

# Macro Simulations for PCs in the Classroom

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There has always been a large difference between macroeconomics in the classroom and macroeconomics as it is used in practice. Macroeconomics of the classroom is basically theoretical, and it is taught almost exclusively in a simple comparative statics framework. Practicing macroeconomists, on the other hand, work with time-series data, sophisticated statistical techniques, and large-scale macroeconometric models. The PC revolution has now made it possible to bring macroeconometric models into the classroom.

The model in Fair (1984), which consists of 128 equations, has been programmed to run on a PC; this paper will discuss its potential for use as a teaching tool at the elementary and advanced levels. The experience so far has been quite encouraging.

## I. Hardware Requirements

The software was written with the aim of minimizing the amount of memory needed to run the program. This amount turned out to be 128K, which includes the memory needed for the operating system of the computer. Although the model is fairly large (238 endogenous and exogenous variables), only five quarters' worth of data are needed in core memory at any one time. Data for five quarters are needed because the model has lagged values of up to four quarters. After the model is solved for a given quarter (the fifth quarter in memory), the results for that quarter are written to the disk, a new quarter's worth of data are read (with the old first-quarter's data dropped from memory),

and the model is solved for the new quarter. This process is repeated throughout the prediction period. Because of this structure, the program does a fair amount of reading from and writing to the disk.

The program runs on IBM and IBM-compatible personal computers; it also runs on the DEC Rainbow and the Wang. It can be used on computers with only one disk drive, although two disk drives are more convenient. A version of the software allows one to use Lotus 123 to analyze the output; for this version the memory requirement is 192K. It takes about 10 to 20 seconds on a standard IBM PC to solve the model for one quarter. A twelve-quarter solution thus takes about 2 to 4 minutes.

## II. The Software

The software is menu driven and is easy to use even for students who have no prior experience using PCs. One of the main things that users must learn is the treatment of data sets. Included with the software is a "base" data set. This data set contains data on the endogenous and exogenous variables for the period of interest and all the other information, such as the coefficient estimates, that are needed to solve the model. For many applications the period of interest is an actual forecast period, for example, 1984:4 to 1987:4. In this case the values of the endogenous variables in the base data set are predicted values. If the period of interest is some historical period, the values of the endogenous variables in the base data set are the actual values. The teacher or student can use the "historical" part of the software to create a base data set for any six-year period from 1952 on.

Assume that the base data set is for an actual forecast period, so that the endogenous variable values are predicted values. This means that if a forecast is run with no changes made to the base data set, the pre-

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dicted values of the endogenous variables will simply be the values already in the data set. The job of the student is to change some of the information in the base data set and run a new forecast. The main menu that the user faces is as follows:

Enter	To
1	Change assumptions about monetary policy.
2	Change exogenous federal government fiscal policy variables.
3	Change exogenous state and local government variables.
4	Change exogenous foreign sector variables.
5	Change other exogenous variables.
6	Change equations by the use of add factors.
7	Drop or add equations.
8	Take equations to begin after the beginning of the forecast period.
9	Change coefficient values.
10	Exit.

The monetary and fiscal policy options (1 and 2) are the ones most often used. These are discussed in Sections III and IV below. Options 3, 4, and 5 allow other exogenous variables to be changed. Option 6 allows add factors to be used, something which is not of much interest for teaching purposes. Option 7 allows equations to be dropped, which means that the equations are not used and the endogenous variables that are explained by the equations are taken to be exogenous. This option is sometimes useful for examining subsets of the model's equations. Option 8 allows the equations to be dropped for only part of the forecast period. Finally, option 9 allows the coefficient values to be changed. An example of the use of this option is presented in Section III.

Once the changes have been made, a new forecast is run. New data are created from this run, which consist of the user's changes from the base data set and the new predicted values. The student can then use the software to examine the differences between the predicted values in the two data sets. These differences are the effects that the changes

have had on the endogenous variables in the model. As many new data sets can be made as the user likes, any previously created data set can be used as a base data set, and any two previously created data sets can be compared. The fact that all the information about an experiment is contained in one data set makes it very easy to compare alternative runs.

