Teaching Dynamic Aggregate Supply-Aggregate Demand Model in an Intermediate Macroeconomics Class Using Interactive Spreadsheets

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Abstract

In our intermediate macroeconomics class in order to initiate student interest we introduce the aggregate supply-aggregate demand models using spreadsheet based interactive graphs. Although we use Excel in our classrooms, we have developed the same framework using “Calc”. Our goal is to engage students in using aggregate supply-aggregate demand models to analyze the impacts of demand and supply shocks by focusing on adjustments over time which are based on price or inflation expectations. We use two models: model 1 is a traditional AS-AD model where updating of price expectations is the key for economic adjustment; model 2 uses the monetary policy rule to derive the (dynamic) aggregate demand curve (DAD) and the Phillips curve to derive the (dynamic) aggregate supply curve (DAS). Here the dynamic adjustment is brought about by updating of expected inflation. To create interactive graphs that students can control we insert “scrollbars” and “spin buttons” from Excel’s toolbar (accessible from the Developer tab in 2007 Excel) on a work sheet that contains the AS-AD or DAD-DAS models. The scrollbars are linked to price or inflation expectations and demand parameters. Spin buttons are linked to demand and supply shocks. Students can move the slider of the scrollbars to the right or to the left to change the values of expected price or inflation. They can also adjust the parameters of the monetary policy rule that affect the DAD curve. The spin buttons give them the control of demand and supply shocks. For each model, following a shock students adjust expected price or inflation and control the shifts of the aggregate supply curves. Although for illustration we use adaptive expectation, the interactive graphs are flexible to handle other expectation formation mechanisms. Students can alter the parameters of the monetary policy rule and the DAD curve and observe their impacts on the effects of shocks. The entire exercise becomes totally dynamic and interactive and students maintain complete control of their learning process. They remain engaged and become better motivated and prepared for analytical discussions of dynamic adjustments.

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1. Introduction

Almost every economics instructor wants their students to “think like an economist”. It is one of the most overused phrases in undergraduate economics syllabi, but represents a laudable goal. While an economist may not have any more or any less claim to be a critical thinker than a physicist, a mathematician or a sociologist, to “think like an economist” implies the ability to think critically using sound economic principles. Students will be able to think like economists only if they understand underlying economic concepts clearly and also can successfully use them in analytical thinking and problem solving. The hardest part of economics instruction can be finding the right method of teaching that will engage the students, grab their attention and ultimately involve them in learning something new and exciting. There are many who argue that if students can be successfully involved in the process of learning, the outcome will definitely be more promising.

There can be many possible methods of classroom teaching that ensure active involvement on the part of the student. Schmidt (2003) noted, “During the last 10-15 years economists have turned increasingly to the use of simulation exercises as a way to introduce active and cooperative learning in their courses.” In this paper we discuss how we have used a visual interface of spreadsheet applications to develop simulations to analyze dynamic adjustments in aggregate supply-aggregate demand models and how we have integrated such simulations in our teaching.

The plan of the paper is as follows. In the following section we discuss in general the concept of active learning and the obstacles to incorporate active learning strategies such as simulations in a classroom. In section 3, we discuss in detail how we have developed two spreadsheet based simulation models for use in intermediate level microeconomics courses. Concluding remarks are made in section 4.

2. Active Learning: Promise and Obstacles

In spite of frequent use of the term “active learning” there is no universally accepted definition of active learning. Instead of a precise definition, active learning is often described by certain features of the process of learning. At the heart of the description of active learning is the notion that “ active learning is more likely to take place when students are doing something besides listening” (Ryan and Martens, 1989).Bonwell and Eison (1991) list the general characteristics of active learning strategies. They include the following:

- Students are involved in more than listening.
- Students are involved in higher-order thinking (analysis, synthesis, evaluation).
- Students are engaged in activities.

Based on these characteristics of active learning strategies, Bonwell and Eison propose the following working definition of active learning: active learning “involves students in doing things and thinking about the things that they are doing.”

