rate is exogenous, 2) the money supply is exogenous, and 4) the value of government securities outstanding is exogenous. If one of these three assumptions is made, then monetary policy is exogenous and equation 30 is dropped. This is discussed further below. The program on the site allows you to use equation 30 or to take the bill rate to be exogenous.

## 2.4 Properties of the Model

As you run the experiments in the following chapters, you will undoubtedly be unsure as to why some of the results came out the way they did. As noted above, however, the model is not a black box, and so with enough digging you should be able to figure out each result. In this section, some examples are given describing the ways in which particular variables affect the economy. The discussion in this section is meant both to get you started thinking about the properties of the model and to serve as a reference once you are into the experiments. You should read this section quickly for the first time and then return to it more carefully when you need help analyzing the experiments.

You may need to use Tables A.2-A.4 in Appendix A when you are puzzled about some aspect of the results. As noted above, these tables provide a complete listing of the variables and equations of the model.

### Interest Rate Effects

There are many channels through which interest rates affect the economy. It will first help to consider the various ways that an increase in interest rates affects consumption and housing investment. 1) The short term after tax interest rate $RSA$ is an explanatory variable in equation 1 explaining service consumption ($CS$), and the long term after tax interest rate $RMA$ is an explanatory variable in equation 2 explaining nondurable consumption ($CN$), in equation 3 explaining durable consumption ($CD$), and in equation 4 explaining housing investment ($IHH$). The interest rate variables have a negative effect in these equations. In addition the long term bond rate is an explanatory variable in the investment equation 12, where a change in the real bond rate has a negative effect on plant and equipment investment.

Interest rates also affect stock prices in the model. The change in the bond rate $RB$ is an explanatory variable in equation 25 determining capital gains or losses on corporate stocks held by the household sector ($CG$). An increase in $RB$ has a negative effect on $CG$ (i.e., an increase in the bond rate has a negative effect on stock prices). When $CG$ decreases, the net financial assets of the household sector ($AH$) decrease—equation 66—and thus total net wealth ($AA$) decreases—equation 89. $AA$ is an explanatory variable in the consumption equations (wealth has a positive effect on spending). Therefore, through the wealth channel, an increase in interest rates has a negative effect on consumption. When $RB$ rises, $AA$ falls and thus spending falls. (It should also be the case that an increase in interest rates lowers wealth in the model through a fall in long term bond prices, but the data are not good enough to pick up this effect.)

It is also the case that an increase in interest rates increases the interest income of

the household sector because the household sector is a net creditor, i.e. the household sector lends more than it borrows. Interest income is part of personal income, which has a positive effect on consumption and housing investment, and so on this score an increase in interest rates has a positive effect on consumption and housing investment. This"income effect" of a change in interest rates on household expenditures is now quite large because of the large federal government debt holdings of the household sector. The negative income effect from a fall in interest rates now offsets more of the positive substitution effect than it did earlier.

A change in interest rates thus affects GDP through a number of channels. The size of the net effect on GDP of a change in interest rates is an empirical question, which the model can be used to answer. The final answer obviously depends on the specification of the stochastic equations, and you may want to experiment with alternative specifications to see how the final answer is affected. The size of the net effect is, of course, of critical importance for policy purposes.

### Tax Rate Effects

An increase in personal income tax rates and/or social security tax rates ($D1GM$, $D1SM$, $D4G$) lowers the after tax wage ($WA$)—equation 126—and disposable income ($YD$)—equation 115. Disposable income is an explanatory variable in the consumption and housing investment equations—an increase in $YD$ increases spending. Therefore, an increase in tax rates lowers consumption and housing investment by lowering disposable income. An increase in personal income tax rates also lowers the after tax interest rates $RSA$ and $RMA$, which on this score has a positive effect on consumption and housing investment because the after tax interest rates have a negative effect.

One obvious exercise with the model is to change the corporate profit tax rate $D2G$ and see how this affects the economy. You will find, for example, that an increase in $D2G$ has a fairly small effect on GDP in the model. It appears from an exercise like this that the government can raise a lot of tax revenue (and thus lower the government deficit) by raising $D2G$ with only a small negative effect on the economy. The way an increase in $D2G$ affects the economy is as follows. An increase in $D2G$ increases corporate profits taxes ($TFG$)—equation 49—which lowers after tax profits . The decrease in after tax profits results in a capital loss on stocks—equation 25—which lowers household wealth, which has a negative effect on consumption and housing investment and thus on sales and production. Also, the decrease in after tax profits results in a decrease in dividends—equation 18—which lowers disposable income, which has a negative effect on consumption and housing investment.

Both of these effects of a change in D2G on GDP are initially quite small. It takes time for households to respond to changes in wealth, and it takes time for dividends

to respond to changes in after tax profits. Whether this specification is realistic is not clear. Changes in $D2G$ may affect the behavior of the firm sector in ways that are not captured in the model, and you should thus proceed cautiously in changing $D2G$ (or $D2S$ for the state and local government sector). This may not be as easy a revenue raiser as the model implies.

### Labor Supply and the Unemployment Rate

The unemployment rate $UR$ is determined by equation 87. $UR$ is equal to the number of people unemployed divided by the civilian labor force. The number of people unemployed is equal to the labor force minus the number of people employed. The labor force is made up of three groups—prime age men ($L1$), prime age women ($L2$), and all others ($L3$). The three labor force variables along with the number of moonlighters ($LM$) are the labor supply variables in the model. Two of the four labor supply variables depend positively on the real after tax wage rate ($WA/PH$), which means that the substitution effect is estimated to dominate the income effect on labor supply.

It is important to note that anything that, say, increases the labor force will, other things being equal, increase the number of people unemployed and the unemployment rate. (Other things equal here includes no change in employment.) For example, suppose the personal income tax rate is lowered, thereby raising the after tax wage rate $WA$. Then the labor force variables $L2$ and $L3$ will rise—equations 6 and 7. This, other things being equal, leads the unemployment rate to rise. Other things are not, of course, equal because the decrease in the tax rate also leads, for example, to a increase in consumption and housing investment, which leads to an increase in production and then to employment. Employment thus rises also. Whether the net effect is an increase or a decrease in the unemployment rate depends on the relative sizes of the increased labor force and the increased employment, which you can see when you run the experiments. The main point to remember is that the labor force responses can be important in determining the final outcome. There is, for example, no simple relationship between the unemployment rate and output (i.e., there is no Okun's"law") because of the many factors that affect the labor force.

$L1$, $L3$, and $LM$ depend negatively on the unemployment rate, and for $L1$ and $L3$ this is the discouraged worker effect at work. In bad times (i.e., when the unemployment rate is high) some people get discouraged from ever finding a job and drop out of the labor force. (When people drop out of the labor force, they are no longer counted as unemployed, and so this lowers the measured unemployment rate.) When things improve, they reenter the labor force. This "discouraged worker effect" is captured by the unemployment rate in the L1 and L3 equations. Be aware when you run experiments that part of any change in the labor force is due to the discour-

aged worker effect in operation. This effect can be quantitatively very important in slack periods. The number of people holding two jobs ($LM$) also decreases in slack periods, and this is captured by the unemployment rate in the LM equation.

Note finally that $L3$ depending positively on the after tax wage rate (substitution effect dominating) is consistent with the theory behind the Laffer curve. Labor supply does respond to tax rates in the model. That is, when taxes decrease, the after tax wage rate increases, leading to an increase in the labor force. If you run various experiments, however, you will see that the quantitative responses are fairly small.

### "Productivity" Movements

The productivity variable $PROD$ in the model is defined in equation 118. $PROD$ is equal to $Y/(JF \cdot HF)$, where $Y$ is output, $JF$ is the number of jobs, and $HF$ is the number of hours paid for per job. $PROD$ is thus output per paid for worker hour. Although this variable is usually called"productivity," it is important to realize that it is not a good measure of true productivity. In slack periods firms appear to pay for more worker hours than they actually need to produce the output; they hold what is called in the model"excess labor." This means that $JF \cdot HF$ is not a good measure of actual hours worked, and so $Y/(JF \cdot HF)$ is an imperfect measure of the true ability of the economy to produce per hour worked.

$PROD$ is a procyclical variable. It falls in output contractions as excess labor is built up (output falls faster than hours paid for), and it rises in output expansions as excess labor is eliminated (output rises faster than hours paid for). The amount of excess labor on hand appears as an explanatory variable in the employment and hours equations—equations 13 and 14.

### Output and the Unemployment Rate

It was mentioned above that there is no simple relationship between output and the unemployment rate in the model (no Okun's law) because of the many factors that affect the labor force. Even though the relationship is not stable, one can say that changes in output are likely to correspond to less than proportional changes in the unemployment rate. That is, when output increases (decreases), the unemployment rate will decrease (increase) but by proportionally less than output. There are three main reasons for this in the model. First, when output decreases by a certain percentage, the number of jobs falls by less than this percentage because firms cut hours worked per job as well as jobs and also build up some excess labor. Second, the number of people employed falls by less than the number of jobs because some of the jobs that are cut are held by people holding two jobs. These people are still employed; they just hold one job now rather than two. Third, as the economy contracts, the discouraged worker effect

leads some people to drop out of the measured labor force and thus the measured labor force falls, which ceteris paribus decreases the unemployment rate. These three effects show why the unemployment rate tends to change by proportionately less than output does. You should examine these effects when you do the various experiments with the model.

