THE DESIGN AND USE OF A MACROECONOMICS SIMULATION USING MAPLE SOFTWARE: A PILOT STUDY

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ABSTRACT

The mathematical models used in intermediate macroeconomics have become increasingly more sophisticated and challenging for students to learn. This paper demonstrates how mathematics software, such as Maple, can be used to design a simulation as a pedagogical aid. The paper proceeds by developing a system of equations to model the economy, simulating the system with Maple, and illustrating the impacts of fiscal and monetary policy changes. A pilot test of the simulation was performed to see if higher levels of mathematical rigor could be introduced in a principles course. The results indicate that symbolic mathematics software can be an effective teaching and student learning tool.

INTRODUCTION

The mathematical models used in macroeconomic analysis have become increasingly sophisticated at the intermediate and advanced levels (Blanchard, 2000; Azaroadis, 1993; and Romer, 1996); and teaching these courses are becoming more challenging. Technologies such as spreadsheet programs, textbook tutorials and electronic blackboards have been used as pedagogical aids and found to be helpful (Fair, 1990; King and McConnell, 1991; Smith and Smith, 1988; Adams and Kroch, 1989; and Gillette, 1994). But more is needed. A study by Allgood, et. al. (2004), published in the American Economic Review, show that student ratings of teaching effectiveness and interest in economics courses are relatively low compared with other fields.

For the past 20 years there has been a growing body of literature in economics education espousing the problems with using lecture or "chalk and talk" as the primary teaching pedagogy (Allgood, et.al. 2004; Simkins 1999). Wetzstein (1988) suggests that instructors at the principles level consider new teaching techniques to increase proficiency in economics by stimulating the student's imagination and interest in the subject matter. He believes that recent developments in teaching – programmed learning, television, and computer-aided instruction – "stifles students' imagination, contribute to a dependent learning style, and fail to stimulate interest in the subject matter." Rishi (1998) argues that traditional teaching methods in economics fail to give students the context they need to support critical thinking and problem solving skills.

Bartlett and King (1990) identify two major reasons why economics instruction at all levels is not as effective as it could be: (1) economics instructors do not understand how students learn, and (2) economics is not taught as a science. According to Bloom (1971), students need to master definitions and basic facts before they can progress to more complex, causal relationships. Once these prerequisites are satisfied students can then tackle complex relationships represented by a system of equations. Bartlett and King (1990) suggest the best approach to learning economics at all levels is not through memorizing the text and "regurgitating lectures" so that students can pass multiple choice exams. They claim that the key to learning economics is by teaching economics as a science. Teaching economics as a science includes computer simulations, statistical analysis and performing experiments.

Schmidt (2003) reported that the use of simulations to teach economics is gaining in popularity and support as an effective pedagogical approach. A primary advantage of a simulation is that it can perform mathematical manipulations quickly, so more complex models can be demonstrated in a short period of time. As examples, Cameron (1997) reported success in using an interactive simulation to teach introductory and intermediate macroeconomics; and Motahar (1994) reported success in using a simulation to teach modeling in microeconomics. The claimed advantages of the simulation included improvement in student performance, retention, and attitude. Three factors accounted for the reported success in the Motahar (1994) study. First, students could see an improvement in their performance as they work with the simulation. Second, there is a complementary relationship between the outcome of the simulation and what is being explained in class. Third, continual feedback from the simulation provided reinforcement of economic concepts.

Robinson and Davis (1999) argue that the use of statistical programs and simulations are particularly useful supporting technologies for courses using advanced mathematical model. An excellent example is the application of *Maple* software by Boyd (1998) to help students understand complex economic systems. *Maple* software, published by Maplesoft (www.maplesoft.com), is a mathematical programming tool for problem-solving, data visualization, and technical authoring.

Boyd (1998) provides a detailed discussion of how he has incorporated *Maple* into his courses. He combined traditional lecture periods with weekly *Maple* computer laboratory sessions and found that a majority of the students had a positive experience with *Maple* because it allowed them to focus on the economic interpretation of the models and less on the tedious task of solving the system. The negative experiences associated with *Maple* were mostly a result of the speed and memory limitations of the computers in the laboratories, an issue that is no longer a problem in most college computer laboratories with current hardware.

The purpose of this paper is to extend the work done by Boyd (1998) and show how *Maple* software can be used to create a simulation model like the one shown in the appendix to illustrate the impacts of monetary and fiscal policies. But it is argued that *Maple* is not a magic box of answers. In order to use it effectively students must first master economics terminology and thoroughly understand the basic economic theories behind the model. The paper will show that, if implemented correctly, a tool like *Maple* can be an effective pedagogical approach.

