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LEARNING MACROECONOMIC THEORY AND POLICY ANALYSIS VIA MICROCOMPUTER SIMULATION

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ABSTRACT

This paper presents a representative set of three macroeconomic models out of a larger set of models used to teach macroeconomic theory and policy analysis at the intermediate level. Besides solving the models by hand, students solve them on the microcomputers. This pedagogical approach is designed to accomplish three objectives: (1) to answer student criticisms that most macroeconomic textbooks do not present them with concrete, numerical models, (2) to improve students' mathematical skills, and (3) to reinforce computer skills.

INTRODUCTION

A few years ago when I began teaching macroeconomics, I soon realized that a deficiency common to almost all textbooks was that they tended to utilize economic concepts which were highly abstract for most students and they never seemed to reduce the concepts to a concrete, operational level, or model which the students could easily manipulate. Student complaints about a variety of texts that we tried through the semesters first made me aware of this problem. Finally, in response to their continued pleas for more concrete examples that they "could get a handle on," I began developing a series of macroeconomic models of the economy to illustrate the major schools of thought. At first we used the mainframe computer at the university but later when we acquired a number of microcomputers which were readily available to students, we modified our models to run on the micros. Over the years, the series of examples, along with their attendant explanations, has gradually grown into the main pedagogical device that we use in teaching Intermediate Macroeconomic Theory. The purpose of this paper is to present three of the models that are used in class, to discuss briefly the advantages and disadvantages of this technique, and to inform you of future plans for the project.

The Classical School of Thought

Two models of the classical system are presented. The first contains only production and consumption sectors--no government sector. Illustrative simulations, using this model, include:

Impact of a policy decision by the Fed to change the

money supply. 2. Effect of a shift in the economy's production function caused by a change in technology.

3. Impact of a change in the profit expectations of businessmen manifesting itself through a shift in the investment function. Figure 1 presents the BASIC computer program to accomplish these simulations. Data entry is explained in program statements 140-220. Figure 2 presents the mathematical model, the values of parameters, exogenous variables, and policy variables, data statements for each simulation, and the output for each simulation. The first simulation demonstrates the classical conclusion that increasing the money supply merely influences the

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price level--when the money supply is doubled, the price level doubles, and so on. Equilibrium values of real variables are left unchanged. The second simulation shows how an increase in the economy's production function, through perhaps improved technology, can increase real output and the real wage as well as lower the price level. The third simulation demonstrates that increased profit expectations under the classical model, manifesting themselves through an increase d demand for loanable funds, will tend to increase the interest rate as well as increase the equilibrium values of the quantity of loanable funds demanded and supplied.

The second classical model introduces the government sector into the model equations, making adjustments in variable definitions where necessary, and simulates the following situations: 1. A growing government with a balanced budget. 2. Growth in government financed by borrowing. Figure 3 presents the computer program to accomplish these simulations. Data entry is explained in program statements 210-320. Figure 4 then presents the mathematical model, the values of parameters, exogenous variables, and policy variables, as well as the output of each simulation. The first simulation demonstrates the classical conclusion that if government finances its own growth through taxation, the result will be a partial "crowding out" of the consuming sector. The second simulation shows that if the expansion is financed through borrowing rather than through taxation, both the consuming sector and the investment sector (i.e., the private demand for loanable funds) will be partially "crowded out."

The Keynesian School of Thought

In class, we first develop the familiar two-sector model consisting of a consumption sector and a production sector. We solve the algebraic model under the assumption that investment is exogenous. Second, we introduce the government sector with its attendant modifications. Third, we return to the question of investment and introduce an investment function that changes the investment variable from an exogenous to an endogenous status. Finally, we add the monetary sector, which enables us to develop the familiar IS/LM analysis. Since the Keynesian models, at this stage, are all linear, and since our students have been exposed to matrix algebra by the time they take this course, in the junior or senior year, we use a matrix format to set up the models for computer solution:

> [A] [X] = [B] $[X] = [A]^{-1} [B]$

where [A] is the matrix of coefficients, [X] the vector of solution variables, and [B] the right hand side vector. The computer program to solve this model is presented in Figure 5. Data entry begins with statement 700 showing the number of equations in the system. Beginning in statement 710, the elements of the [A] matrix are entered and the last element of each statement is the corresponding element of the [B] matrix. This will be clear when examining Figure 6. In Figure 6, we present the final Keynesian Model, which includes the government and monetary sectors. This model specification makes it very easy for students to enter new values of policy variables such as the money supply, government spending, or the tax rate, and explore the consequences of such changes on the endogenous variables. It is also very easy to play