While there may not be a universally accepted precise definition of active learning, the importance and benefits of active learning cannot be overstated. Chickering and Gamson (1987) proclaim, “learning is not a spectator sport. Students do not learn much just by sitting in class listening to teachers….They must make what they learn part of themselves.” Cross (1987) goes a step further and argues that “when students are actively involved in learning, they learn more than when they are passive recipients of instruction.” It is now generally accepted that active learning, however clumsily it may be defined, significantly enhances student learning.

While in general a college faculty may appreciate the benefits of active learning strategies, there is still a great deal of hesitation among faculty in incorporating active learning strategies in their classroom teaching. Bonwell and Eison list some of the barriers to the use of active learning strategies. Faculty members often refrain from using active learning strategies because they feel that (i) incorporation of active learning strategies may reduce coverage of content, (ii) it is too time consuming to develop appropriate active learning strategies and, (iii) it may not be possible to promote active learning strategies in large classes.

But perhaps the biggest obstacle to the use of active learning strategies is the perception of two types of risks associated with such learning strategies. The first type of risk is that students may not participate in the “activities” and consequently, instead of taking charge of their own learning, they will be more disengaged. The second type of risk that the faculty often is fearful of is that active learning strategies may not be readily integrated with their existing teaching strategy and as a result students will not learn as much.

Simulations have long been viewed as a very effective active learning tool. Some twenty-five years back Day (1987) discussed the use of simulation models in the classroom and Scheraga (1986) argued that instruction through simulated programming can motivate “ the student to think for herself and to think like an economist”. But in spite of the recognition of the importance of active learning approach and the growing interest in simulation as an effective active learning model, it is somewhat disappointing to note that “educators still use these practices in undergraduate economics courses relatively infrequently” and that “computer labs and computer games and simulations are almost never used to teach economics”. (Watts and Becker, 2008)

We now turn to the two spreadsheet based simulation models that we have developed and used to teach dynamic adjustments in aggregate supply-aggregate demand models in our intermediate macroeconomics course.

3. Two Examples of Dynamic Adjustment Simulations in Aggregate Supply-Aggregate Demand Models.

Aggregate supply-aggregate demand (AS-AD) model plays a crucial role in an Intermediate macroeconomics course. It is used to analyze the effects of demand and supply shocks, explain the working of macroeconomic policies but perhaps most importantly, to demonstrate the economic adjustments over time. In an intermediate macroeconomics class students need to understand the analytical concepts with the help of graphical expositions. However, they often find the graphical analysis of the AS-AD model difficult to understand, let alone use them appropriately to analyze the dynamic adjustments in the economy or evaluate the effectiveness of fiscal and monetary policies. Admittedly, the graphs for the AS-AD model, in particular the shifts of the curves that are at the heart of analyzing the adjustments of the economy developed are somewhat complex. Students often find them difficult to understand and fail to follow the analysis as presented in the text or in a regular class lecture.

In our Intermediate Macroeconomics class we have developed an active learning framework to teach the working of the AS-AD models. We use a visual interface of spreadsheet applications to develop interactive graphs. Students themselves control the graphs and thus create numerous graphical combinations to aid their understanding.

We present these materials using Excel spreadsheets. Since students and faculty are usually very familiar with Excel, the navigation of the spreadsheet and the minimal programming that is needed to make the spreadsheets interactive, are not likely to pose any great difficulty for students and faculty and they can focus on the economic content of the subject matter. Although we use Excel in our classrooms, these exercises can be presented using “Calc” of the popular open-source software, “Open Office.” We usually hold these classes in computer labs or classrooms that are equipped with laptops. However, the student activities required in these models can also be assigned as home works without diminishing their value as active learning tools.

We develop two dynamic aggregate supply – aggregate demand simulation models. Model 1 is the traditional AS-AD model where the AS and AD curves show the relationships between real GDP, Y and the price level P. Dynamic adjustments work through updating of expected price level P^e. While the aggregate supply curve is a variant of the Phillips curve, the aggregate demand curve is usually derived from an IS-LM framework (Blanchard (2011)). Model 2 is based on the relationship between GDP and rate of inflation, π. Dynamic adjustments work through updating of expected inflation π^e. Here the aggregate supply curve is nothing but the Phillips curve, but the aggregate demand relationship is based on an explicit monetary policy rule (Mankiw 2010).