The paper proceeds by first constructing the aggregate demand and supply model used in traditional courses in macroeconomic principles. Second, *Maple* software is used to create a simulation model to solve and graphically display the system. Third, two fiscal policy applications using the *Maple* simulation are given as examples of how the simulation works. The simulation graphs the effects of changes in fiscal policies, calculating the resulting GDP growth, inflation rates, trade balance, government budget deficits, and the policy multiplier. The paper concludes with a discussion of student perceptions of the simulation and future pedagogical research.

AGGREGATE EXPENDITURE SCHEDULE AND DEMAND EQUILIBRIUM

We begin with the basic building blocks of the traditional aggregate demand model, i.e. the aggregate expenditure (*AE*) schedule is

$$AE = C + I + G + X - M \tag{1}$$

where:
- C = consumer expenditures
- I = business and new home investment expenditures
- G = government expenditures
- $X - M$ = net exports.

The general form of the consumption function is

$$C = A + mpc \cdot DI \tag{2}$$

where:
- A = autonomous level of consumption
- mpc = marginal propensity to consume
- DI = disposable income.

Baumol and Blinder (2005) discuss four consumption function shifters, consumer wealth (*W*), price level (*PL*), real interest rate (*r*) and future income expectations (Y_e). Because these parallel shifters essentially increase or decrease the intercept *A*, the autonomous consumption (*A*) is further defined as follows:

$$A = W - PL + Y_e - u \cdot r \tag{3}$$

where:
- W = wealth
- PL = price level
- Y_e = income expectations
- $u \cdot r$ = interest rate sensitivity parameter (u) times the interest rate (r)

Any factor that changes autonomous consumer spending can be included in equation 3.

The final component of the traditional *AE* schedule is disposable income (*DI*), which is income less *taxes net of government transfers* (*T*). If *t* is the percentage of income paid in taxes, then disposable income is

$$DI = (1 - t) \cdot Y \tag{4}$$

Substituting equations 2, 3, and 4 into 1 we get the expanded form of *AE*.

$$AE = \left[I + G + X - M + W - PL + Y_e - u \cdot r \right] + \left\{ mpc \cdot (1 - t) \right\} \cdot Y \tag{5}$$

Equation (5) is just a line whose intercept and slope are the expressions in the [ ] and { }, respectively. The values for the *AE* constants (shift parameters: *I*, *G*, *X*, *M*, *W*, *PL*, Y_e, $u \cdot r$), and the *AE* slope parameters (*mpc*, *t*) can be set to any value with the *Maple Software* and graphed. To illustrate, the solid black line in Figure 1 is the graph of the *AE* schedule, equation 5, with an intercept value of 1600 and a slope less than one.

The "demand-side" equilibrium occurs when real GDP (*Y*) equals aggregate expenditure (*AE*). Thus we have the familiar demand side equilibrium relationship.
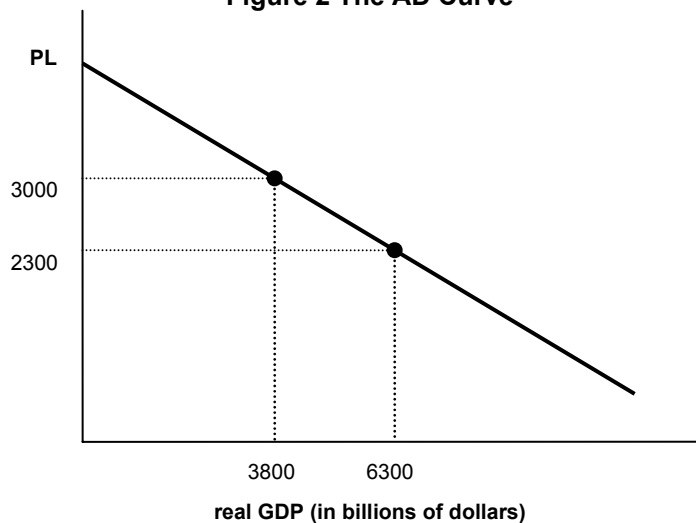
$$AE = Y \tag{6}$$

The dashed line shown in Figure 1 is the graph of equation (6), showing the equilibrium level of real GDP is $6300 billion in this illustration. If one of the shift parameters with a positive one coefficient increases, the *AE* schedule shifts