### Price Responses to Output Changes

One of the most difficult issues in macroeconomics is trying to determine how fast inflation increases as the economy approaches full capacity. The data are not good at discriminating among alternative specifications because there are so few observations at very high levels of capacity or low unemployment rates. The demand pressure variable used in the price equation (equation 10) is simply the level of the unemployment rate. No nonlinear transformation of the unemployment rate or output gap measure has been used. When other functional forms were tried, the fit of the equation was not quite as good as the fit using the level of the unemployment rate.

Because of the uncertainty of how the aggregate price level behaves as unemployment approaches very low levels, you should be cautious about pushing the model to extremely low unemployment rates. The price response that the model predicts for very low unemployment rates may be much less than would actually exist in practice. Again, the data are not good in telling us what this response is. You should probably not push the economy much below an unemployment rate of about 3.5 percent if you want to trust the estimated price responses.

You will notice if you run an experiment that increases output that the estimated size of the price response is modest, especially in the short run. This is a common feature of econometric models of price behavior. The estimated effects of demand pressure variables on prices are usually modest. This is simply what the data show, although many people are of the view that the effects should be larger. If you would like a larger response in the model, simply make the coefficient of the unemployment rate in equation 10 larger in absolute value (i.e., make it more negative). Advanced users may want to reestimate the equation using various nonlinear transformations of the unemployment rate. Be warned, however, that this is unlikely to make much difference to the fit of the price equation.

The key price variable in the model is $PF$, which is determined by equation 10, and this is the variable you should focus on. For most experiments $PF$ and the GDP price deflator $GDPD$, respond almost identically. If, however, you, say, increase government purchases of goods, $COG$, which is a common experiment to perform, this will initially have a negative effect on the GDP price deflator even though it has a positive effect on $PF$. One would expect a positive effect because the increase in $COG$ increases $Y$, which lowers the gap. The problem is that the GDP price deflator

is a weighted average of other price deflators, and when you change $COG$ you are changing the weights. It so happens that the weights change in such a way when you increase $COG$ as to have a negative effect on the GDP price deflator. This is not an interesting result, and in these cases you should focus on $PF$, which is not affected by the change in weights.

Although demand pressure effects on prices are modest in the model, the effects of changing the price of imports ($PIM$) on domestic prices are fairly large, as you can see if you change $PIM$. In fact, much of the inflation of the 1970s is attributed by the model to the increases in $PIM$ in this period. The model also attributes much of the drop in output in the 1970s to the rise in import prices. The reason for this is as follows. When $PIM$ rises, domestic prices initially rise faster than nominal wages (because wages lag prices in the model). Higher prices relative to wages have a negative effect on real disposable income ($YD/PH$) and thus on consumption and housing investment, which leads to a drop in sales and production. In addition, if the money supply is held unchanged, the rise in prices leads to an increase in interest rates (through the standard LM story), which has a negative effect on consumption and housing investment. Interest rates also rise if the Fed instead behaves according to the interest rate reaction function—equation 30—because the Fed is estimated in this equation to let interest rates rise when inflation increases. One of the experiments in Chapter 8 is to examine what the 1970s might have been like had $PIM$ not risen in this period.

### Response Lags and Magnitudes

You will soon see as you begin the experiments that the effects of any change on the economy take time. There are significant response lags estimated in the model; it is by no means the case that firms and households respond quickly to policy changes. You should also be aware regarding the magnitudes of the responses that they depend on the sizes of the estimated coefficients in the stochastic equations. If, say, one category of consumption responds more to a particular change than does another category, this reflects the different coefficient estimates in the two relevant stochastic equations. Also, some potentially relevant explanatory variables have been dropped from one equation and not from another (variables are generally dropped if their coefficient estimates have the wrong sign), which can account for the differences in responses. Another way of putting this is that no prior constraints on, say, the consumption equations have been imposed in order to have the responses of the different categories of consumption be the same. The data are allowed to determine these differences.

## 2.5 Monetary Policy

One of the key uses of the model is to examine the links between monetary policy and fiscal policy. This can be done carefully because the model has accounted for all balance sheet and flow of funds constraints. This section discusses some of the key features of the monetary policy/fiscal policy links. The material is somewhat difficult, but if you take the time to work through the discussion and the equations, you should have a good understanding of how monetary policy works. You can consider the equations discussed in this section to be the LM part of the model—they replace equations (4)-(6) above. The following are four of the equations in the model. (The symbol $\Delta$ means"change in." For example, $\Delta AG = AG - AG_{-1}$, where $AG_{-1}$ is the value of $AG$ of the previous period.)

$$MF = f(RS, ...), \tag{17}$$

$$CUR = f(RS, ...), \tag{26}$$

$$0 = SG - \Delta AG - \Delta MG + \Delta CUR + \Delta(BR - BO) - \Delta Q - DISG, \tag{77}$$

$$M1 = M1_{-1} + \Delta MH + \Delta MF + \Delta MR + \Delta MS + MDIF, \tag{81}$$

There is also the interest rate reaction function, equation 30:

$$RS = f(...), \tag{30}$$

The notation $f()$ means that the equation is stochastic. The variables inside the parentheses are explanatory variables. For the sake of the present discussion, only the explanatory variables that are needed for the analysis are listed in the parentheses.

The relevant notation is:

| | |
|---|---|
| $AG$ | net financial assets of the federal government |
| $BO$ | bank borrowing from the Fed |
| $BR$ | total bank reserves |
| $CUR$ | currency held outside banks |
| $DISG$ | discrepancy for the federal government |
| $M1$ | M1 money supply |
| $MDIF$ | discrepancy between M1 and other variables |
| $MF$ | demand deposits and currency of firms |
| $MG$ | demand deposits and currency of the federal government |
| $MH$ | demand deposits and currency of households |
| $MR$ | demand deposits and currency of the foreign sector |
| $MS$ | demand deposits and currency of the state and local governments |
| $Q$ | gold and foreign exchange of the federal government |
| $RS$ | three month Treasury bill rate |
| $SG$ | financial saving of the federal government |

Equations 17 and 26 are the demand for money equations.

Equation 77 is the budget constraint of the federal government. $SG$ is the saving of the federal government. $SG$ is almost always negative because the federal government almost always runs a deficit. If the government runs a deficit, it can finance it in a number of ways. Two minor ways are that it can decrease its holdings of demand deposits in banks ($MG$) and it can decrease its holdings of gold and foreign exchange ($Q$). More importantly, it can increase the amount of high powered money (currency plus non borrowed reserves) in the system, which is $CUR + (BR - BO)$. Finally, it can increase the value of government securities in the hands of the public, meaning the government borrows from the public. $-AG$ in the model is the value of government securities outstanding. ($AG$ is negative because government securities are a liability of the government, and so $-AG$ is the (positive) value of government securities outstanding). $DISG$ in equation 77 is a discrepancy term that is needed to make the NIPA data and the FFA data match. It reflects errors of measurement in the data. Ignoring $MG$, $Q$, and $DISG$ in equation 77, the equation simply says that when, say, $SG$ is negative, either government securities outstanding must increase or the amount of high powered money must increase. This is the budget constraint that the government faces, the government being defined here to be the federal government inclusive of the monetary authority.

Equation 81 is the definition of $M1$. The change in $M1$ is equal to the change in $MH + MF + MR + MS$ plus some minor terms that are included in the $MDIF$ variable.

The importance of the above equations for understanding how monetary policy works and the relationship between monetary policy and fiscal policy cannot be overstated. We are now ready to consider various cases. First, it is important to consider what is exogenous in the above equations, what is determined elsewhere in the model, and what is endogenous. The following variables are taken to be exogenous in the model: $BO$, $BR$, $MH$, $MR$, $MG$, $MS$, $Q$, $DISG$, and $MDIF$. In addition, there is a monetary policy tool, namely $AG$, which for now can be assumed to be exogenous. $AG$ is the variable that is changed when the Fed is engaging in open market operations. The variable $SG$ is determined elsewhere in the model (by equation 76 in Table A.3 in Appendix A). This leaves four endogenous variables for the four equations (we are not using equation 30 yet): $MF$, $CUR$, $RS$, and $M1$. Given the other values, the four equations can be used to solve for the four unknowns. (It is usually the case in macroeconometric models that counting equations and unknowns is sufficient for solution purposes.)

If $AG$ is exogenous and if fiscal policy is changed in such a way that the deficit is made larger ($SG$ larger in absolute value), then the increase in the deficit must be financed by an increase currency ($CUR$). With $AG$ exogenous, there is nothing else endogenous in equation 77 (except $SG$, which is determined elsewhere). If

government spending is increased with $AG$ exogenous, this will lead to a fall in the interest rate ($RS$). Here is where the insights from the IS-LM model might help (although be careful of oversimplification). In order for $CUR$ to increase, households and firms must be induced to hold it, which is done through a lower interest rate.

Although $AG$ is the main tool used by the Fed in its conduct of monetary policy, it is actually not realistic to take $AG$ to be exogenous. The Fed is much more concerned about $RS$ or $M1$ than it is about $AG$. A better way to think about this setup is that the Fed uses $AG$ to achieve a target value of $RS$ or $M1$.