If the period of interest is historical (any period except the current forecast period), then the endogenous variable values in the base data set are the actual values, and a new "base" data set must be created before any changes are made. This data set is created by simply solving the model over the period of interest with no changes made. The endogenous variable values in this data set are then predicted by the model and are the appropriate ones from which to make comparisons when changes are made in running experiments. If the changes were made from the original base data set, the differences between the endogenous variable values in the new and base data sets would have included the predictive errors, which are not, of course, a result of the user's changes.

### III. Intermediate and Advanced Teaching

Knowledge of the structure of the model is needed for intermediate and advanced teaching. The theory behind the model is that agents make decisions by solving multiperiod optimization problems. The key decision variables for households are consumption and leisure, and the key decision variables for firms are prices, wages, production, investment, and employment demand. A typical estimated equation in the model has a decision variable on the left-hand side and variables that are assumed to affect the decision on the right-hand side.

The first step in teaching with the model is simply to go through the 30 estimated equations. There are 9 estimated equations for the household sector: three categories of consumption (service, nondurable, and durable), housing investment, four categories of labor supply (labor force participation of males 25-54, females 25-54, and all others, and the number of people holding two jobs), and

a demand for money equation. There are 12 equations for the firm sector. The 7 most important explain the firm sector's price level, production, investment, demand for workers, demand for hours per worker, the wage rate, and the demand for money. The other 5 equations explain overtime hours, dividends, interest, inventory valuation adjustment, and depreciation. The explanatory variables in the main equations are consistent with the view that households maximize utility and firms maximize profits. The equations are fairly easy to explain since one can appeal to students' knowledge of microeconomics.

The short-term interest rate in the model is explained by an interest rate reaction function of the Federal Reserve, and this is a good equation to discuss next. It is a "leaning against the wind" equation in the sense that the Fed is estimated to allow the short-term interest rate to rise as 1) inflation rises, 2) labor markets get tighter, 3) real output growth increases, and 4) lagged growth of the money supply increases. The inclusion of this equation in the model means that monetary policy is endogenous.

The remaining 8 estimated equations in the model include two term structure equations (explaining a long-term bond rate and a mortgage rate), a stock price equation, a demand for currency equation, an equation explaining bank borrowing from the Fed, a demand for imports equation, an equation explaining unemployment insurance benefits, and an equation explaining the interest payments of the federal government.

The next task is to review the 98 identities. A key feature of the model is that all flow-of-funds and balance-sheet constraints are met, and many of the identities relate to these constraints. There are six sectors in the model (household, firm, financial, foreign, state and local government, and federal government), and for each sector there is an identity determining its level of savings. The sum of savings across sectors is zero, since the revenue of one sector is the expense of some other sector or sectors. There is also an identity for each sector that relates the level of savings of the sector to changes in its assets and liabilities: any nonzero value of savings in a period must result in the change

in at least one asset or liability. Explaining these identities carefully for one sector allows one to go through them quickly for the other sectors. The remaining identities in the model, which are equations like the *GNP* definition, can also be quickly reviewed.

One is now in a position to have the students run some experiments. A good starting point is to have the change be an increase in federal government purchases of goods, which is a standard expansionary fiscal-policy action. This change can be analyzed under four different assumptions about monetary policy. In other words, four solutions of the model can be made for the fiscal-policy change, each solution corresponding to a different assumption about monetary policy. The four assumptions are: 1) the interest rate reaction function used (monetary policy endogenous), 2) the short-term interest rate unchanged from the base case, 3) the money supply unchanged from the base case, and 4) nonborrowed reserves unchanged from the base case.