Model 1: Traditional AS-AD Model

In order to develop an interactive AS-AD model we start with the following linear model:

Aggregate Supply (AS): $Y_t = Y_n + c(P_t - P_t^{\,e}), \quad c>0$ (1)

Aggregate Demand (AD): $Y_t = a - bP_t, \quad a, b > 0$ (2)

Adaptive Expectations: $P_t^{\,e} = P_{t-1}$ (3)

where Y_n denotes the natural rate of output and P_t^e the price level expected to prevail in period t.

For the purpose of our simulation we parameterize the above AS-AD model with the following baseline model:

AD: $Y_t = 550 - 50P_t$ (4)

AS: $Y_t = 400 + 50\,(P_t - P_t^e)$ (5)

and, $Y_n = 400$ (6)

The purpose of this simulation is to demonstrate how the economy adjusts following a demand shock. We begin by drawing the graphs of the above aggregate demand and aggregate supply curves using Excel's chart drawing tool. As shown in figure 1, initially the economy is at long run full employment equilibrium with real GDP at the natural rate of output of 400 and $P = P^e$=3.

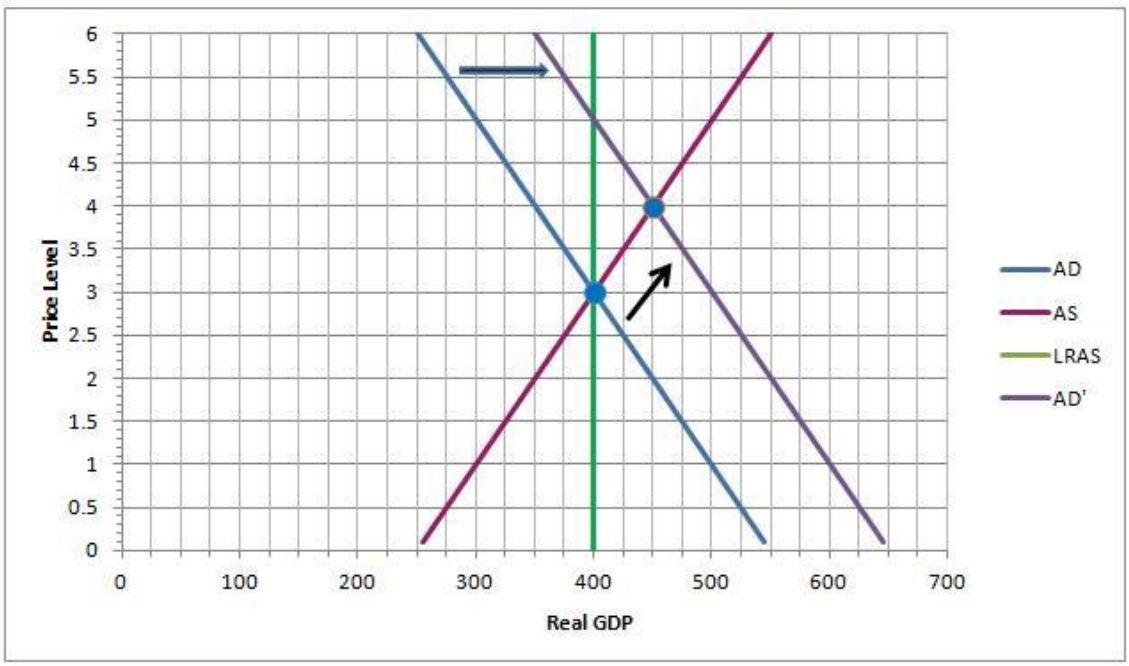
As the first step of our simulation we need to demonstrate how a demand shock affects the AS-AD model. To accomplish this, we insert on our worksheet a "spin button" from Excel's toolbar (accessible from the Developer tab in 2007 excel or the View tab in 2003 excel). Using the linked cell property under the format control for the spin button we link cell I4 to the value of the spin button that controls the direction as well as the magnitude of the demand shock. By pressing the up or down arrow on the spin button, students can choose the demand shock. Figure 1 shows the impact of a positive demand shock of 100. When students generate a positive demand shock of 100, the AD curve shifts to the right and as shown on the worksheet and the accompanying diagram real GDP increases to 450 and the price level rises to $4. But there is no immediate adjustment of expected price.