Consider an $M1$ target first. If the Fed picks a target value for $M1$, then $M1$ is now exogenous (set by the Fed). This means that we now have an extra equation above—81—with no unknown matched to it. The obvious choice for the unknown is $AG$. In other words, $AG$ is now endogenous; its value is whatever is needed to have the target value of $M1$ be met. A similar argument holds for an $RS$ target. If the Fed picks a target value for $RS$, then $RS$ is exogenous and $AG$ is endogenous. $AG$ is whatever is needed to have the RS target be met. This is also where equation 30 can come in. Instead of setting a target value of $RS$ exogenously, the Fed can use an equation like 30 to set the value. If this is done, then $RS$ is endogenous—it is determined by equation 30. $AG$, of course, is also endogenous, because its value must be whatever is needed to have the value of $RS$ determined by equation 30 be met.

As a final point about the above equations, note the relationship between fiscal policy and monetary policy. Fiscal policy changes $SG$, which from equation 77 must be financed in some way. If the Fed keeps $AG$ unchanged, an unrealistic assumption, the financing will all be through a change in currency. If the Fed keeps M1 unchanged, then $AG$ will adjust to offset any effects of the fiscal policy change that would have otherwise changed $M1$. If the Fed keeps $RS$ unchanged, then $AG$ will adjust to offset any fiscal policy effects on $RS$. It should be clear from this that the size of fiscal policy effects on the economy are likely to be sensitive to what is assumed about monetary policy.

In terms of solving the model by the Gauss-Seidel technique, which needs one left hand side variable per equation, the four equations above have to be rearranged depending on what is assumed about monetary policy. If equation 30 is used or if $RS$ is taken to be exogenous, then the matching is $MF$ to equation 17, $CUR$ to equation 26, $AG$ to equation 77, and $M1$ to equation 81. If $M1$ is taken to be exogenous (no equation 30), the matching is $RS$ to equation 17, $CUR$ to equation 26, $AG$ to equation 77, and $MF$ to equation 81. If $AG$ is taken to be exogenous (also no equation 30), the matching is $MF$ to equation 17, $RS$ to equation 26, $CUR$ to equation 77, and $M1$ to equation 81.

It is difficult to solve the model when $M1$ or $AG$ is taken to be exogenous, and the site does not allow this to be done. The two options are to use equation 30 or take

RS to be exogenous. If $RS$ is taken to be exogenous, the user can enter values for $RS$.

## 2.6 Important Things to Know About the Program

### The Datasets

The datasets are discussed in *About US Model User Datasets* on the site, and you should read this now if you have not already done so. It is important to note that the data in YAOBASE up to the beginning of the forecast period are actual data. From the beginning of the forecast period on, the data are forecasted data. Each quarter the model is used to make a forecast of the future, and the new forecast is added to the Web site as soon as it is done. The exogenous variable values for the forecasted quarters are the values chosen before the model is solved. The endogenous variable values for the forecasted quarters are the solution values (given the exogenous variable values).

YAOBASE also contains the coefficient estimates that existed at the time of the forecast (the model is reestimated quarterly). All the other information that is needed to solve the model is also in YAOBASE, and this is also true of the datasets that you create.

*It is important that you understand the following.* If you ask the program to solve the model for the forecast period (or any subperiod within the forecast period) *and* you make no changes to the coefficients and exogenous variables, the solution values for the endogenous variables will simply be the values that are already in YAOBASE. If, on the other hand, you ask the program to solve the model for a period prior to the forecast period, where actual data exist, the solution values will not be the same as the values in YAOBASE because the model does not predict perfectly (the solution values of the endogenous variables are not in general equal to the actual values). It is thus very important to realize that the only time the solution values will be the same as the values in YAOBASE when you make no changes to the exogenous variables and coefficients is when you are solving within the forecast period.

### Using the Forecast Period to Examine the Model's Properties

The easiest thing to do when running experiments with the model is to run them over the forecast period. Say that you want to examine what happens to the economy when government purchases of goods ($COG$) is increased by $10 billion. You make this change in the program and ask for the model to be solved, creating, say, dataset NEW. If you do this over the forecast period, the solution values in NEW can be compared directly to the values in YAOBASE. If you had not changed $COG$, the solution values NEW would have been the same as those in YAOBASE, and so any

differences between the solution values in NEW and YAOBASE can be attributed solely to the change in $COG$.

Many of the experiments in this workbook are thus concerned with making changes in the exogenous variables, solving the model over the forecast period, and comparing the new solution values to the solution values in YAOBASE. The difference between the two solution values for a particular endogenous variable each quarter is the estimated effect of the changes on that variable.

You should be aware that most of the time one is comparing the solution value in one dataset with the solution value in another dataset. One is not generally examining solution values over time in a single dataset. Students often confuse changes over time in a given dataset with changes between two datasets. It is critical that you understand this distinction, and so make sure that you do before going on.

You should also be clear on what is meant when a variable is said to be "held constant" for an experiment, such as the the interest rate being held constant. This means that the values of the variable for the experiment are the same as the values in the base dataset. They are not changed from the base values during the experiment. Being held constant does not mean that the variable is necessarily unchanged over time. If the values of the variable in the base dataset change over time (which most values do), then the variable values in the new data set will change over time; they just won't be changed from the values in the base dataset.

### Using Non Forecast Periods to Examine the Model's Properties

In some cases one must use non forecast periods to carry out the experiment. If, for example, you are concerned with examining how the economy would have behaved in the 1970s had the price of imports ($PIM$) not increased so dramatically, you must deal with the period of the 1970s. Say you are interested in the 1973:1-1979:4 period, and you want to know what would have happened in this period had $PIM$ not changed at all. The only new thing you need to do is to click "Use historical error" and ask to use the historical errors. These errors are taken to be exogenous, and if you solve the model making no other changes you will just get back the actual values—a perfect tracking solution. If you use the historical errors, you can thus make changes to the exogenous variables and compare the new solution values with the actual values in the base dataset. The new solution values are based on the use of the historical errors.

### Changing Coefficients

Some of the experiments call for changing one or more coefficients in the model. Even if you are dealing with the forecast period, once you make a change in a coefficient, the solution values are not the same as the values in YAOBASE even if no exogenous

variables have been changed. When you change one or more coefficients, you must first solve the model with only these coefficients changed. The dataset created by this solution, say BASEA, is then your base dataset. You can then make changes in the exogenous variables and solve the model for these changes. The dataset created from this solution, say NEWA, can then be compared to BASEA. It is not correct to compare NEWA to YAOBASE, because the differences between these two datasets are due both to the coefficient changes and to the exogenous variable changes. When you do this you should *not* use the historical errors. These errors pertain only to the original coefficients.

### Selecting Variables to Display

The following are some of the variables you might want to display when examining the output. This list is a subset of all the variables in the model.

| | |
|---|---|
| $AA$ | Total net wealth of the household sector |
| $AG$ | Net financial assets of the federal government |
| | (-AG is roughly the federal government debt) |
| $BO$ | Bank borrowing from the Fed |
| $BR$ | Total bank reserves |
| $CD$ | Consumer expenditures for durables |
| $CG$ | Capital gains (+) or losses (-) on stocks held by households |
| $CN$ | Consumer expenditures for nondurables |
| $COG$ | Federal government purchases of goods |
| $COS$ | State and Local government purchases of goods |
| $CS$ | Consumer expenditures for services |
| $CUR$ | Currency held outside banks |
| $D1G$ | Personal income tax parameter for federal taxes |
| $E$ | Total employment |
| $EX$ | Exports |
| $GDPD$ | GDP price deflator |
| $GDPR$ | Real GDP |
| $IHH$ | Residential investment, household sector |
| $IKF$ | Nonresidential fixed investment of the firm sector |
| $IM$ | Imports |
| $INTF$ | Interest payments of the firm sector |
| $INTG$ | Interest payments of the federal government |
| $IVF$ | Inventory investment of the firm sector |
| $JF$ | Number of jobs in the firm sector |
| $KK$ | Capital stock of the firm sector |
| $L1$ | Labor force, men 25-54 |
| $L2$ | Labor force, women 25-54 |
| $L3$ | Labor force, all others 16+ |
| $LM$ | Number of moonlighters |
| $MB$ | Net demand deposits and currency of banks |
| $MF$ | Demand deposits and currency of the firm sector |
| $MH$ | Demand deposits and currency of the household sector |
| $M1$ | Money supply |
| $PCGDPD$ | Percentage change in the GDP price deflator (annual rate) |
| $PCGDPR$ | Percentage change in real GDP (annual rate) |
| $PCM1$ | Percentage change in the money supply (annual rate) |
| $PF$ | Price deflator for the firm sector |
| $PG$ | Price deflator for COG |
| $PIEF$ | Before tax profits of the firm sector |
| $PIM$ | Import price deflator |

| | |
|---|---|
| $POP$ | Population, 16+ |
| $POP1$ | Population, men 25-54 |
| $POP2$ | Population, women 25-54 |
| $POP3$ | Population, all others 16+ |
| $PROD$ | Output per paid for worker hour (”productivity”) |
| $RB$ | Bond rate |
| $RM$ | Mortgage rate |
| $RS$ | Three month Treasury bill rate |
| $SG$ | Savings of the federal government |
| $SGP$ | Federal government surplus (+) or deficit (-) |
| $SHRPIE$ | Ratio of after tax profits to the wage bill |
| $SRZ$ | Household saving rate |
| $SR$ | Savings of the foreign sector ($-SR$ is the U.S. current account) |
| $THG$ | Personal income taxes to the federal government |
| $TRGHQ$ | Transfer payments from the federal government to households |
| $U$ | Total number of people unemployed |
| $UR$ | Unemployment rate |
| $WA$ | After tax nominal wage rate |
| $WF$ | Nominal wage rate of the firm sector |
| $WR$ | Real wage rate |
| $X$ | Total sales of the private sector |
| $Y$ | Total production of the private sector |

# Chapter 3

# Historical Data

Before running any experiments, it will be useful simply to examine some of the macroeconomic data to see what they look like. Graphs are a good way of getting a "feel" for the data. Since 1970 there are five periods that can be classified as general recessionary periods: 1974:1-1975:4, 1980:2-1983:1, 1990:3-1991:1, 2001.1-2001.3, and 2008:1-2009:2. Similarly, two subperiods can be classified as general inflationary periods: 1973:2-1975:1 and 1978:2-1981:1. These subperiods are useful for reference purposes.