Having the students explain carefully the reasons for the differences across the monetary-policy assumptions is an effective way of having them learn about the links between monetary policy and fiscal policy. Under each of the assumptions, the amount of government securities outstanding (the open market operations variable of the Fed) is endogenous, and the students should be required to explain why the government securities variable changed in the particular way that it did for each run. An example of a difference between runs is that the economy is more expansionary under the assumption of an unchanged interest rate than it is under the use of the interest rate reaction function. With the interest rate reaction function, the Fed responds to the fiscal-policy action by allowing interest rates to rise, which slows the expansion. The increase in government securities outstanding is larger in this case.

Explaining the four cases generally takes two or three class periods. There are two types of things to be learned from these results. One is the response of the household and firm sectors to the fiscal-policy change, and the other is the relationship between monetary policy and fiscal policy. The results

for the household and firm sectors can be related to the prior discussion of the individual equations for these sectors. The model has the feature that both an expansionary fiscal policy and an expansionary monetary policy stimulate private demand, and so to some extent one can consider the question of the relationship between monetary policy and fiscal policy without knowing too much about the detailed responses of the household and firm sectors. This makes the results somewhat less model specific than one might otherwise think. Also, accounting for the flow-of-funds and balance-sheet constraints is not model specific in the sense that these are just identities, and so anything that is learned from this accounting framework is not model specific. For example, crowding out issues can be easily examined since any deficit that the government runs from an expansionary fiscal-policy action must be financed by an increase in savings of at least one other sector, and the model tells one directly which sectors are doing the increased saving.

The next step is to run other fiscal-policy experiments. Various tax rates can be changed, the level of transfer payments can be changed, and the number of government jobs can be changed. These runs allow the effects of different fiscal policies to be compared (given the same monetary-policy assumption for each experiment). For example, a decrease in the personal income tax rate increases labor force participation in the model (a positive labor supply response), which, other things being equal, leads to a rise in the unemployment rate. The relationship between output changes and unemployment rate changes is thus different for this experiment than it is for the experiment in which government spending on goods is increased, where there is no direct labor supply response.

Pure monetary-policy experiments can also be run. The short-term interest rate, the money supply, or the level of nonborrowed reserves can be made exogenous and changed.

An example of an interesting advanced experiment is the following. First, run a particular experiment and record the results. Second, change the coefficients in the demand for money equations to alter the inter-

est sensitivity of the demand for money. Then run the same experiment for the different coefficient values, record the effects, and explain the differences. (This experiment will require a different base run because of the different coefficients used.)

Many other exogenous variables in the model can be changed. One of considerable current attention is the price of imports. An increase in this variable generally has the effect of increasing domestic inflation and decreasing real output. This negative correlation between inflation and output is contrary to the positive correlation that generally results when demand is stimulated by monetary or fiscal policy. These different correlations show the student that there is no simple relationship between inflation and output in the economy.

After a few weeks of going through results, students begin to understand simultaneous effects. They can think through a rather complicated series of variables affecting one another. They also learn that most changes take time to work themselves out in the economy.

As a final note, we have found that students often think of interesting experiments. One example is the following. The two term structure equations in the model are not consistent with the expectations theory of the term structure if expectations of the short-term interest rate are rational in the Muth sense. In other words, the model does not have rational expectations in the bond market. One student, however, forced the model to have this feature by dropping the two estimated term structure equations and adjusting the long-term rates to be consistent with the model's future predictions of the short-term rate. This was done by solving the model many times, each solution corresponding to a particular set of values of the long term rates, until, given the model's predictions of the short-term rate, the consistency requirement was met.

#### IV. Elementary Teaching

Elementary students are introduced to the basic concepts of macroeconomics through simple comparative static models. Textbooks begin with an explanation of "equilibrium

national income determination." The simple aggregate supply/demand equilibrium model continues to be a very useful pedagogical tool. It provides a basic structure within which theoretical debates and policy options can be discussed. Although many concepts and alternative theories can be incorporated into this structure (for example, theories of consumption/savings behavior), there are a number of problems that result from its use.

