Walk-trough for the stock-flow lab

Minsky Summer School – Levy Institute – June 23-25, 2011

Lab #1 June 23rd

We begin by refreshing some notions on models, exogenous variables, simultaneity, and recursive systems. Check the file LAB_SLIDES1.PPT. A recursive model can be solved one equation at a time, starting from the equation where the endogenous variable Z depends only on exogenous variables, moving then to the equation where the endogenous variable depends only on exogenous and from Z, etc.

When we create a model in Eviews, the software "compiles" it, in the sense that it determines the best sequence for solving equations, identifying recursive blocks and simultaneous blocks (see View/Block Structure from with an Eviews model object).

We next moved to setting up our first model. We start from a simple model with only Households, Business and Banks (closed economy, with no Government, no Central Bank).

First step was to build the matrices for initial values for stocks, flows and flow of funds. We did this in the Excel file named MATRICES.XLS

Assume that GDP is 1000, and the capital/ouput ratio is 1, so that the stock of capital is 1000, no net wealth for firms, and a stock of equities oustanding equal to 800. This implies that the stock of loans is equal to 200.
Assume again for simplicity that the stock of net wealth for banks is zero. This implies that households are holding all of the stock of capital. Assuming households are willing to purchase any amount of equities supplied by firms, it follows that the stock of deposits must be 200.

We next built the social accounting matrix. We start by assuming that consumption would be 800. Given a value of GDP equal to 1000, it follows that investment must be 200 (for simplicity we assume no inventories, and perfect expectations on demand so that firms always produce exactly what is demanded. You are encouraged to change the model by introducing expectations on aggregate demand and a stock of inventories).

Assume now that the distribution of income between wages and profits is exogenously given by the parameter PARW, equal to 90 percent. This implies wages at 900 and profits at 100. Other sources of income for households are given by dividends: assume they are a fixed share of total profits given by PARD fixed at 30 percent ,so that dividends are 30. Interest payments on deposits are given by the exogenous interest rate RM fixed at 2 percent, times the stock of deposits at 200, so that interest payments are 4. This implies a total income for households of 934. Given that consumption is 800, saving will be 134.

Firms pay dividends and interest on loans: assuming the interest rate on loans to be 3 percent, interest payments on a stock of loans of 200 will be equal to 6, and this implies retained earning at 64.

We want banks to distribute all profits to households: with the current data profits are equal to 2, so we add them to the payments banks make to households, and households income increases to 936, and savings to 136.

Finally, we verify that the accounting is correct by the identity between the horizontal and the vertical sum for the capital account.

We next move to the flow of funds. The total here is taken from the row for the capital account in the SAM. We assume that firms issue equities to finance a share PARZ (equal to 10 percent) of the stock of capital. Given investment and retained earnings, it follows that the change in loans must be 116, which will also be the increase in households deposits.

We can now proceed to building the model in Eviews. The result is in the file CLASS1.TXT (notice that you have to change the file name to CLASS1.PRG to execute in Eviews: but our software will not allow to upload .PRG materials on the web...).

The model is solving but... we expected it to converge to steady state values, but when we simulate, output (y_0) is growing! Something must be wrong, and yes, although our accounting is correct, there must be some inconsistency.

Lab #2 – June 24th

When something goes wrong, and the model is simple enough, trying to find analytical solutions is a good strategy!

We have a model with constant investment, but the stock of capital is affecting output or demand, so the model should converge to a steady state where all stocks at time T should be equal to the stock at T-1.

Consider the equation for the stock of capital:

$$K = K(-1)*(1 - park) * I$$

where park = depreciation rate. In steady state K=K(-1), and therefore

$$K = I/park$$

so, if we want K to be 1000, and investment I = 200, park must be equal to 1/5 = 0.2.

We move the line creating the series for PARK, and K to the top of our program (see CLASS2.TXT for the final result of Lab #2)

Next consider the equation for the budget constraint of business

$$L = L(-1) + I - FU - (EQ - EQ(-1))$$

where we assumed that new loans were demanded to finance whatever portion of investment could not be paid for with retained earnings FU or by selling equities. In steady state L=L(-1) and EQ=EQ(-1), so that investment must be equal to retained earnings. We can use this result to find better starting values for GDP and other parameters determining profits and retained earnings.

Note also that our equation for the supply of equities was

$$EQ = EQ(-1) + parz*I$$

since we were assuming that a constant share of investment was financed by issuing equities. This is our inconsistent equation! Since it forcing firms to issue equities even at steady state. A consistent hypothesis is to assume instead that firms finance a constant share of investment which is not covered by retained earnings, so that the equation becomes

$$EQ = EQ(-1) + parz*(I - FU)$$

Going back to retained earnings and investment, and their relation to GDP, notice that total profits are given by

$$FT = (1 – parw)*Y$$

and distributed profits are given by

$$FD = pard*FT = pard*(1 – parw)*Y$$

so that retained earnings are equal to

$$FU = FT – FD – rl*L(-1)$$

$$FU = (1 – parw)*Y - pard*(1 – parw)*Y – rl*L(-1)$$

$$FU = [(1 – parw - pard*(1 – parw)]*Y – rl*L(-1)$$

$$FU = (1 – parw)*(1 – pard)*Y – rl*L(-1)$$

assume for simplicity that interest rates are zero (we will Eviews find the steady-state values for positive interest rates). Using our steady-state result that FU = I, it follows that

$$Y = I/((1 – parw)*(1 – pard))$$

so in our model (forgetting about interest payments for the moment) the steady-state multiplier will increase with the wage share parw, and increase with the share of distributed profits pard (as it should be obvious, since investment is fixed and profits have no other feedbacks...)