Figure 1 The Aggregate Expenditure Schedule
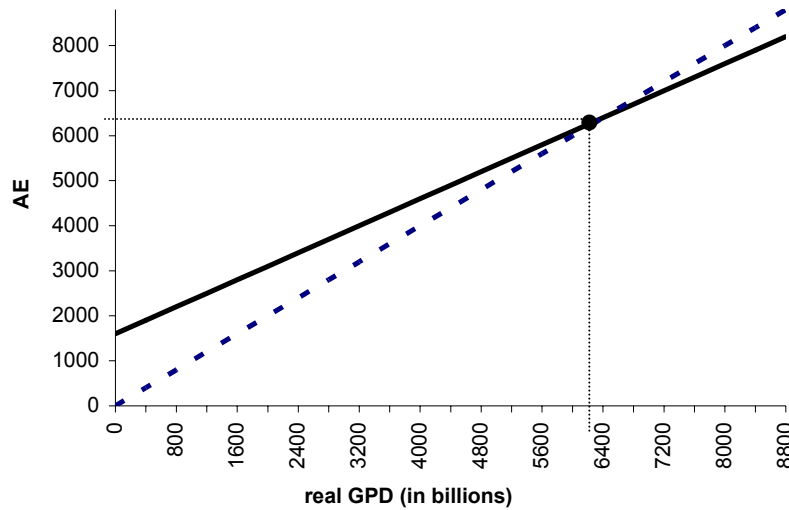
$$PL = \left[I + G + X - M + W + Y_e - u \cdot r \right] - \left\{ 1 - mpc \cdot (1-t) \right\} \cdot Y_{AD} \qquad (7)$$

Figure 2 The AD Curve

upward increasing real GDP. On the other hand just the opposite would be true if a shift parameter with a negative one coefficient increases. If the *mpc* increases or *t* is cut, *AE* gets steeper raising real GDP.

DERIVING THE AGGREGATE DEMAND CURVE

We obtain the aggregate demand (*AD*) curve when we solve equation (5) explicitly for *PL* after we impose the equilibrium condition, equation 6, that $Y = AE$. Replacing Y and *AE* with Y_{AD} and simplifying yields the general form of the AD curve: (See equation 7)

The term in brackets [ ] is the intercept term while the expression in the { } represents the slope of the *AD* curve.

The aggregate demand equation can be illustrated graphically with *Maple Software,* as shown in Figure 2. For our example, suppose the price level is increased from $2300 to $3000. Since *PL* enters the intercept of equation (5) with a negative one coefficient, an increase in *PL* means the intercept of equation (5) decreases. This results in a downward shift of the *AE* schedule shown in Figure 1 and the slide along the *AD* curve shown in Figure 2. In this

Figure 3 The AD-AS Equilibrium
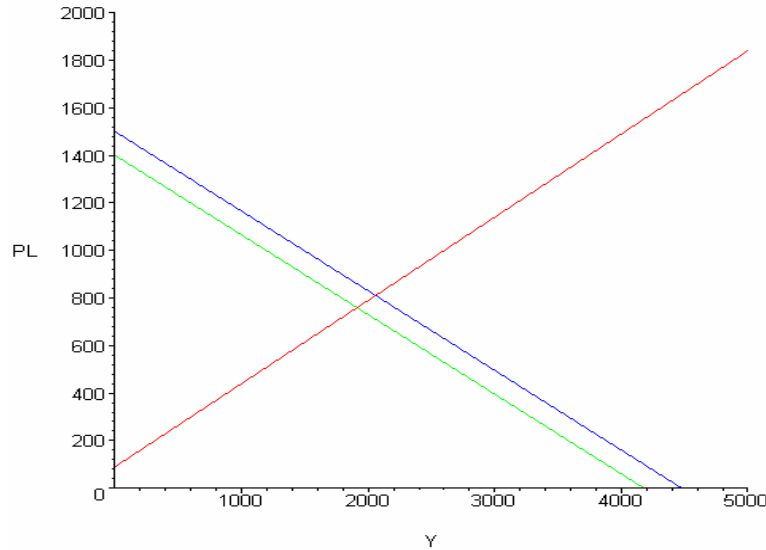
case, aggregate expenditures decline and real GDP decreases from $6300 to $3800 billion.

The Aggregate Supply Curve

The construction of the *AS* curve is simpler than its *AD* counterpart. The simulation model allows the *AS* curve to satisfy both Keynesian and Classical schools of thought. The slope of the *AS* curve is generically defined as β, which ranges between zero and infinity. Baumol and Blinder (2005) discuss six major *AS* curve shifters, which include the money wage rate (w), prices of other inputs to production (p), supply-side taxes (τ), technology and productivity (z), labor (L), and capital (K). Consistent with this model, the aggregate supply schedule is specified as:

$$PL = \left[w + p + \tau - z - K - L\right] + \beta \cdot Y_{AS} \qquad (8)$$

where:

β = slope of the line, ranging from zero to infinity.

The *AS* curve shows the relationship between each possible price level and the value of goods and services that the nation's businesses are willing to produce during a specified period of time, holding all of the *AS* curve's shifters constant.

THE AD-AS EQUILIRIUM

In this section, *Maple* is used to solve the *AD* and *AS* equations 7 and 8 simultaneously, plot the equations in the same diagram, and perform fiscal policy analysis.