In this chapter you are asked to table and graph the variables listed in Section 2.6 for the period since 1970:1 and examine how they behave during the recessionary and inflationary subperiods. You should save these tables and graphs for future reference. You may also want to table and graph the variables for the entire period since 1952:1. If you do so, how many other recessionary and inflationary subperiods can you pick out?

In doing the work in this chapter (and the others) you should always use Table A.2 in Appendix A as the reference for the variable names. The definition of a variable is not always repeated when the notation for the variable is used in describing the experiments.

---

### Experiment 3.1: Variables for the 1970:1-2015:4 Period

**Table and graph the variables listed in Section 2.6 for the 1970:1-2015:4 period.**

Some of the following questions may require more knowledge of macroeconomics than you currently have. Do your best for now to get a feel for the data, and then come back to the tables and graphs to review the data from time to time as you gain more knowledge.

### Recessionary Periods

1. From the table and graph for real GDP, $GDPR$, can you pick out the four recessionary periods mentioned above? Which of the other variables tend to follow the business cycle, and which do not? Can you think of reasons why some do and some don't? Focus in particular on the components of $GDPR$ and on the saving rate, $SRZ$.

### Inflationary Periods

1. From the table and graph for the percentage change in the GDP deflator, $PCGDPD$, can you pick out the two inflationary periods? How does the import price index, $PIM$, behave during these periods? How about the nominal wage rate, $WA$, and the real wage rate, $WR$?

2. How much overlap is there between the recessionary and inflationary periods? (These overlap periods are called periods of "stagflation.") Can you speculate on what might have caused the stagflation? Can you pick out any variables that you have graphed as possible culprits?

### Labor Market Variables

1. How did the unemployment rate, $UR$, behave during the recessionary and inflationary periods?

2. Is there a tight relationship between $UR$ and the rate of inflation, $PCGDPD$?

3. How did productivity, $PROD$, behave during the recessionary periods? Why might $PROD$ be procyclical?

4. Calculate the values of the labor force participation rates $L1/POP1$, $L2/POP2$, and $L3/POP3$ for a few of the quarters within the overall period. Note how they have changed over time, and note the remarkable rise in L2/POP2, the participation rate for women 25-54, since 1970. What might have caused this rise?

5. Are the labor force participation rates procyclical or countercyclical or neither? Do they seem to vary with $UR$? Why might they vary with $UR$?

### Fiscal Policy Variables and Other Federal Government Variables

1. Examine how the fiscal policy variables $COG$, $D1G$, $D2G$, $D3G$, $D4G$, $D5G$, and $TRGHQ$ have changed over time.

2. Examine how the government deficit $SGP$ and the government debt $-AG$ have changed over time. What are some of the factors that led to the large rise in the deficit?

3. Why are interest payments of the government, $INTG$, growing so rapidly? What consequences does this have for $SGP$ and $AG$?

## Monetary Policy Variables and Other Financial Variables

1. How did the bill rate, $RS$, behave during the recessionary periods? During the inflationary periods? What does this say about Fed behavior?

2. What is the relationship between the long term bond rate, $RB$, and $RS$? Why might $RS$ fluctuate more than $RB$?

3. Examine carefully the behavior of $RS$ during the period 1979:4-1982:3. Does this behavior seem different than at other times? How did the money supply, $M1$, behave during this period versus at other times? Does it seem to you that the Fed behaved differently during this period than otherwise?

4. Compute velocity, $GDP/M1$, for a few quarters and examine how it has changed over time. How stable over time does it seem?

5. What happened to $GDPR$ and $GDPD$ in 1974? What was the monetary response to this in 1975? (Look at $RS$ and $M1$.)

6. What was the monetary response following the stock market crash in 1987? Can you pick out the effects of the stock market crash on household wealth, $AA$?

## Foreign Sector Variables

1. Examine how $PIM$, $IM$, $PEX$, and $EX$ have changed over time.

2. How has the saving of the foreign sector, $SR$, changed over time? What are the main factors that have led to this change? ($-SR$ is roughly the U.S. current account.)

3. $SGP$ and $-SR$ are sometimes call the"twin deficits." Examine their relationship over time. Can you think of reasons why the two deficits might be positively correlated?

## Extra Credit

1. If you have tabled or graphed the variables from 1952:1 on, answer the relevant questions above for this longer period. For example, how many recessions can you pick out since 1952? How many high inflation periods? Are some of the relationships that were not stable after 1970 closer to being stable before 1970?

# Chapter 4

# NIPA and FFA Data

The National Income and Product Accounts (NIPA) and the Flow of Funds Accounts (FFA) are more than just the places where much macroeconomic data come from. They help us organize our thoughts about the structure of the economy, and they provide the framework for constructing models of the economy. The exercises in this chapter are designed to get you acquainted with the two sets of accounts.

## 4.1 Identities

By definition, GDP is equal to consumption plus investment plus government spending plus exports minus imports. In the US model there are six sectors and a number of categories of consumption, investment, and government spending, which make the GDP identity and other identities somewhat more involved. It will be useful to begin with the definition of total sales of the private sector, denoted $X$, which is defined in equation 60. Equation 60 is:

$$X = CS + CN + CD + IHH + IKF + EX - IM + COG + COS + IKH + IKB + IKG + IHF + IHB \tag{60}$$

---

## Experiment 4.1: The Components of X

**Table variable X and its components (from equation 60) for 2015:4.**

1. Note that some components are quite small. You should use this experiment to get a feel for the size of the various components. Note what a large fraction consumption is of total sales.

---

By definition production minus sales is the change in inventories. This definition is equation 63:

$$V = V_{-1} + Y - X \quad 63$$

where $V$ is the stock of inventories at the end of the quarter, $Y$ is production, and $X$ is sales. Also, by definition, the change in inventories is inventory investment, which is equation 117:

$$IVF = V - V_{-1}, \quad 117$$

where $IVF$ is inventory investment. In the model $Y$ is determined by equation 11, which reflects production smoothing behavior, $X$ is determined by the identity 60, $V$ is determined by the identity 63, and $IVF$ is determined by the identity 117.

$Y$ is not total GDP; it is only the part of GDP produced by the private sector. Some production also takes place in the and government sectors. Equation 83 defines real GDP as production in the private and government sectors:

$$GDPR = Y + PSI13 * (JG * HG + JM * HM + JS * HS) + STATP, \quad 83$$

the term after $Y$ is production in the federal and state and local government sectors. $STATP$ is a statistical discrepancy pertaining to the use of the chain weighted data, which is discussed in *Macroeconometric Modeling*.

---

**Experiment 4.2: Going from X to GDPR**

**Table $X$, $Y$, $IVF$, and $GDPR$ for 2015:4.**

1. Note that $IVF$ is small relative to $Y$ and that most of $GDPR$ is $Y$ (i.e., most of $GDPR$ is produced by the private sector).

---

## 4.2 Nominal versus Real GDP

As any introductory economics textbook discusses, it is important to distinguish between nominal and real GDP. By definition, nominal GDP is equal to real GDP times the GDP price index. In the model, this relationship is equation 84, which is used to determine the GDP price index:

$$GDPD = GDP/GDPR, \quad 84$$

Use the tables and graphs of $GDP$, $GDPR$, and $GDPD$ from Experiment 3.1 in the previous chapter to examine the relationship between $GDP$ and $GDPR$, i.e., to examine $GDPD$. During which periods would it have been particularly misleading to have focused on GDP instead of GDPR as a measure of output?