FIGURE 3 BASIC PROCKAM TO SOLVE THE SECOND CLASSICAL HODEL			
IO REM: MACKUZ			
20 NEM: EXTENSIONS OF THE		SICAL MODEL	
30 NEM; STRUCTURE OF THE 40 NEM; Y-FI+F2*L-F3*L'2		ONONY'S PRODUCTION FUNCTION	
50 KEM; LU-F2/(2*F3)-(1/0	2*(*)))*V LA	BOR DEMAND	
LO REM; LS=C1+C2*W		BOK SUPPLY	
70 KKM; LU=LS		ULL. IN LABOR MET.	
BU KEM: HD=K*P*Y 90 KEM: HS=HU		NINAL MONEY DEMAND	
TOO REM: MD-MS		MINAL MONEY SUPPLY DIL. IN MONEY MET.	
110 KEM: GAGO		VERNNENT SPENDING	
120 KEM: TR-TRO	3.8	ANSFER PATMENTS	
130 REN: 11-TEO		TR2	
140 KEN: 55+50+51*8 150 KEN: 1=10-11*8		PPLY OF LOANABLE FUNDS IVATE DEMAND FOR LOANABLE PUNDS	
140 KEM: 50-1+6+TH-TH		TAL DEMAND FOR LOANABLE FUNDS	
170 KEM: 50-55		UIL. IN MET. FOR LUANABLE FUNDS	
100 RFM: YD-Y-TI+TE	p1	SPUSABLE INCOME	
190 REM: C. TD-SS		NSIMPTION EIPENDITURES	
200 KFM: Y=C+I+G 210 KFM: YOU MUST PROVIDE	AG RANAMETERS AND	GRE. SUPPLY-AGGRE. DEMAND	
220 KEM: IN DATA STAFEHER			
ZDO REM: STATEMENT # : 11			
240 REM: 600	PARAMETERS OF P	RODUCTION FUNC. F1.F2.F3	
250 KEM: 610	PARAMETERS OF L	ABOR SUPPLY FUNCTION, G1. G2	
260 KIM: 620		MINAL DEMAND FOR MONEY, &	
270 KFM: 630 280 KFM: 640	EXOCENCIUS MONEY EXOCENCIUS COVER	NMENT SPENDING, CO	
290 KLM: 050		FER PATMENTS, THO	
300 KLM: 600	ETOGENOUS TALES	.110	
310 KEM: 670	PARAMETERS OF S	UPPLY FUNC FOR LOAN. FUNDS, 50, 51	
JZ0 81.4: 680	PARAMETERS OF P	RIV. DEM. FOR LOAN. FUNDS, 10, 11	
130 READ F1,F2,F3:READ G 340 READ TRO:READ TXO:REA	I GZ:KEAD K:KEAD	HU:READ CO	
350 W-(F2-2*F3*G1)/((2*F)			
360 L-(G1+G2*F2)/((2*F3*			
370 1-F1+F2*L-F3*L 2			
380 P-MU/(K*Y)			
390 K=(10+C0+TR0-T10-SU)	(\$1+11)		
400 SS=S0+S1*R 410 I=10-11*R			
420 TB-T-TX0+TR0			
430 C-Y0-55			
440 PRINT: PRINT: PRINT "M	DEL SOLUTION"		
450 PRINT "REAL Y = ";Y 460 PRINT "NOMINAL Y = "			
470 PRINT "QUANTINT OF L 480 PRINT "REAL MACE"":W	ABOK+";L		
490 PRINT "NOMINAL WAGE-	- W#P		
500 PRINT "PRICE LEVEL."			
SIQ PRINT "REAL INTEREST			
520 FRINT "SAVINGS+";SS			
530 PRINT "INVESTMENT-";			
540 PRINT "CONSUMPTION-" 600 DATA 5,80,1	,c		
600 DATA 55			
620 DATA .5			
630 DATA 700			
640 DATA O			
USU DATA D			
DOU DATA U			
670 DATA -10,800 680 DATA 120,500			
700 END			

FIQURE 4					
and the second	AL	and senable	AND IN THE REAL PROPERTY.	1. OF 1993	INCOME.

	 		Desires and	
Conditions Simulated:		t with a b		

(2) A growing gover	usent financed	by borrowin	ay.
Nathematical No.	del			
$ \begin{bmatrix} 1 \\ 1 \\ 2 \\ 2 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\$	п	Economy's dem Economy's sopp Equilibrium co Economy's dem Economy's dem Economy's sopp determined 1 Equilibrium co Government tra Government tra Economy's sopp Frivate secto Economy's tot.	and function ply function and function ply of more by the fed, condition for modify and for model payment res-exogen ply function r demand for al demand for all demand for all demand for all demand for all demand for all demand for all demand for all demand	n tor labor. r the labor market. 8 tor momer. y: Exogenously r the money market. exogenous veriable. mtsexogenous.
<u>Baulc Solution</u> <u>Data Statements</u> : 600 DATA 5,60,1 610 DATA 5,5 620 DATA 5,5				
530 DATA 700 540 DATA 0 560 DATA 0 570 DATA -10,800 690 DATA 120, 500 Soletian:	G + TH - TH - O			
Y = 1298.75 Nominal Y = 1400	C = 1228.75 I = 70	SS = 70 SD = 70	L = 22.5 W = 35	Numinel Wage = 37,73 E = .1
Stmulation 1: Government	Spending and Tr	enafor Payments	Kipe Lo 40), Taxes Rise to 40 to
Changes in Data States 640 DATA 40 660 DATA 40	halanced Budget. Anta:			
<u>Solution</u> : Y = 1298.75 Nominal Y = 1400	C = 1168.75 1 = 70	\$5 = 70 50 = 70	L = 22.5 W = 35	Nominal Wage = 37,73 2 = .1
Simulation 2: Covernment Covernment Changes in Bata States GO DATA 0 Solution:	Rens a Deficit.		- 40; Yer	as - 0.
Y = 1298.75 Nominel Y = 1400	C = 1204.14 1 = 54.62	SS = 94.02 SV = 94.02	L = 22.5 W = 35	Nosinal Wage = 37.73 K = .13