We now focus on the economic adjustment that follows the demand shock. Since this is brought about by updating of price expectation that causes the aggregate supply curve to shift, we insert a "scrollbar" on our worksheet. Just as the spin button, the scrollbar is also accessible from the Developer tab in 2007 Excel or the View tab in 2003 Excel. The function of the scrollbar is to control the adjustment of the expected price level, P^e .Using the format control of the scrollbar we set the range of values of the scrollbar slider between 0 and 6 with an increment of .05. We use the linked cell property of the scrollbar to link it to cell N4. Thus the value in cell N4 shows the expected price level which students can control by moving the scrollbar slider. A rightward

Figure 1

Model 1: Dynamic Aggregate Supply and Aggregate Demand Model; Response to a Demand Shock

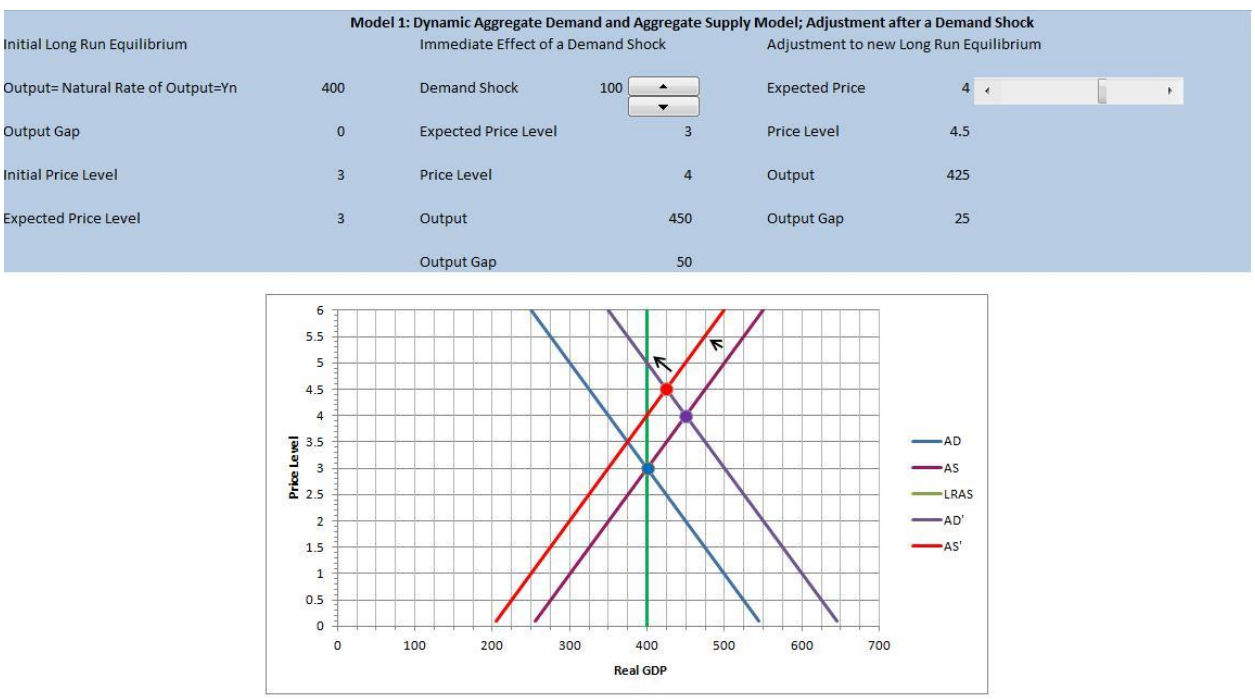
Initial Long Run Equilibrium		Immediate Effect of a Demand Shock	
Output= Natural Rate of Output=Yn	400	Demand Shock	100
Output Gap	0	Expected Price Level	3
Initial Price Level	3	Price Level	4
Expected Price Level	3	Output	450
		Output Gap	50



movement of the scrollbar slider raises the value of the expected price level, while a leftward movement reduces it.