The impact of an increase in government spending from $500 to $600 is evaluated using *Maple Software* and shown in Figure 3. Aggregate demand increases, raising both the price level and real GDP. Initially, the equilibrium price level and real GDP were about, 760 and 1910, respectively. After the increase in government spending, the price level and real GDP rose to about 810 and 2060, respectively. In this example, the government spending multiplier (change in *Y* divided by the change in government spending) was 1.46, yielding an economic growth rate (percent change in *Y*) of 7.63%, and an inflation rate (percent change in price) of 6.73%.

THE AD-AS SIMULATION MODEL

This section discusses how an instructor can use the *AD-AS* simulation code in *Maple* to illustrate fiscal policy analysis. But this is not a replacement for having the students learn and understand the theory behind the equations. Student are not shown the simulation result until they can do equilibrium analysis using equations (7) and (8) with paper and pencil.

The *Maple* simulation graphs the initial and final *AS* and *AD* curves; plots the corresponding equilibria; and reports the resulting economic growth and inflation rates, the trade and budget deficits, and the policy multiplier. The simulation captures student attention and is a catalyst for class discussion of the impacts of fiscal and monetary policies.

GOVERNMENT SPENIDNG EXAMPLE

The simulation starts with the definition of the initial and final conditions (the only difference between the final and

Figure 6 Keynesian Equilibrium Analysis: Increased *G*
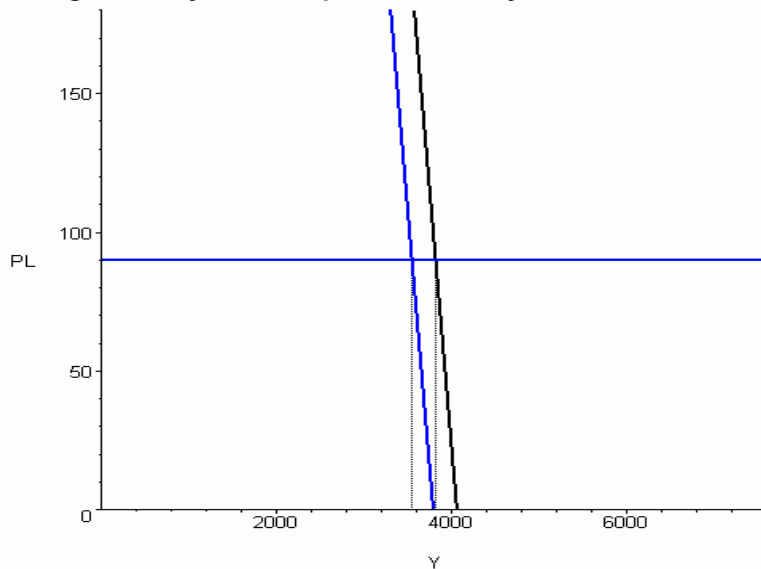
$econ\_growth := 7.633587790$ $inflation := .003001741389$

$Budget\_Deficit_0 := 562.133456$ $Budget\_Deficit_1 := 543.212346$

$Trade\_Deficit_0 := -100$ $Trade\_Deficit_1 := -100$

$Multiplier_G := 2.702629660$

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initial conditions is the change in *G*), which are listed near the beginning of the *Maple* simulation code located in the appendix. Suppose we are interested in finding out what happens when the government increases spending from $G_0 = 500$ to $G_1 = 600$. Before the simulation is executed, the students are asked to predict the impacts on price and output by looking at equations (7) and (8) and anticipating the affect on the equilibrium in the *AD-AS* model.

Figure 4 displays the actual output of the *Maple* simulation. Both the price level and real GDP increase. The model reports that economic growth and inflation rates are 7.6 and 6.4 percent, respectively. The trade deficit remained at –$100, while the budget deficit decreased from 189.47 to $142.11, a 25 percent decline. The government spending multiplier suggests that each dollar spent by government is associated with a $1.75 increase in real GDP.

TAX CUT EXAMPLE

Next we analyze the effect of a cut in the tax rate instead of an increase in government spending. In this example it is assumed the government cuts tax rates from $t_0 = 30$ percent to $t_1 = 25$ percent.

Figure 5 shows the actual output of the *Maple* simulation when the tax rate is cut. Again, both the price level and real GDP increase. The multiplier listed in the *Maple* output is calculated by taking the ratio of the change in the equilibrium level of real GDP and the corresponding change in taxes. According to the *Maple* output in Figure 5, each dollar decrease in taxes resulted in a $3 increase in real GDP. Notice that budget deficit is also included and decreased from 189.47 to $123.81. These results serve as an excellent source of classroom discussion as to the factors that contribute to this result.