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FIGURE 5 SIMULTANEOUS EQUATIONS PROGRAM TO SOLVE EXTENSION HODELS IOU EFM: MACHUS 100 EFM: MACHUS 100 FEM: MACHUS 100 F

FIGURE 6

KEYMESTAN MODEL	FIGURE 6 INCLUDING COVERNMENT AND MOMETARY SECTORS.
	THE DOTAL COVERNMENT AND HOMETAKE SECTORS.
Mathematical Model	
[1] C - Ca + bYd	Consumption is a linear function of disposable income.
[2] Td - T - TX + TK	Dispussion income is equal to total incometaxes + Limitsici payments.
[3] TX = cY	Taxes are a proportion, t, of total income.
[4] TK = TKs [5] I = [s - eK + JY	Transfet payments are excessions with a value of TRs. Investment expenditories are inversely felated to the
	interest rate and directly related to Y.
[6] G = Ga [7] Y = C + I + G	Government spending is exogenous with a value of Ga. Total spending (income) is the sea of C. I. and G.
	Equilibrium condition for the product market.
[8] HD = H1 + H2(Y) - H3(B)	Economy's domand for money is directly related to Y and inversely related to K.
(9) HS - Ha	The money supply is exogenous with a value of Ma.
[10] HS = HD .	Equilibrium condition for the money market.
Motrix Specification-	
0-6 1 0 0 0	
	0 0 0 TI TKa
-100001 •	0 0 0 TK - In 0 0 1 1 Gn
-c 0 0 1 0 0 0 D 0 0 0 1 0 0 -f 0 0 0 0 1 e 0 0 0 0 0 1 e 1 0 -1 0 0 -1 0	0 0 -i
-H2 0 0 0 0 0 H3	100((MD) NI
0 0 0 0 0 0 0 0	
L	, , , , ,
Values of Parameters and Exogen-	ous Variables.
Ca = 5 e = 4300	M2 = .2 Ga = 800
69 t01 63 MI - 600	H3 = 5000 I = 1600 TKs = 100 Hs 1000
1 - 13 AI - 800	144 - 100 AL 1000
Bata Statesents.	
700 DATA 10	
710 DATA 0,9.1.0,0.0,0.0,0	
720 DATA -1,1,0,1,-1,0,0,0,0 730 DATA3,0,0,1,0,0,0,0,0	
740 PATA 0,0,0,0,1,0,0,0,0,0	0,100
750 DATA01,0,0,0,0,1,450 760 DATA 0,0,0,0,0,0,0,0,0,0,0	
770 DATA 1,D,-1,0,0,-1,0,0,	0,-1,0
780 DATA2,0,0,0,0,0,0,5000 790 DATA 0,0,0,0,0,0,0,0,0,1,1	
BUU DATA 0,0,0,0,0,0,0,0,-1,1	.0,0
Model Solution.	
Y = 4953,704	
14 = 3567,593 C = 3215,833	
TX = 1460, 111	
14 = 100 1 = 937.870	
x = .1581	
Mit - 1000	

HD = 1000 HS = 1000 C = 800 the "what-if game" with behavioral equations such as the consumption function, the investment function, the demand for money, and so on to see how shifts in the parameters of these functions affect the model solution. Multiplier concepts are also easy to illustrate by, for example, changing autonomous investment and noting the impact on Y.

Advantages and Disadvantages of the Computer Modeling Approach to Learning Macroeconomics

We have found this method of instruction to have three advantages. First, students seem to develop a fuller and deeper understanding of the economic theory when they work with concrete models such as these. They are better able to constructively criticize the models, understand their assumptions and suggest ways of making the models more realistic. Second, students, of necessity, must reinforce their mathematical skills to successfully manipulate the smaller models by hand, which we have them do before working on the computer. Third, it gives the students another opportunity to reinforce their computer skills, which we believe should be done more frequently in classes outside the computer discipline itself.

Unfortunately, these advantages do not come without a cost. The main cost we have discovered is that it is very difficult to cover as much material as is usually covered in a more traditional macroeconomics class. For example, we have not yet been successful in getting beyond the Keynesian model to the Rational Expectations Model. We are currently trying to develop a series of models to help students explore the rational expectations philosophy, but we suspect that to cover this material might require a two semester sequence. Another possibility is to offer the full course at the graduate level rather than at the junior/senior level as it is currently offered. If this were done, it is likely that the graduate students could cover the entire range of models in one semester. We intend to explore this alternative in the future.