One problem is that students often come away from principles courses with a very inaccurate impression of time lags and of the magnitude of potential policy impacts. Shifting the aggregate demand curve in a static model, for example, will reveal the direction that most variables will move, but not the magnitude or timing of the movements. Good students in principles courses will be able to tell you that a personal tax cut is likely to increase disposable income, initially increase both savings and consumption, and ultimately raise the "equilibrium level of *GNP*" by a multiple of the original tax cut. What they cannot tell you is how long it takes to get to the new "equilibrium," or how large the ultimate change in *GNP* is likely to be.

In teaching the multiplier we speak of "periods" (as smaller and smaller disequilibria lead to the new equilibrium), but the periods are used only to teach the character of the adjustment process and they are never tied to actual intervals of time. The multiplier values that students think exist in the real world are usually not sensible. It is not uncommon for even good students to think that the multiplier is greater than five "since the marginal propensity to save is less than .2."

The use of the software for the Fair model provides a useful way of teaching students about the adjustment process and about the likely size of the policy effects. The model can be used for this purpose without having to teach the detailed specification of the model. For example, students can simply take the base forecast for some period, increase real government purchases of goods by one billion dollars, and observe and plot the resulting changes in real *GNP* over the period. This can be done under the various assumptions about monetary policy, and by running these experiments the students can

get a good idea of both the size of the policy effects over time and the influence of monetary policy on fiscal policy.

Another important use of the software at the elementary level is examination of the historical data. Elementary students receive only a cursory exposure to the empirical side of macroeconomics and recent economic history. If data are discussed at all, they are presented in simple tables. Elementary texts do contain descriptions of recent events, but students "hands on" learning is generally accomplished by working through exercise sets built around simple hypothetical economies ("the king decides to stimulate demand with a tax cut of 10").

Experiments with the Fair model use real data and can be constructed around actual historical events. To prepare for the experiments, it is useful to have students do a series of descriptive exercises with the quarterly macroeconomic data. Over the last fourteen years, when was the unemployment rate the highest? What happened to real *GNP* over the same period? Explain the relationship between real and nominal *GNP*. How much did real *GNP* per capita grow between 1960 and 1970? Between 1970 and 1980? Describe the behavior of the money supply between 1970 and 1975.

Once the students have some familiarity with the data, the simulation experiments can begin. The workbook that accompanies the software contains 49 experiments. Most experiments begin with a newspaper or magazine article describing some event, controversy, or historical period. For example, last year there was a widely publicized debate between Martin Feldstein and Donald Regan about whether the Fed should hold the line at 6 percent money growth or move to an 8 percent target. The model can be used to simulate these two policies, and students can compare the results. Which yields higher interest rates? Is there an impact on nominal *GNP*? On real *GNP*? Explain the links. What happens to projected inflation under the two policies?

Another experiment is more historical. President Ford asked for and got a substantial tax cut in the spring of 1975 (newspaper article). At the same time the Fed was pursuing an easy monetary policy (look at *M1*

growth and interest rates). Both policies were in response to the recession that hit bottom in May of 1975 (verify). A modest "recovery" began in the second half of 1975 (what is meant by recovery?). Now go back to 1975 and do away with the tax cuts. What would have happened? Now restore the tax cuts, but hold money growth to 4 percent. Who was more responsible for the recovery, Arthur Burns or Gerald Ford, or is this question meaningful?

Other experiments include an examination of the effects of policy changes on labor supply and investment. In 1981 Robert Eisner did a major project for the Office of Tax Analysis at the Treasury Department in which he simulated the corporate tax cuts of the 1981 Economic Recovery Tax Act using

several large econometric models (DRI, Chase, etc.). Nearly identical experiments were run by 37 undergraduate Public Finance students at Wellesley College who analyzed the supply-side impacts of smaller and larger tax cuts.

#### REFERENCES

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