THE KEYNESIAN EQUILIBRIUM MODEL

Because the Keynesian school believes the *AS* curve is elastic, the slope of the *AS* curve can be flattened by changing the beta coefficients from $\beta = 0.2$ to $\beta = 0.00001$.

Figure 6 replicates the government spending example above, but this time the *AS* curve is relatively elastic. According to Figure 6, real GDP increases substantially, while inflation is approximately zero. The government spending multiplier is $2.70 and the budget deficit fell 3.5 percent as a result of the shift in *AD*. Similar findings result when the tax rate is cut instead. Therefore, according to Keynesian economics, fiscal policy (increased government spending and/or tax cuts) leads to higher real GDP with no appreciable increase in prices (zero inflation).

THE CLASSICAL ECONOMICS EQUILIBRIUM

The Classical school of economics believes the *AS* curve is inelastic. This is achieved with the *Maple*
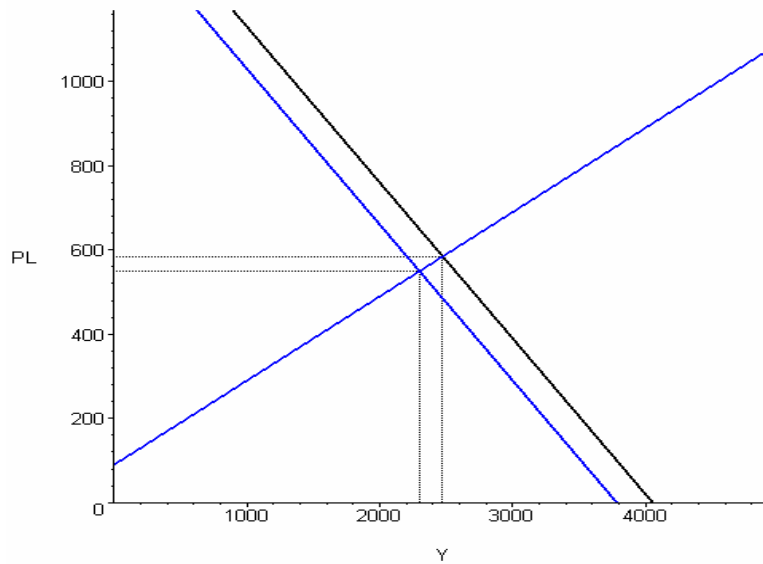
simulation code by simply making the *AS* curve steeper. In the previous examples the slopes of the *AS* curves were $\beta = 0.2$ and $\beta = 0.00001$, in this example we set $\beta = 100$.

Figure 7 replicates the tax cut example above only this

Figure 4 Increased Government Spending

$$econ\_growth := 7.633587809 \qquad inflation := 6.383657855$$
$$Budget\_Deficit_0 := 189.4736842 \qquad Budget\_Deficit_1 := 142.1052633$$
$$Trade\_Deficit_0 := -100 \qquad Trade\_Deficit_1 := -100$$
$$Multiplier_G := 1.754385970$$

Figure 5 Demand-side Tax Cuts
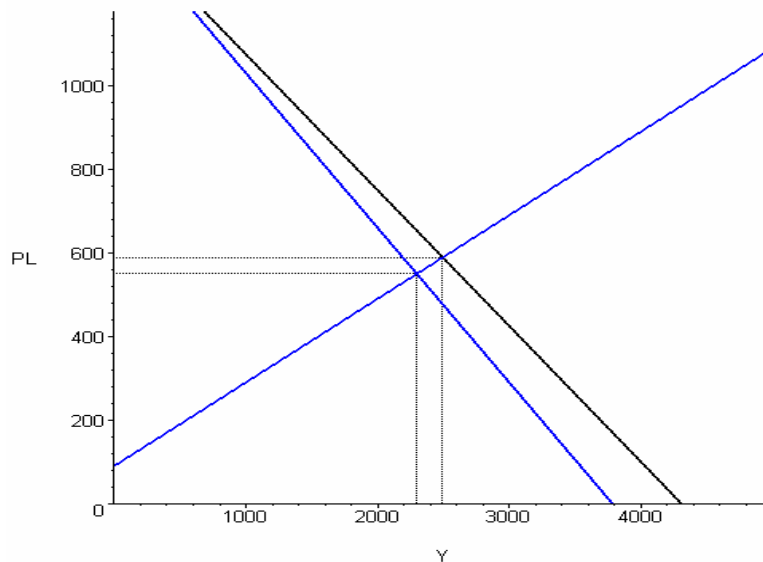
$$econ\_growth := 8.571428563 \qquad inflation := 7.167935791$$
$$Budget\_Deficit_0 := 189.4736842 \qquad Budget\_Deficit_1 := 123.8095238$$
$$Trade\_Deficit_0 := -100 \qquad Trade\_Deficit_1 := -100$$
$$Multiplier_T := -2.999999997$$