As shown in figure 1, the demand shock creates a positive output gap and a mismatch between the actual price level and the expected price level. At this point the expected price level needs to be updated. We can now update the expected price level following the adaptive price expectation rule shown in equation 3. As illustrated in Figure 2, Students can move the scrollbar slider to the right to raise expected price to the level of the current price of $4. It should be emphasized that although we use adaptive expectation formation for illustrating the simulation, the simulation model can handle any type of price expectation. The updating of expected price level triggers a change in the AS-AD model. As shown in Figure 2, it leads to an upward shift of the AS curve. A new equilibrium is reached at Y = 425 and the price level increases further to P = 4.25. The positive output gap and a mismatch between the actual and expected price level necessitate further updating of expected price level. Students can continue to adjust the expected price level by moving the control of the scrollbar. The AS curve continues to shift up and leftward. The process of economic adjustment comes to an end when the economy returns to a long run full employment equilibrium at $Y = Y_n$ = 400 and with $P = P^e$ =$5.

Figure 2



Model2: Dynamic Aggregate Supply-Dynamic Aggregate Demand Model with Monetary Policy Rule

This variation of the aggregate supply-aggregate demand model focuses on the relationship between real GDP and inflation and incorporates a monetary policy rule (Taylor rule). Following Mankiw (2010) we will refer to this model as the DAS-DAD model. It is based on the following relationships.

Phillips Curve: $\pi_t = \pi_t^e + \sigma(Y_t - Y_n), \quad \sigma>0$ (7)

Demand for Goods and Services: $Y_t = Y_n - \beta(r_t - r_n), \quad \beta>0$ (8)

Fisher Equation: $r_t = i_t - \pi_{t+1}^e$ (9)

Monetary Policy Rule: $i_t = \pi_t + r_n + \theta_1(\pi_t - \pi^*) + \theta_2(Y_t - Y_n), \quad \theta_1, \theta_2 >0$ (10)

Adaptive Expectations: $\pi_t^e = \pi_{t-1}$ (11)

where π_t^e is the inflation rate expected to prevail in period t, r_t the real rate of interest, r_n the natural real rate of interest, i.e., the rate of interest when the real GDP Y is at the natural rate of output, Y_n in the absence of any shock, i_t is the nominal rate of interest or the federal funds rate set by the Fed, π^* the target rate of inflation and θ_1, θ_2 are the weights assigned by the Fed to the inflation gap and the output gap in the monetary policy rule.

We can rewrite (7) as the following DAS (Dynamic Aggregate Supply) equation:

DAS: $Y_t = Y_n + \varphi(\pi_t - \pi_t^e), \quad \varphi >0$ (12)

Substituting (9), (11) and (10) in (8) we can derive the equation for the DAD (Dynamic Aggregate Demand) curve:

DAD: $Y_t = Y_n - \alpha(\pi_t - \pi^*)$ (13)

where $\alpha = [\beta\theta_1/(1+ \beta\theta_2)]>0$

(For details of the derivation of DAD see Mankiw)

For the purpose of our simulation we parameterize the above DAS-DAD model with the following baseline model:

DAS: $Y_t = 50 + 2(\pi_t - \pi_t^e)$ (14)

DAD: $Y_t = 50 - .5(\pi_t -2)$ (15)

where $Y_n = 50$ and $\pi^*=2$ (percentage point).

The purpose of this simulation is to demonstrate how the economy adjusts following a supply shock. We begin by drawing the graphs of the above DAS and DAD curves using Excel's chart drawing tool. As shown in figure 3, initially the economy is at long run full employment equilibrium with real GDP at the natural rate of output of 50 and $\pi = \pi^* = \pi^e = 2\%$. Initially, the nominal interest rate, $i = 4\%$, while the real rate of interest is at the natural raate level, $r = r_n = 2\%$.

As in the simulation for model 1 we insert a "spin button" on our worksheet. The linked cell I4 shows the direction as well as the magnitude of the supply shock that is controlled by the spin button. Figure 3 shows the impact of an adverse supply (inflation) shock of 2.5 percentage point. When students generate such an adverse supply shock, the DAS curve shifts up and as shown on the worksheet and the accompanying diagram real GDP falls to 49 and the inflation rate rises to 4%. Furthermore, the nominal and the real rates of interest both increase—the nominal rate increasing to 6.5% and the real rate increasing to 2.5%.