We want output to be 1000, so we must choose parw and pard to give this result...and parw=0.75 and pard=0.2 provide it. So we change the values to the lines in the program generating these series, and we move them to the top of the program.

Next, let’s check the parameters determining the stock of households wealth. Our consumption function is

$$CONS = parc1*YH + parc2*VH(-1)$$

where

$$VH = VH(-1) + SH$$

$$SH = YH – CONS$$

using the steady-state condition VH = VH(-1), it is easy to check that in steady-state

$$VH = (1 – parc1)*YH/parc2$$

Let us compute YH in relation to output Y

$$YH = WB + FD + rm*M(-1) + FB$$

where

$$FB = rl*L(-1) - rm*M(-1)$$

$$WB = parw*Y$$

and FD has been determined above. Substituting we get

$$YH = (parw + pard*(1 - parw))*Y + rl*L(-1)$$

and assuming again that interest rates are zero, the wealth to output ratio will be

$$VH = (1 - parc1)*(parw + pard*(1 - parw))*Y/parc2$$

Given that YH = 800 with our choice of parw and pard parameters, we want to choose parc1 and parc2 to imply wealth to be at 1000, and this can be parc1=0.875 and parc2=0.1

So we move the definition of these series to the top of the program, and run it again. This time the model is immediately at steady-state, with retained earnings equal to investment, loans equal to deposits (the missing equation!), and the net wealth of firms at zero.

We can now let the model compute the steady-state values when interest rates are positive, so we reset rl = 0.03 and rm = 0.02.

The model now runs smoothly at steady-state. However, net wealth of firms is negative, so the model has a “logical” inconsistency, since a negative value for this stock is not feeding back into any flow or portfolio decision.

To examine the property of the model, we can shock any of the exogenous variables (investment or interest rates) or parameters. Assume we want to examine the impact of a shift in the distribution of income towards wages. Given our model properties, this should imply an increase in GDP...

We can use the program in the file SHOCK1.TXT to give a shock in period 10. You can verify that all variables converge to a new steady-state, and examine the effects of the shock on, say, output by comparing the scenario solution Y_1 to the baseline simulation Y_0

We can now obtain (exogenous) growth in output by adding a new variable G for the growth rate in investment

$$I = I(-1)*(1 + G)$$

With a growth model, it is not interesting to look at the level of variables, which will be growing exponentially, but at their growth rates. We can verify, too, that all stocks will grow at the same rate as flows, and therefore that stock-flow norms will converge to stable values.

We can now make growth “endogenous” by adding an investment equation. Assume that growth in investment depends on an accelerator term and (negatively) on debt outstanding. We can include the following equation

G = 0.04-0.01*L(-1)/K(-1)-0.005*K(-1)/Y(-1)

We usually want to start with parameter values which imply results not too far from our previous exogenous growth rate. We can compute the steady-state values for L/K and K/Y, check what they would be when multiplied by our parameters, and set the constant so that it implies our previous growth rate. For instance, in this case L/K converges to 0.8 and K/Y to 0.9, so that our parameters imply a negative growth rate of 1.26 percent, and adding a constant at 4 percent will give us a growth rate slightly below 3 percent.

Check the file CLASS3.TXT for the final model.

We can verify the properties of the new model by shocking one parameter at a time. Let's run again our shock to PARW. The effect of an increase in the wage share on income is now positive only in the short run. You can encouraged to play around with values of parameters in the G equation or to add additional feedbacks to investment, say from the lagged values of FU/Y or from interest rates, etc.

Lab #3 – June 24th

We started the last lab with some remarks on accounting at constant prices, just to remind that when you develop an empirical model from national accounts, you will have different deflators for the different components of demand, and will therefore need assumptions on how to model relative prices.

We next discussed how to model expectations. Eviews can handle forward-looking expectations, but this may increase too much the simultaneity of the model and make solutions not viable. Backward-looking expectations will be correct on average when the variable being forecasted is stationary. In this case, for variable X, you can assume, say

Xe = X(-1) – pare*(Xe(-1) – X(-1))

This will imply that expected value of X at time t, given by Xe, is equal to the previous value of X plus an error correction component on the error made last period in predicting X.

If X is non stationary, but its time difference (its growth rate) is stationary, then we should model expectations of the growth rate in the variable, rather than in its level.