## 4.3 Federal Government Variables

The NIPA are useful for examining the role that the government plays in the economy. Net expenditures of the federal government ($EXPG$) are defined in equation 106, and net receipts ($RECG$) are defined in equation 105:

$$EXPG = PUG + TRGH + TRGR + TRGS + INTG + SUBG - IGZ, \tag{106}$$

$$RECG = THG + TCG + IBTG + SIG + TRFG - DG, \tag{105}$$

The federal government surplus (+) or deficit (-) ($SGP$) is the difference between receipts and expenditures, which is defined in equation 107:

$$SGP = RECG - EXPG, \tag{117}$$

---

**Experiment 4.3: The Federal Government Budget**

**Table the variables in equations 105, 106, and 107 for 2015:4.**

1. What are the largest components of government expenditures? What are the largest sources of government receipts?

---

## 4.4 Financial Saving

We now turn to some equations that relate to the links between the NIPA and the FFA. There are six sectors in the model, and there is an equation that defines the financial saving of each sector. The financial saving of the household sector ($SH$), for example, is defined in equation 65:

$$\begin{aligned} SH = {} & YT - SIHG - SIHS + USAFF - THG - THS - PCS \cdot CS \\ & - PCN \cdot CN - PCD \cdot CD + TRGH + TRSH + UB \\ & + INS + NICD + CCH - CTH - PIH \cdot IHH - CDH \\ & - PIK \cdot IKH - NNH \end{aligned} \tag{65}$$

The financial saving of a sector is all the receipts of the sector minus all of its expenditures. If receipts are greater than expenditures, there is positive saving; otherwise the sector is running a deficit.

There is also an equation for each sector that defines its budget constraint. If, for example, a sector's financial saving is positive, this must result in an increase in at least one of its assets or a decrease in at least one of its liabilities. The budget constraint of the household sector is equation 66 (remember that $\Delta$ means "change in"):

$$0 = SH - \Delta AH - \Delta MH + CG - DISH, \qquad 66$$

$AH$ is the household sector's net financial assets except for its holding of demand deposits and currency ($MH$). $CG$ is the capital gains variable, and $DISH$ is a discrepancy term. If $CG$ is positive, then $AH$ increases because corporate stocks held by the household sector are included in $AH$. Taking $CG$ as given, equation 66 shows that if $SH$ is positive and $MH$ is unchanged, then $AH$ must increase. In other words, a positive level of saving must result in an increase in net financial assets unless it all goes into demand deposits and currency.

The same considerations apply to the other sectors of the model. The five other saving equations are 69 (firm sector), 72 (financial sector), 74 (foreign sector), 76 (federal government sector), and 78 (state and local government sector). Note that federal government saving ($SG$) is almost always negative because the federal government almost always runs a deficit. (The federal government surplus or deficit variable in the model is actually $SGP$, not $SG$, but for all intents and purposes $SG$ and $SGP$ are the same. There are minor accounting differences between the two variables.) Note also that the saving of the foreign sector ($SR$) is the negative of the U.S. balance of payments on current account. The five other budget constraint equations are 70 (firm sector), 73 (financial sector), 75 (foreign sector), 77 (federal government sector), and 79 (state and local government sector). Equation 77, the federal government budget constraint, was discussed in Section 2.5.

An important constraint in the FFA is that the sum of the financial saving across sectors is zero except for the sum of three minor items: $STAT + USAFF$. Someone's expenditure is someone else's receipt, which is what this constraint says. This constraint is equation 80 in the model:

$$0 = SH + SF + SB + SG + SS + SR + STAT + USAFF, \qquad 80$$

Equation 80 is redundant in the model because it is implied by other equations. The equation is, of course, a good way of checking that the data are correct.

---

### Experiment 4.4: Saving Equations and Budget Constraints

**Table the variables in equations 65 and 66 for 2015:3 and 2015:4. Do the same for the variables in equations 69 and 70, in equations 72 and 73, in equations 74 and 75, in equations 76 and 77, and in equations 78 and 79.**

1. Note that the budget constraints are met in the data aside from rounding errors.
2. Observe that the six saving variables, $SH$, $SF$, $SB$, $SG$, $SS$, and $SR$, sum to $-STAT - USAFF$. Who are the big savers and who are the big dissavers?
3. Check equation 77 carefully, and review the discussion of this equation in Section 2.5.
4. Check the budget constraint for the foreign sector carefully. Why has $AR$ been increasing so rapidly recently?

---

The final constraint that will be discussed is the demand deposit identity, equation 71:

$$0 = \Delta MB + \Delta MH + \Delta MF + \Delta MR + \Delta MG + \Delta MS - \Delta CUR, \quad 71$$

$MH$, $MF$, $MR$, $MG$, and $MS$ are demand deposit and currency holdings of the various sectors. $CUR$ is the amount of currency in the hands of the public. $MB$ is the total amount of demand deposits held; it is negative because demand deposits are a liability of banks.

---

### Experiment 4.5: The Demand Deposit Identity

**Table the variables in equation 71 for 2015:3 and 2015:4.**

1. Check that equation 71 is met for 2015:4. Which sector holds the largest amount of demand deposits and currency? Which sector holds the smallest?

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# Chapter 5

# Fiscal Policy Effects under Alternative Assumptions about Monetary Policy

A good way to learn about the properties of a model (and if the model is any good about the properties of the economy) is to consider the effects of changing various fiscal policy variables. We know from Chapter 2 that fiscal policy effects depend on what is assumed about monetary policy, and so we must also consider monetary policy in this chapter. We begin with a very straightforward experiment: a decrease in government purchases of goods with the interest rate reaction function used. Federal government purchases of goods in the model is denoted COG. COG is to be decreased with equation 30 used.

## 5.1 Changes in Government Purchases of Goods

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**Experiment 5.1: Increase in Government Spending, Interest Rate Reaction Function**

**Change $COG$ by 10 in each quarter of the forecast period. The default option in the program is to use the interest rate reaction function (equation 30), and so no changes are needed regarding the assumption about monetary policy. Solve the model.**

The following are some of the questions you should consider about this experiment, but they are by no means exhaustive. You should add to the list. For most questions, you should focus on the results about four quarters out. After four quarters the economy has adjusted enough to the government spending change for the effects to be noticeable.

1. How are the following variables affected over time and why: real GDP ($GDPR$), the price level ($PF$), the unemployment rate ($UR$), the short term interest rate ($RS$), and the federal government deficit ($SGP$)? Note that the change in $GDPR$ divided by the change in $COG$ is the multiplier. How does the multiplier change over time? Why?

2. Examine how the main components of GDP are affected and try to explain why they move the way they do: $CS$, $CN$, $CD$, $IHH$, $IKF$, $IVF$, and $IM$.

3. Note that in the first quarter of the change the increase in $X$ is greater than the increase in $Y$. Why? Relate this to the theory behind equation 11.

4. Examine the employment and labor force responses in the model, and again try to explain the reasons behind the movements: $JF$, $E$, $L1$, $L2$, $L3$, and $LM$. What happened to productivity, $PROD$?

5. Why did $RS$ increase? Why did $RB$ and $RM$ increase? What happened to $M1$ and why?

6. What happened to the change in stock prices, $CG$, initially and then over time? Why?

7. How did $AG$ change? ($-AG$ is the value of federal government securities outstanding.) Why?

8. How was the level of profits, $PIEF$, affected? How was the saving rate of the household sector, $SRZ$, affected?

9. What happened to the percentage change in the real wage, $WR$, and why?

10. Use the discussion in Section 2.4 to help you in understanding the reasons for the results.

The second experiment is the same as the first except that the interest rate, $RS$, is taken to be exogenous.

---

### Experiment 5.2: Increase in Government Spending, Interest Rate Unchanged

**Change $COG$ by 10 in each quarter of the forecast period. Take $RS$ to be exogenous. Solve the model.**

1. The key feature of this experiment is that it is more expansionary than Experiment 5.1. Explain carefully why.
2. How did the Fed's behavior differ in this experiment from that in the first one? In which experiment was the change in AG larger in absolute value? Why?

---

The experiments so far have been for a permanent change in government purchases of goods. The next experiment examines the effects of a temporary change. This experiment is the same as Experiment 5.1 except that the change in $COG$ is only for the first quarter.

---

### Experiment 5.3: Temporary Increase in Government Spending, Interest Rate Reaction Function

**Change $COG$ by 10 in the first quarter of the forecast period. Use the interest rate reaction function—the default. Solve the model.**

1. Compare the results of this experiment with those of Experiment 5.1. (Note that the results for the first quarter are the same.)
2. How long does it take for the effects of the $COG$ change on the economy to be essentially negligible?

---

## 5.2 Other Fiscal Policy Variables

We now turn to other tools of fiscal policy. For the rest of the experiments in this chapter we will use the interest rate reaction function as our assumption about monetary

policy. Keep in mind, however, that somewhat different results would be obtained if instead we took $RS$ to be exogenous.

Say that instead of increasing government spending $COG$ by \$10 billion, you wanted to lower personal income taxes by approximately the equivalent amount. How do you do this? The federal personal income tax rate in the model is $D1G$, and so $D1G$ needs to be lowered. Say that we want $D1G$ to be lowered so that the initial impact of the tax decrease adds about the same amount money to the economy as did the increase in $COG$. $COG$ is in real terms and tax payments are in nominal terms, and so the first thing we need to do is to convert the \$10 billion increase in $COG$ into nominal terms. $PG$ in the model is the price index for $COG$, and its value in 2015:4 was 1.084. The nominal change in government spending corresponding to a \$10 billion real change is thus \$10 billion times 1.084 = \$11 billion. We thus need to lower taxes by \$11 billion.