We now focus on the economic adjustment that follows the supply shock. Since the adjustment is triggered by changes in expected inflation rate that cause further shifts of the DAS curve, we insert a "scrollbar" on our worksheet that controls expected inflation. Using the format control of the scrollbar we set the range of values of the scrollbar slider between 0 and 6% with an increment of .01%. We use the linked cell property of the scrollbar to link it to cell N4. Thus the value in cell N4 shows the expected inflation rate which students can control by moving the scrollbar slider.

As shown in figure 3, the supply shock creates a negative output gap. But it also creates a mismatch between the actual and the expected inflation rates. As the DAS curve shifts up due to an exogenous supply shock, individual workers and firms should have expected an increase in inflation by the full amount of the supply shock. But instead of an inflation rate of (2+2.5) or 4.5 percentage point, following the supply shock, inflation is seen to increase only to 4%. The less than full increase in inflation rate can be attributed to the central bank's automatic adjustment of the nominal interest rate, which influences the slope of the demand curve. Since there is a mismatch between the actual and the expected inflation rates, individuals update their expectations. As for model 1 simulation, we use adaptive expectations rule, shown in equation (11) for updating expectations, but the simulation can handle any other type of expectation formation. As illustrated in Figure 4, following the adaptive expectations rule, students move the scrollbar slider to change expected inflation to 4%--the current inflation rate. Since a 4.5% inflation could be expected in the absence of the central bank's automatic policy adjustment, the change in expected inflation is construed as a downward revision of expected inflation. Consequently, the DAS curve shifts down and to the right to a new GDP of 49.2, thereby reducing the size of the negative output gap. Nominal interest rate falls to 6%, while the real rate of interest falls to 2.4%. The inflation rate falls to 3.6%. The negative output gap and a mismatch between the actual and expected price level necessitate further updating of expected inflation. Students can continue to adjust expected inflation rate by moving the control of the scrollbar. The DAS curve continues to shift down until the economy returns to the initial long run equilibrium with $Y = Y_n = 50$, $\pi = \pi^* = 2\%$, $i = 4\%$ and $r = r_n = 2\%$.

Figure 3

Model 2: Dynamic Aggregate Supply and Aggregate Demand Model with Monetary Policy Rule; Response to a Supply Shock

Initial Long Run Equilibrium		Immediate Effect of a Supply Shock	
Output = Natural Rate of Output	50	Supply Shock (%)	2.5
Natural Rate of Interest (%)	2		
Target Rate of Inflation (%)	2		
		Expected Inflation	2.00
Output Gap	0	Rate of Inflation	4.00
Rate of Inflation (%)	2	Output	49
Expected Rate of Inflation (%)	2	Output Gap	-1
Nominal Interest Rate (%)	4	Nominal Interest Rate	6.50
Real Interest Rate (%)	2	Real Interest Rate	2.50