Figure 7: Classical Equilibrium Analysis: Demand-side Tax Cuts
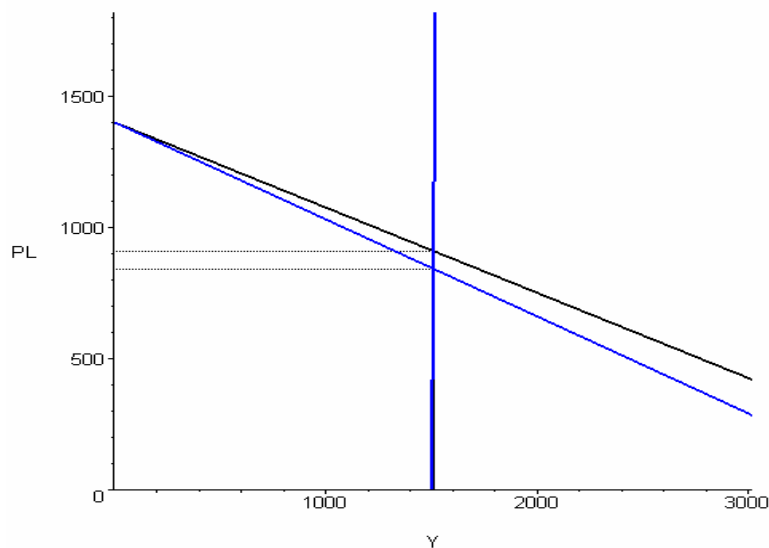
$$econ\_growth := .04485425252 \qquad inflation := 8.036602915$$
$$Budget\_Deficit_0 := -47.4743450 \qquad Budget\_Deficit_1 := -122.7261400$$
$$Trade\_Deficit_0 := -100 \qquad Trade\_Deficit_1 := -100$$
$$Multiplier_T := -.008991014766$$

time the *AS* curve is relatively inelastic. According to Figure 7, inflation increases substantially while real GDP is essentially constant. The tax cut multiplier suggests that a $1 cut in taxes results in less than a one cent increase in real GDP. The budget deficit ballooned, increasing by 160 percent. Similar findings result when the government spending is increased instead. Therefore, according to Classical School of macroeconomics, fiscal policy leads to higher prices (inflation) with no noticeable increase in real GDP.

EVALUATION AND ASSESSMENT

The *Maple* simulation was tested at NC A&T State University to determine if the level of rigor could be increased (i.e. using more sophisticated mathematical models) in the non-honors macroeconomic principles course taught during the Spring 2005 semester, compared to the Fall 2004 semester non-honors course. Since the teaching evaluations scores prior to using the simulation were very high in the 2004 semester (4.7 out of a 5 point scale – see Table 1), the hypothesis was that a higher level of mathematics could be introduced into the non-honors principles course in 2005 without lowering student evaluations of course effectiveness.

According to the course evaluations summarized in Table 1, the 25 students in the Spring 2005 course rated the course slightly lower than the 22 students in the Fall 2004 course—a difference of 0.1 on a 5 point scale (see the last row in the table). The variance for the spring 2005 course

was slightly higher as well, 0.5 and 0.4 respectively. However, according to the last column of Table 1, the differences in course evaluations were all insignificant. Specifically, the *t*-stat corresponding to the difference (or gain) in course evaluations, located in the last row of Table 1, was –0.51. With any reasonable level of significance, this *t*-stat suggests that there was an insignificant change in overall course evaluations. But because the spring 2005 class was taught at a significantly higher level of rigor—the fall course was taught at the traditional level—one would have expected a significant drop in course evaluations, especially at the principles level. The fact that course evaluations showed no statistically significant difference, support the hypothesis that a higher level of mathematics could be introduced without lowering the course evaluations, owing to the use of the *Maple* simulation.

Table 2 compares the gain in the overall course evaluations relative to course evaluation gains made by other macro principles sections, the Department, the School and the University. Column (iv) reports the difference-n-differences while column (vi) reports the corresponding *t*-statistics. The only significant difference-n-difference is the one that compares the instructor's gain (an insignificant loss in this case) to the gains posted by all other macro principles instructors within the department. This value, $\Delta\mu_c - \Delta\mu_i = -0.2$, suggests the drop in the instructor's course evaluations was significantly lower than the gains posted by the other macro principles courses. The other difference-n-difference values were all insignificant. In this case, the decrease may be a result of the course being taught

at a more rigorous level. The current survey instrument used by the University does not ask students to rate the difficulty of the course or compare the amount of non-reading assignments required by the course relative to other courses they have taken are currently taking on campus. Students are also not asked what their approximate grades are in the class. Had this survey instrument addressed these issues, we could have possibly identified the reasons for the relative fall in the instructor's overall course evaluations compared to the other macroeconomic sections.