You can verify this by running the following simple program:

```
wfcreate u 1 200

series x=0
series xe=0
series par_rho = 0.75
series par_a = 0.25
smpl 2 @last
' Next line generates a stationary time series
'  when par_rho < 1
x = +par_rho* x(-1)+par_a + nrnd
xe = x(-1)-0.75*(xe(-1)-x(-1))
smpl @all
' Next command opens a window containing
```

```
`  the expectation error.
` You can verify if it is different from zero
show xe-x
```

You can play around with this program by changing the values of PAR_RHO. When it is equal to one, and PAR_A is large enough to provide a clear trend, the expected value of X will always have a negative mean error, while the expected value of the difference in X should not.

Instead of using backward-looking expectations, we can use model-consistent expectations by iterative simulation of a model. In this case, expectations are exogenous, and their starting value is arbitrary. We next simulate the model, and calculate values Xe for the expected variable X. We then use this simulated value to compute our (exogenous) expectations (Xe=X), and simulate the model again. If the new values X do not differ (by more than a small number) from the expected values Xe, the model has converged and expectations are consistent. Otherwise we copy again our solutions to expectations (Xe=X) and simulate the model again.

This can be done through a WHILE loop in Eviews. Assume we have a model called SFC, and that our criterion for convergence is called EPS. The following program should provide consistent expectations:

```
…
` Convergence criterion
!eps = 0.001
` First observation number in simulation
!first_sp = 2
` Last observation number in simulation
!last_sp = 200
` Maximum number of iterations
!max_it = 100
` Variable to check convergence
!converged=0
` We choose the baseline scenario
SFC.scenario "Baseline"
` and solve the model SFC
SFC.solve
` now will be changing the value of expected X
SFC.override Xe
` and we initialize the value of Xe
series Xe_0 = X_0
` start counting iterations
!iter_n = 0
WHILE (!converged=0)
   !iter_n = !iter_n + 1
   ` Solve the model
   SFC.solve
   ` Creates a series with the discrepancy in expectations
   series X_disc = X_0 - Xe_0
   ` Starts verifying convergence
   !converged=1
```

```
      ' By checking that errors are < eps for all sim. periods
      for !i = !first_sp to !last_sp
         if @elem(X_disc,@otod(!i)) > eps
         ' if at least one element is greater than eps
         ' the simulation will be iterated
            !converged=0
         endif
      next
      ' if we exceed the maximum number of iterations
      ' the program will stop
      if !iter_n > !max_it
         stop
      endif
   WEND
```

(In class I explained how to write this program, but we did not write and test the code. I have not tested the code above, yet...)

We next moved to writing a more complex model, with a government and a Central bank, where the Central bank would issue cash and provide advances to banks, while the government would finance its deficit by issuing bills.

We started by changing the model matrices, as in the file MATRICES2.XLS

Starting from the balance sheets, we introduce a reserve requirement through the PARRR parameter, calculating the stock of cash held by banks. We assume that cash held by households is 100, and this implies a total amount of cash for the economy, registered as a liability for the Central bank.

We next assume a stock of public debt of 500, held by both households and the Central bank, with an arbitrary initial share. Finally, the stock of advances for banks must be such that banks wealth is zero. The accounting is consistent since the total amount of cash in circulation is equal to the amount of assets held by the Central bank (advances plus government bills).

Moving now to the SAM, we assume the interest rate on bills to be 2 percent, and this allow us to compute interest payments from the government to households and the Central bank. Fixing the interest rate on advances to 1 percent allow us to calculate bank payments to the Central bank (and to change the value for dividends paid by banks to households) and the amount of "profits" the Central bank transfers to the government. Assuming a tax rate of 17.5 percent on household income allow us to compute household disposable income and saving, as well as government deficit.

We did not compute the matrix for the flow of funds, because of the lack of time and also because it would be implied by our assumptions about portfolio balance equations, and we preferred to have Eviews compute it.

We then used our accounting to generate starting values for a new model, reported in the file CLASS4.TXT

We started from the previous model in CLASS3.TXT, and eliminated the equation for the growth rate of investment, to get back to a stationary state model. We then added the new variables, documented in the file, and proceeded to amend the existing equations and add the new accounting identities. In particular, we now need identities defining disposable income YD, tax receipts TAX, government deficit DEF, Central bank profits FC. Consumption now depends on disposable income.

The portfolio equation were written assuming that households want to hold 30 percent of their wealth in bank deposits, 30 percent in equities, 30 percent in government bills, and the remaining 10 percent in cash. The rate of return on equities has been calculated taking into account expected capital gains and actual dividends.

In the first formulation of the model, the supply of new equities depended on the actual price. This created a strong simultaneity, since the price of equities is determined by the portfolio equation for households, and it influenced the supply, so the model would not solve. Assuming instead that the supply of new equities depends on the expected price, rather than the actual price, as in the final file, the model solved.

The lab was over, so we did not have time to work with the model, which is not consistent and has an explosive oscillatory behaviour, instead of converging to steady-state. This is left to interested students to work with. However, models of this kind, or more complex, are already available with parameters implying consistent accounting and steady-state solutions.

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