The level of federal personal income taxes in the model ($THG$) is determined by equation 47:

$$THG = [D1G + (TAUG \cdot YT)/POP]YT, \tag{47}$$

where $YT$ is taxable income. The federal tax system is estimated in the model to be slightly progressive, and so the tax rate increases as $YT$ increases. $TAUG$ is the estimated progressivity parameter. Now, the question is, in order to decrease $THG$ by \$11 billion, how much do we have to lower $D1G$? To answer this, we need to know the level of $YT$. $YT$ in 2015:4 was \$3,309.8 billion, and \$11 billion is .332 percent of this. Therefore, we need to lower $D1G$ by .00332. We will so this in the following experiment.

You should be aware that calculations like we have just done are rough. You cannot change $D1G$ to hit a particular change in $THG$ exactly because $YT$ is endogenous. As $D1G$ is changed, the economy changes, including $YT$, and so $THG$ will also change for this reason as well as from the initial change in $D1G$. Calculations like the above give one a fairly good idea where to start, but it may be after the first run that you want to adjust $D1G$ slightly to meet more accurately the $THG$ target.

---

## Experiment 5.4: Decrease in the Personal Income Tax Rate, Interest Rate Reaction Function

**Change $D1G$ by -.00332 in each quarter of the forecast period. Solve the model.**

1. Compare the results of this experiment with those of Experiment 5.1. Why is the economy slower to respond in this case? Which policy change is best for decreasing the federal government deficit and why?

2. What does the Fed do in response to the decrease in taxes and why?

3. How has the tax rate decrease affected the labor force? How has it affected the personal saving rate, $SRZ$?

---

Another important fiscal policy variable is $TRGHQ$, the level of transfer payments from the federal government to households. $TRGHQ$ is in real terms. Say that instead of decreasing the personal tax rate to lower personal taxes by approximately \$11 billion in real terms, the government wanted to increase $TRGHQ$ by \$11 billion. The experiment is:

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### Experiment 5.5: Increase in Transfer Payments, Interest Rate Reaction Function

**Change $TRGHQ$ by 11 in each quarter of the forecast period. Solve model.**

1. Compare the results of this experiment to those of Experiments 5.1.

2. Compare the different labor force responses between this experiment and Experiment 5.1. How do these differences affect the unemployment rate? In answering this question, review the discussion in Section 2.4 under the heading "Labor Supply and the Unemployment Rate."

3. Although the model has nothing to say about this, are the distributional consequences of lowering $D1G$ versus raising $TRGHQ$ likely to be different? How?

---

There are other fiscal policy variables that can be changed, which you may want to do as additional assignments. The following are additional changes that can be made.

### Changes in the Profit Tax Rate $D2G$

WARNING: Please read Section 2.4 under the heading"Tax Rate Effects" regarding the likely effects of changing $D2G$. Changing $D2G$ may not be a sensible thing to do.

Federal corporate profit taxes ($TFG$) is determined in equation 49:

$$TFG = D2G(PIEF - TFS), \qquad 49$$

where $PIEF$ if the level of profits, $TFS$ is the level of state and local profit taxes (which are deductible from profits before computing federal taxes), and $D2G$ is the profit tax rate. If, say, you want to decrease $TFG$ by \$11 billion ($TFG$ is in nominal terms), how much do you decrease $D2G$? In 2015:4 the value of $PIEF - TFS$ was \$322.4 billion, and \$11 billion is 3.41 percent of this. Therefore, $D2G$ should be lowered by .0341 to decrease profit taxes by \$11 billion.

### Changes in the Indirect Business Tax Rate D3G

The level of federal indirect business taxes ($IBTG$) is determined by equation 51:

$$IBTG = [D3G/(1+D3G)]*(PCS*CS+PCN*CN+PCD*CD-IBTS), \quad 51$$

The last term in parentheses is the tax base. Its value in 2015:4 was \$2827.9 billion. The value of $D3G$ in 2015:4 was .0138 If, say, you want to decrease $IBTG$ by about \$11 billion, which is .389 percent of \$2827.9 billion, $D3G$ should be lowered by .00389(1 + .0138) = .00394.

### Changes in the Social Security Tax Rates $D4G$ and $D5G$

The level of employee social insurance contributions to the federal government ($SIHG$) is determined by equation 53, and the level of employer social insurance contributions to the federal government ($SIFG$) is determined by equation 54:

$$SIHG = D4G[WF \cdot JF(HN + 1.5HO)], \quad 53$$

$$SIFG = D5G[WF \cdot JF(HN + 1.5HO)], \quad 54$$

$WF \cdot JF(HN + 1.5HO)$ is the wage base. The value of the wage base in 2015:4 was \$2266.0 billion. If, say, you want to decrease $SIGH$ and $SIFG$ each by \$5.5 billion (for a total of \$11 billion), then $D4G$ and $D5G$ should be decreased by .00243 each since \$5.5 billion is .243 percent of \$2266.0 billion.

### Changes in the Number of Military Jobs $JM$

$JM$ is the number of federal military jobs (in millions of jobs). From equation 104 (see Table A.3 in the appendix), each job costs the government $WM \cdot HM$, where $WM$ is the wage rate per hour (divided by 1000) and $HM$ is the number of hours worked per job in the quarter (which for military jobs is always taken to be 520 hours). In 2015:4 the value of $WM$ was \$.0770 and as just noted the value of $HM$ was 520. If, say, you want to increase $JM$ to correspond to an increase in nominal government spending of \$11 billion, this is an increase in $JM$ of $11/(.0770 \cdot 520)$ = .275 million jobs.

### Changes in the Number of Federal Government Civilian Jobs $JG$

Similar considerations apply to the number of civilian jobs $JG$. From equation 104, the cost of a civilian job to the government is $WG \cdot HG$, where $WG$ is the wage rate per hour (divided by 1000) and $HG$ is the number of hours worked per job in the quarter. In 2015:4 the value of $WG$ was \$.0346 and the value of $HG$ was 465.6. If you want to increase $JG$ to correspond to an increase in nominal government spending of \$11 billion, this is an increase in $JG$ of $11/(.0346 * 465.6)$ = 0.683 million jobs.

### Change in Grants in Aid to State and Local Governments $TRGSQ$

$TRGSQ$ is the level of grants in aid to state and local governments from the federal government. It is in real terms, and you can change it like $TRGHQ$ was changed in Experiment 5.5. Remember, however, that any change in $TRGSQ$ is likely to change state and local government behavior. If you increase $TRGSQ$, state and local governments are likely to spend more or tax less, and if you decrease $TRGSQ$, they are likely to spend less or tax more. You should thus change some state and local government variable along with $TRGSQ$ in order for the experiment to be sensible.

### A Note on Being Sensible

You should be aware that large, rapid changes in government policy variables are not realistic. It takes time for the government to put policy changes into effect, and the political process is such that large changes are seldom done. Also, if you make large changes in policy variables, the results from the model are less trustworthy than if you make small changes. Changes in policy variable that are outside the range of past changes means that you are analyzing events that are historically unprecedented, and since models are estimated over historical data, they may not capture the effects of extreme events well. So don't go wild with the policy variables.

# Chapter 6

# Monetary Policy Effects

When the interest rate reaction function—equation 30—is included in the model, monetary policy is endogenous. In other words, there is no exogenous monetary policy variable to change. One can, however, drop equation 30 and examine the effects of exogenous changes in $RS$. This is done in experiment 6.1.

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**Experiment 6.1: Increase in the Short Term Interest Rate $RS$**

**Take $RS$ to be exogenous and increase it by 1.0 in each quarter of the forecast period. Solve the model.**

1. Answer the questions posed at the end of Experiment 5.1. (Experiment 6.1 is another key experiment that you should have a good understanding of.)
2. What did $M1$ do in response to the increase in $RS$? Why?
3. Remember that $-AG$ is the value of government securities outstanding. This is the open market operations variable of the Fed. Note that $-AG$ increased in the experiment. Why?
4. What was the effect on government interest payments $INTG$? How did this affect $SGP$?

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# Chapter 7

# Price Shocks and Stock Market Shocks

## 7.1 Price Shocks

The key exogenous variable regarding the behavior of prices is the price of imports ($PIM$). If $PIM$ increases, this increases domestic prices through the price equation 10. The effect of a change in $PIM$ on domestic prices is in fact quite large. Experiment 7.1 examines this question.

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**Experiment 7.1: Increase in the Import Price Index $PIM$**

**Increase $PIM$ by 10 percent in each quarter of the forecast period. Solve the model.**

1. Note that stagflation resulted from this experiment. Why? In particular, why did aggregate expenditures fall in real terms?
2. What did the Fed do in response to all of this? (Remember that equation 30 is in the model for this experiment since it is the default option and you made no changes regarding monetary policy.)
3. What happened to the real wage and why? To the labor force? To the household saving rate? To corporate profits in nominal terms ($PIEF$)? To corporate profits in real terms ($PIEF/PF$)?

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The model attributes much of the stagflation of the 1970's to the huge increase in $PIM$ that occurred during this period. This can be seen in the following experiment.

---

### Experiment 7.2: What if $PIM$ had not changed after 1973?

**Set the prediction period to be 1974:1–1978:4. Ask to use the historical errors. Change the values of $PIM$ for 1974:1-1978:4 to be equal to the actual value in 1973:4. Solve the model.**

1. How different would the U.S. economy have been had $PIM$ not changed from its value in 1973:4, i.e., had there been no oil price shock? Examine the key variables in the model. How much of the stagflation during this period does the model attribute to $PIM$?