In addition to the course evaluations, the results of a separate student survey distributed in the spring 2005 course indicated that all but one of the non-honors students had a generally favorable experience with the simulation. A

number of students commented that the simulation allowed them to focus more on the "analysis" and less on the "math" or the "memorization of the curve shifts" in the aggregate consumption and *AD-AS* models. Furthermore, according to the instructor, student responses on essay test questions improved dramatically as a result of using the simulations in class. Students were able to answer essay questions with a higher of degree accuracy and breadth.

Given the statistically insignificant change in the instructor's own overall course evaluation, the increased rigor, the mostly positive comments in the simulation survey, and the instructor's assessment of improved student performance, the simulation is argued to have been effective, but more supporting research is needed.

TABLE 1 Changes in Course Evaluations

Item	FALL 2004		Spring 2005		Difference	
	μ_f	σ_f^2	μ_s	σ_s^2	$\Delta\mu$	t
The course syllabus was distributed at the beginning of the course	4.8	0.3	4.6	0.3	-0.2	-1.2
The course objectives were clearly explained at the beginning of the course	4.7	0.3	4.5	0.4	-0.2	-1.2
The course evaluation measures were presented in the course syllabus	4.8	0.3	4.6	0.3	-0.2	-1.2
The course was carefully planned	4.5	0.7	4.6	0.3	0.1	0.5
The course readings related to the course goals	4.6	0.6	4.7	0.2	0.1	0.5
The instructor met classes as scheduled	4.8	0.3	4.7	0.3	-0.1	-0.6
The instructor was well prepared for class	4.6	0.3	4.7	0.3	0.1	0.6
The instructor appropriately presented practical application of the course material	4.7	0.4	4.6	0.4	-0.1	-0.5
The instructor was knowledgeable about the subject matter	4.8	0.3	4.7	0.3	-0.1	-0.6
The instructor was organized in class	4.7	0.3	4.6	0.3	-0.1	-0.6
The instructor showed enthusiasm for the subject matter	4.8	0.3	4.7	0.3	-0.1	-0.6
The instructor communicated course material in a clear manner	4.6	0.6	4.5	0.4	-0.1	-0.5
The instructor used examples to clarify course subject matter	4.6	0.6	4.6	0.5	0	0.0
The instructor utilized teaching aids effectively	4.6	0.4	4.6	0.5	0	0.0
The instructor encouraged students to ask questions during class	4.6	0.6	4.6	0.4	0	0.0
The instructor provided feedback to students' questions	4.7	0.3	4.6	0.4	-0.1	-0.6
The instructor summarized the material effectively	4.6	0.6	4.4	0.4	-0.2	-1.0
The instructor used various teaching strategies for this course	4.6	0.4	4.4	0.8	-0.2	-0.9
The instructor maintained a positive instructor/student relationship in class	4.7	0.3	4.6	0.4	-0.1	-0.6
The instructor was available to provide assistance outside of class	4.7	0.4	4.6	0.4	-0.1	-0.5
The instructor promoted the development of thinking skills in the course	4.7	0.3	4.6	0.4	-0.1	-0.6
The instructor promoted the development of communication skills in the course	4.7	0.3	4.5	0.6	-0.2	-1.0
The grading system was fair	4.6	0.8	4.5	0.6	-0.1	-0.4
The methods used for evaluating my work were consistent	4.6	0.5	4.5	0.5	-0.1	-0.5
The instructor returned tests and graded assignments in a timely manner	4.6	0.4	4.5	0.5	-0.1	-0.5
The instructor provided feedback to regarding my progress during the course	4.6	0.6	4.5	0.6	-0.1	-0.4
The textbook(s) were useful to my understanding of the course content	4.3	0.9	4.3	1.1	0	0.0
Course and Section Overall Rating	**4.7**	**0.4**	**4.6**	**0.5**	**-0.1**	**-0.5**

TABLE 2 Course Comparison to Other Units in the University

	Difference			Difference-n-Difference		
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
	$\Delta\mu$	σ^2_Δ	t_Δ	$\Delta\mu_c - \Delta\mu_i$	$\sigma^2_{\Delta\Delta}$	$t_{\Delta\Delta}$
Course and Section Overall Rating	-0.1	0.04	-0.51	-	-	-
Course (regardless of section)	0.1	0.08	0.35	-0.2	0.01	-2.82
Department	0.0	0.08	0.00	-0.1	0.01	-1.20
School	-0.1	0.08	-0.36	0.0	0.01	0.00
University	0.0	0.07	0.00	-0.1	0.01	-1.25

CONCLUSIONS AND FUTURE RESEARCH

Principles students are not accustomed to seeing equations with more than two variables. The general forms of the *AD* and *AS* curves, equations (7) and (8), have 12 and 9 variables, respectively. Students that are challenged by math find it very difficult to learn economics. As a consequence many studies on economics education find that at an early stage in their education, students become turned-off to economics.