2. What does the model estimate the Fed would have done differently had $PIM$ not risen? How would $AG$ have been different?

3. How would the labor force have been different, and what would the unemployment rate have been?

4. This is an important experiment in that it shows that according to the model the 1970's would have been fine had it not been for the oil shock and the other price shocks that caused $PIM$ to increase so rapidly.

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## 7.2 Stock Market Shocks

Almost everyone knows the stock market crashed in October of 1987. After the crash, how was the economy affected? The model can be used to estimate these effects. The stock market variable in the model is $CG$, the capital gains (+) or losses (-) on stocks held by the household sector. The crash in October resulted in a fall in $CG$ of about $500 billion. Although the October crash is history, we can ask how the economy would respond if there were a large fall in, say, 2016:1, the first quarter of the forecast period. We will assume a fall of $2000 billion in 2016:1, but no further fall after that.

---

### Experiment 7.3: Stock Market Crash in 2016:1

**Drop equation 25, and change the value of CG in 2016:1 by -2000. Solve the model for the forecast period (beginning in 2016:1).**

1. How did the crash affect household net wealth, $AA$? How did households respond to this change in $AA$ regarding consumption and labor supply? (Note that there is a lag of one quarter in the effects of $AA$ on household behavior.)

2. What roughly was the fall in consumption per year as a percent of the fall in $AA$? Does this percent seem reasonable?

3. How did the Fed respond to the crash?

4. What is roughly the loss of real GNP per year as a result of the crash?

5. This experiment is important in that it shows that a crash of this size may result in a recession, but not a depression.

---

# Chapter 8

# Housing Price Shocks

Nominal housing wealth in the model is $PKH \cdot KH$, where $KH$ is the real stock of housing and $PKH$ is the market price of $KH$. Nominal housing wealth enters in the definition of $AA$ (equation 89), which is the wealth variable that affects consumption demand (equations 1, 2, and 3). $PKH$ is determined (equation 55) as $PSI14 \cdot PD$, where $PD$ is the price deflator for domestic sales and $PSI14$ is exogenous. It is thus possible to change housing wealth in the model by changing $PSI14$. For example, if you think housing prices are going to fall (relative to $PD$) in the future, you can decrease $PSI14$. This is done in the experiment in this chapter. It allows you to see the estimated effects on the economy of falling housing prices.

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### Decrease in PSI14

**Decrease $PSI14$ by 20 percent for the forecast period. Solve the model.**

1. How much did nominal housing wealth, $PKH \cdot KH$, fall? How much did the real wealth variable $AA$ fall?
2. What effect did this change have on the consumption variables, $CS$, $CN$, and $CD$? On the labor supply variables, $L1$, $L2$, $L3$, and $LM$? (Note that there is a lag of one quarter in the effects of $AA$ on household behavior.)
3. How did the Fed respond to the fall in housing prices?
4. What is roughly the loss of real GNP per year as a result of the fall in housing prices?

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# Chapter 9

# Sensitivity of the Results to the Fed's Weight on Inflation

Equation 30, the interest rate reaction function, is estimated. It is an estimate of Fed behavior. The coefficient estimate on inflation in this equation is an estimate of how the Fed responds to inflation regarding its interest rate policy. The experiment in this chapter asks the question of how much different it would make regarding fiscal-policy effects if the inflation coefficient were larger.

We have seen in Chapter 5, Experiment 5.1, how the economy responds to an increase in $COG$ when the interest rate reaction function is used. We now examine the question of how the results change when the Fed's weight on inflation is larger. We will make the inflation coefficient in equation 30 three times as large as the estimated value and then rerun Experiment 5.1 for this version of the model.

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### Experiment 9.1: Experiment 5.1 with more weight on inflation in equation 30

**Triple the third coefficient in equation 30. Solve the model for the forecast period. Call this dataset BASEA. Create a new dataset using BASEA as your base dataset. Call this dataset NEWA. Change $COG$ by 10 in each quarter of the forecast period. Solve the model for the forecast period. Answer the following questions by comparing NEWA to BASEA. (You should use names other than NEWA and BASEA because these have already been used. It doesn't matter what the dataset names are.)**

1. Note that a new base dataset had to be created because a coefficient was changed. The predictions of the new version of the model are not the same as the pre-

dictions in YAOBASE, and so a new base dataset had to be created. It is not of interest to compare the predicted values in BASEA with the values in YAOBASE. They differ, but only because a coefficient estimate has been arbitrarily changed. Make sure you understand what is going on here.

2. Compare these results to those of Experiment 5.1. Explain carefully the differences. Do these differences make sense given that the Fed now cares more about inflation?

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There are many other experiments of this type that you can perform. For example, you can change other coefficients in equation 30, say increasing the weight on unemployment, and examine how this affects the results of changing $COG$. You can also run different fiscal-policy experiments (other than just changing $COG$) once you have your new version of the model. Be sure each time you change a coefficient that you get a new base dataset (like BASEA above).

# Chapter 10

# Sensitivity of the Results to the Interest Elasticity of Aggregate Expenditures

An important issue in a macroeconomic model is the interest elasticity of aggregate expenditure. How much do consumption and investment respond to changes in interest rates? How much would the properties of the model change if the responses were different? These questions can be analyzed by running different experiments. We first consider the case in which the interest elasticity of consumer expenditures for durable goods is larger. We then explore the case in which the interest elasticity of nonresidential fixed investment equation is larger.

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## Experiment 10.1: Experiment 6.1 with more Interest Elastic Consumer Expenditures

**Change the eighth coefficient in equation 3 to be twice its size in absolute value. Solve the model for the forecast period. Call this dataset BASEA. Create a new dataset using BASEA as your base dataset. Call this dataset NEWA. Take $RS$ to be exogenous, and increase $RS$ by 1 in each quarter of the forecast period. Solve the model for the forecast period. Call this dataset NEWA. Answer the following questions by comparing NEWA to BASEA. (As mentioned in Experiment 9.1, you should use names other than NEWA and BASEA.)**

1. Note that as in Experiment 9.1 a new base dataset had to be created because a coefficient was changed. The predictions of the new version of the model are not the same as the predictions in YAOBASE, and so a new base dataset

had to be created. Again, it is not of interest to compare the predicted values in a dataset like BASEA with the values in YAOBASE. They differ, but only because a coefficient estimate has been arbitrarily changed.

2. Compare these results with those of Experiment 6.1. Explain the differences carefully.

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## Experiment 10.2: Experiment 6.1 with more Interest Elastic Capital Stock

**Change the ninth coefficient in equation 12 to be twice its size in absolute value. Solve the model for the forecast period. Call this dataset BASEA. Create a new dataset using BASEA as your base dataset. Call this dataset NEWA. Take $RS$ to be exogenous, and increase RS by 1 in each quarter of the forecast period. Solve the model for the forecast period. Call this dataset NEWA. Answer the following questions by comparing NEWA to BASEA. (As mentioned in Experiment 9.1, you should use names other than NEWA and BASEA.)**

1. Compare these results with those of Experiment 6.1. Explain the differences carefully. In particular, how does the behavior of nonresidential fixed investment, $IKF$, differ? Remember that $IKF$ is equal to the change in the capital stock plus depreciation (equation 92).

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# Chapter 11

# Sensitivity of the Results to the Specification of the Price Equation

Prices in the model respond only modestly to changes in the unemployment rate. This seems to be what the data are telling us, but many may feel that prices are likely to respond more than the model indicates. It is easy to change the model to make it more price sensitive to unemployment changes. This is done by making the coefficient of the unemployment rate in equation 10 larger in absolute value. This is what Experiment 11.1 does.

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### Experiment 11.1: Experiment 5.1 with a more Unemployment Sensitive Price Equation

**Change the fifth coefficient in equation 10 to be twice its size in absolute value. Solve the model for the forecast period. Call this dataset BASEA. Create a new dataset using BASEA as your base dataset. Call this dataset NEWA. Change $COG$ by 10 each quarater. Solve the model for the forecast period. Call this dataset NEWA. Answer the following questions by comparing NEWA to BASEA. (As mentioned in Experiment 9.1, you should use names other than NEWA and BASEA.)**

1. The price index $PF$ rises more in this experiment than it does in Experiment 5.1. Why? Do you think the price response should be even larger?

2. Why was the increase in real GDP slightly less here than in Experiment 5.1? Be sure to trace through the effects.

3. How did the Fed behave here as compared to Experiment 5.1?

The sensitivity of prices to changes in demand is one of the key questions in macroeconomics, and experiments like 11.1 help to examine it.

# Chapter 12

# Foreign Sector Effects

The two key exogenous foreign sector variables in the model are the real value of exports $EX$ and the price index for imports $PIM$. Imports $IM$ and the price of exports $PEX$ are endogenous. We have seen the effects of changing $PIM$ in Experiments 7.1, 7.2, and 8.6. We have seen the effects of changing $EX$ in Experiments 8.4 and 8.5.

It is not always sensible to take $EX$ and/or $PIM$ to be exogenous when experiments are being run, and we have so far ignored this problem. Without building a multicountry model, it is not really possible to endogenize $EX$ and $PIM$, but a few partial steps in this direction can be taken. Say that you are increasing interest rates and you feel that this will lead to an appreciation of the dollar. If the dollar appreciates, $PIM$ should go down (imports will be cheaper in dollars) and $EX$ should go down (U.S. exports are now more expensive in foreign currencies). There are, of course, lags in the effects of exchange rate changes on $PIM$ and $EX$, and these lags can be fairly long.

You can take foreign sector effects into account in the model if you are willing to specify ahead of time how $PIM$ and $EX$ are affected by whatever change you are making. You can enter your changes to $PIM$ and $EX$ along with your other changes and then solve the model. In the example of an interest rate increase, you will have to specify 1) how the interest rate increase affects the value of the dollar, 2) how the change in the value of the dollar translates into a change in $PIM$, and 3) how the change in the value of the dollar translates into a change in the U.S. price of exports in foreign currencies and how this in turn affects $EX$.

There is obviously some work involved in doing this, but it is necessary to do this short of constructing a complete multicountry model. Fortunately, there are only two key variables that you need worry about, $PIM$ and $EX$, and so the adjustments are not too burdensome. Also, many of the changes that one makes when running

experiments are likely to have only minor effects on $PIM$ and $EX$, and so in many cases ignoring these effects is not likely to be very serious.

# Chapter 13

# Other Possible Experiments

The suggested experiments in this workbook by no means exhaust the possible experiments that can be performed. Indeed, the workbook is really only meant to get you started on your way to your own analysis of macroeconomic questions and issues. This chapter presents a few more possible experiments for you to ponder.

## 13.1 Combinations of Policies

It is best when first learning about the properties of a model to change only one exogenous variable at a time. Otherwise, one can get hopelessly lost in trying to figure out what is affecting what. In practice, however, one is usually concerned with more than one exogenous variable at a time. The government may want to know the consequences of changing both taxes and government expenditures at the same time. A business forecaster may want to know the outcome of an increase in import prices and an increase in exports. You would probably want to change state and local government expenditures or taxes at the same time that you change federal grants in aid to state and local governments.

Now that you have gone through the workbook, you should not be shy about trying more complex sets of exogenous variable changes. If you know the consequences of changing one variable at a time, you should be able to explain the outcome when many variables are changed. A common type of experiment to perform is to pick a target path for some endogenous variable, say the federal government deficit, and keep changing policy variables until the target path is roughly met. You can answer questions like the following. What combinations of monetary and fiscal policy changes would lead to the target path being met, and are any of these combinations politically feasible? The variety of these types of experiments is quite large. Note also that you can phase in changes in policy variables. It is not necessary, for example, to have $COG$ change

by \$10 billion from the first quarter on or to have $RS$ change by one percentage point beginning immediately. The changes can differ by quarters and gradually work up to the final change that is desired.

Don't forget that any experiment that you choose can be performed with different versions of the model. The types of changes in the model that were made in Chapters 9-11 can be made for any experiment.

## 13.2 Effects of Changing State and Local Government Variables

The tax and spending variables of the state and local government sector are similar to those of the federal government sector. These variables are changed in the same way that federal government variables are changed. The same types of experiments that were performed in Chapter 5 for the federal government can be performed for the state and local governments.

## 13.3 Imposing Rational Expectations on the Model

In some cases it is possible to impose rational expectations on the model. Consider the bond market and the bond rate $RB$. $RB$ is determined in the model by the term structure equation 23, where $RB$ is a function of current and lagged values of the short term interest rate $RS$. If there are rational expectations in the bond market, then $RB$ should instead be a function of current and expected future values of $RS$, where the expected future values of $RS$ are what the model predicts them to be.

Say we take an seven quarter horizon and we take $RB$ to the be average of $RS$ and the next six future values of $RS$:

$$RB = (1/7)(RS + RS_{+1} + RS_{+2} + RS_{+3} + RS_{+4} + RS_{+5} + RS_{+6})$$

where the future values of $RS$ are those predicted by the model. Can this version of the model be analyzed using the program. The answer is yes, with a little extra work. The way this is done is as follows.

1. Specify the above equation for $RB$ and the same equation for $RM$. Drop equations 23 and 24.

2. Pick a prediction period, say 2016:1-2017:4. Choose eight future values of $RS$ for the eight quarter period beyond the end of the prediction period (i.e., for the period 2018:1-2019:4). These eight values will remain the same throughout

the analysis; they are your guesses as to what the $RS$ values will be in these eight quarters.

3. Given your guessed values and the base values of $RS$, compute $RB$ from the above equation for each quarter of the prediction period (2016:1-2017:3). Do the same for $RM$. (If the $RM$ equation is the same as the $RB$ equation, then $RM$ is always equal to $RB$.) Enter these values of $RB$ and $RM$ into the program (you can do this because equations 23 and 24 are dropped and thus $RB$ and $RM$ are exogenous).

4. Solve the model for the 2016:1-2017:4 period (making no other changes). The new solution values of $RS$ will in general be different from the base values you used to compute $RB$ and $RM$. Now use these new values of $RS$ to compute new values of $RB$ and $RM$ and enter the new values of $RB$ and $RM$ into the program. Solve the model again. Use the new values of $RS$ to compute new values of $RB$ and $RM$, enter the new values of $RB$ and $RM$, and solve again. Keep doing this until the new solution values of $RS$ are close to the values from the previous solution. At this point you have converged. The values of $RB$ and $RM$ are consistent with the future values of $RS$, and expectations in the bond and mortgage market can be said to be rational. Convergence can usually be achieved to a reasonable level of accuracy in less than 10 iterations.

5. You are not really done at this point, however, because presumably you would like to use this new version of the model to analyze policy changes. Call the last dataset you created in step 4 (the dataset for which convergence was achieved) BASER. This is your base dataset for the new version of the model. Now take BASER as your base dataset and make a policy change, such as a change in $COG$. Solve the model, and call the new dataset NEWA. (Remember that the use of BASER as the base dataset means that $RB$ and $RM$ are treated as exogenous.) NEWA is not, however, the final dataset to compare to BASER because the predicted values of $RS$ in NEWA are not consistent with the values of $RB$ and $RM$ that are in the dataset. You must now change the values of $RB$ and $RM$ (using the above equation) to be consistent with the new values of $RS$. Enter these in the program and solve again. Keep doing this until you reach convergence. Call the dataset at the point of convergence NEWR.

6. You can now compare the solution values in NEWR with those in BASER. These differences are the effects of the policy change in the new version of the model, the version in which there are rational expectations in the bond and mortgage markets.

If you work through and understand this example, you can probably think of other ways of adding rational expectations to the model. Iteration in the above manner is fairly straightforward and not too much extra work once you get practiced.

## 13.4 Making Major Changes to the Model

The site is limited in how much you can change the model. You can drop equations and change coefficients. You cannot, however, add variables to the equations, and you cannot add new equations (except ones that have been dropped previously). Fortunately, there is software that allows you to change the model as much as you want. If you use the US model in the Fair-Parke program, you can respecify the existing equations, add new equations, reestimate, and then solve the new version. In fact, if you don't like anything in the US model except the identities (which no one can complain about since they are always true), you can start from scratch and specify your own stochastic equations. Once you get your version of the model specified and estimated, you can use the Fair-Parke program to change policy variables and examine the model's properties. The range of possibilities here is essentially endless.

## 13.5 Supply Side Experiments

Some"supply side" experiments are not sensible to perform within the model. The main example concerns the variable $LAM$ in equation 94. If, say, you increase $LAM$, this makes labor more productive. If labor is suddenly more productive, there is more excess labor on hand, which has a negative effect on employment demand and hours paid for ($JF$ and $HF$). These are not likely to be the effects one has in mind when considering exogenous productivity increases. There is simply no direct way in which productivity increases stimulate demand in the model, and if this is what one has in mind, the model is of really no use for this purpose. Supply experiments like price shocks are fine to run, but you should probably stay away from changing LAM.

Regarding supply side experiments, note that changing variables like tax rates that affect the labor force have supply side components. If personal tax rates are lowered, more people enter the labor force looking for work (the quantity of labor supplied increases). This in and of itself, however, does not create new jobs, only more people looking for jobs. Unless something is done to create new jobs, the main thing that happens when the labor force increases is that the unemployment rate increases. (A tax cut, of course, also stimulates demand, and so in this example new jobs will be created.)

## 13.6 Counterfactual Experiments

It is easy with the model to ask questions like"what would the economy have been like had something that was done not been done or had something that was not done been done?" These"counterfactual" questions are popular with economic historians, among others. Experiment 7.2 is a counterfactual one, where we are asking what the economy would have been like had the price of imports not risen in the 1970s.

This workbook has not stressed counterfactual experiments because it is easier to learn about the properties of the model (and hopefully about the economy) by running simpler experiments. If you have worked through the experiments in this workbook, you are now ready to launch into counterfactual experiments if you wish. You should now have no trouble understanding the results from such experiments. How would the economy have been different had President A done $x$, $y$, and $z$ instead of what he actually did? What if $c$, $d$, and $e$ had not happened? What if $f$, $g$, and $h$ had happened? There is room for many term papers here, so you can now get to work.