Simulation technology with software like *Maple* offers more than just a new way of doing things. Rather, it has the possibility of changing significantly the way economics is taught and how students learn by engaging them in a way not possible with other pedagogical tools.

Using the *Maple* simulation in the classroom allowed more mathematical rigor to be included in the course, similar to the honors sections, without a decline in student ratings of the course. Student feedback on a separate survey indicated the students enjoyed the simulation because it freed them from tedious mathematical manipulation, and made the economic models much easier to visualize than the traditional classroom lecture. By practicing with the simulation, students found it easier to understand complex mathematical systems and remember the economic theories.

The evidence presented in this pilot study on the pedagogical effectiveness of the *Maple* simulation is largely tentative owing to the limited supporting data. More comprehensive course evaluation and simulation survey instruments are being constructed to more accurately measure teaching effectiveness of new technologies, and future research is needed to design a more formal testing scheme.

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APPENDIX: The *Maple* © code for the simulation:

```
restart:

"****** AD initial and final conditions *****************":
mpc := 0.9:
W0   := 250:      W1   := 250:
X0   := 500:      X1   := 500:
M0   := 600:      M1   := 600:
t0   := 0.3:      t1   := 0.3:
G0   := 500:      G1   := 600:
Ye0  := 250:      Ye1  := 250:
I0   := 500:      I1   := 500:

"****** AS initial and final conditions *****************":
beta := 0.1:
w0 := 120:    w1 := 120:
p0 := 100:    p1 := 100:
T0 := 30:     T1 := 30:
z0 := 50:     z1 := 50:
K0 := 50:     K1 := 50:
L0 := 60:     L1 := 60:


"****** The general forms of the AD and AS curves *******":

AD:=(W,Ye,X,M,t,G,In,Y)->W+Ye+In+G+X-M-(1-mpc*(1-t))*Y:
AS:=(w,p,T,z,K,L,Y)->w+p+T-z-K-L+beta*Y:


PD[0]:=AD(W0,Ye0,X0,M0,t0,G0,I0,Y);
PS[0]:=AS(w0,p0,T0,z0,K0,L0,Y);
PD[1]:=AD(W1,Ye1,X1,M1,t1,G1,I1,Y);
PS[1]:=AS(w1,p1,T1,z1,K1,L1,Y);
if beta > 99 then
    PS[0]:=-150000+100*Y:
    PS[1]:=PS[0]:
    fi:
d:=1: if PD[0]=PD[1] then d:=0: fi:
s:=1: if PS[0]=PS[1] then s:=0: fi:
Y0:=solve(PD[0]-PS[0],Y);
PL[0] :=AD(W0,Ye0,X0,M0,t0,G0,I0,Y0);
Y1:=solve(PD[1]-PS[1],Y);
PL[1] :=AD(W1,Ye1,X1,M1,t1,G1,I1,Y1);
plot([PD[0], PS[0], PD[1]*d+PS[1]*s,
     [[Y0,PL[0]],[Y0,    0 ]],
     [[0,      PL[0]],[Y0,PL[0]]],
     [[Y1,PL[1]],[Y1,    0 ]],
     [[0,      PL[1]],[Y1,PL[1]]]              ],
     Y=0..Y1*2,
     PL=0..PL[1]*2,
     color=[blue,blue,black,black,black,black,black],
     linestyle=[SOLID,SOLID,SOLID,DOT,DOT,DOT,DOT],
     thickness=[3,3,3,1,1,1,1],
     tickmarks=[4,4]);
econ_growth:=(Y1-Y0)/Y0*100;
inflation:=(PL[1]-PL[0])/PL[0]*100;
T0:=t0*Y0:
T1:=t1*Y1:
Budget_Deficit[0]:=T0-G0;
Budget_Deficit[1]:=T1-G1;
Trade_Deficit[0]:=X0-M0;
Trade_Deficit[1]:=X1-M1;
if T0 <> T1 then       c := t1*Y1 - t0*Y0:
                       var:=T:
                       fi:
if G0 <> G1 then       c := G1 - G0:
                       var:=G:
                         fi:
if I0 <> I1 then       c := I1-I0:
                       var:=Inv:
                         fi:
Change[GDP]:=Y1-Y0;
Change[var]:=c;
Multiplier:=(Change[GDP])/c;
```