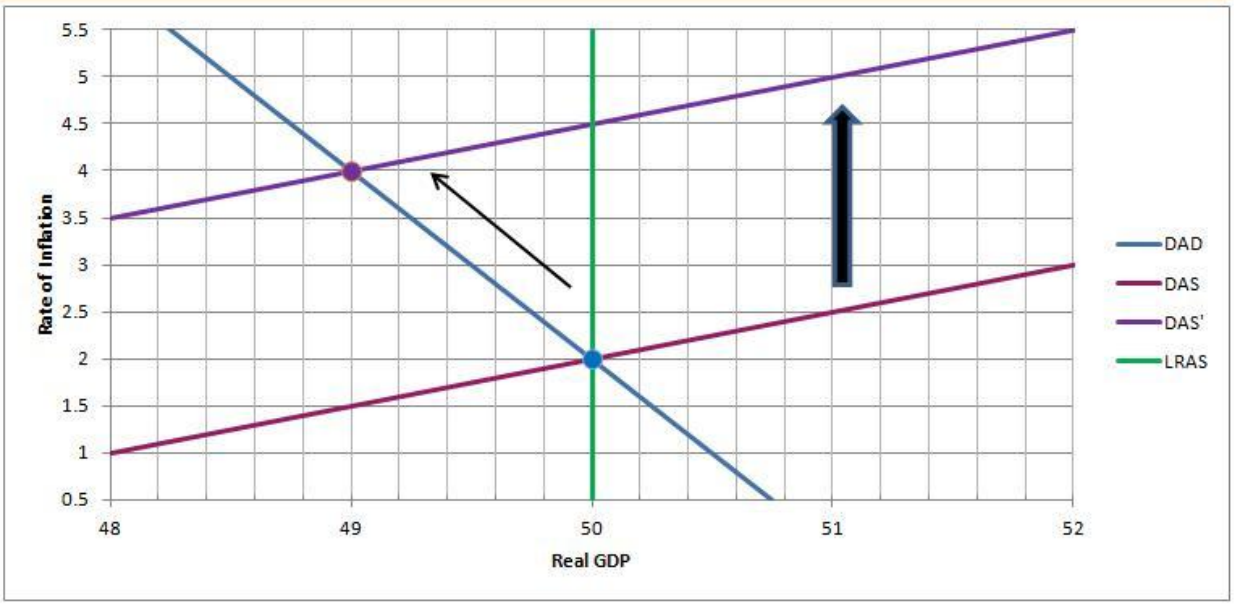
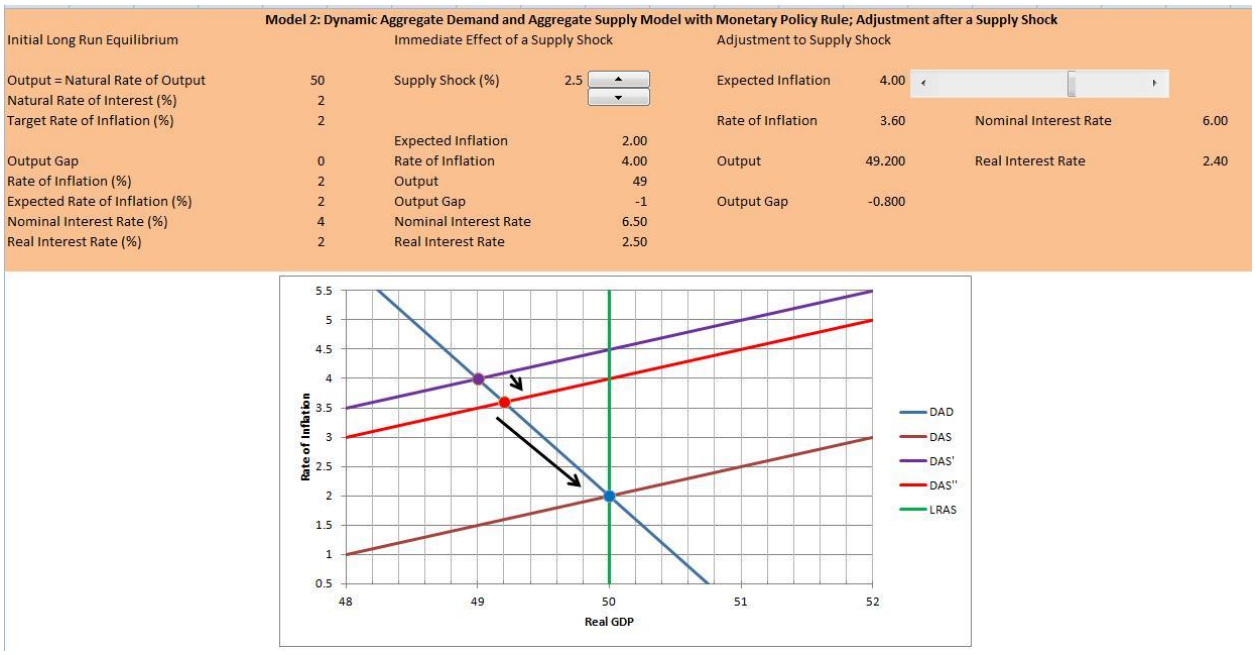


Figure 4



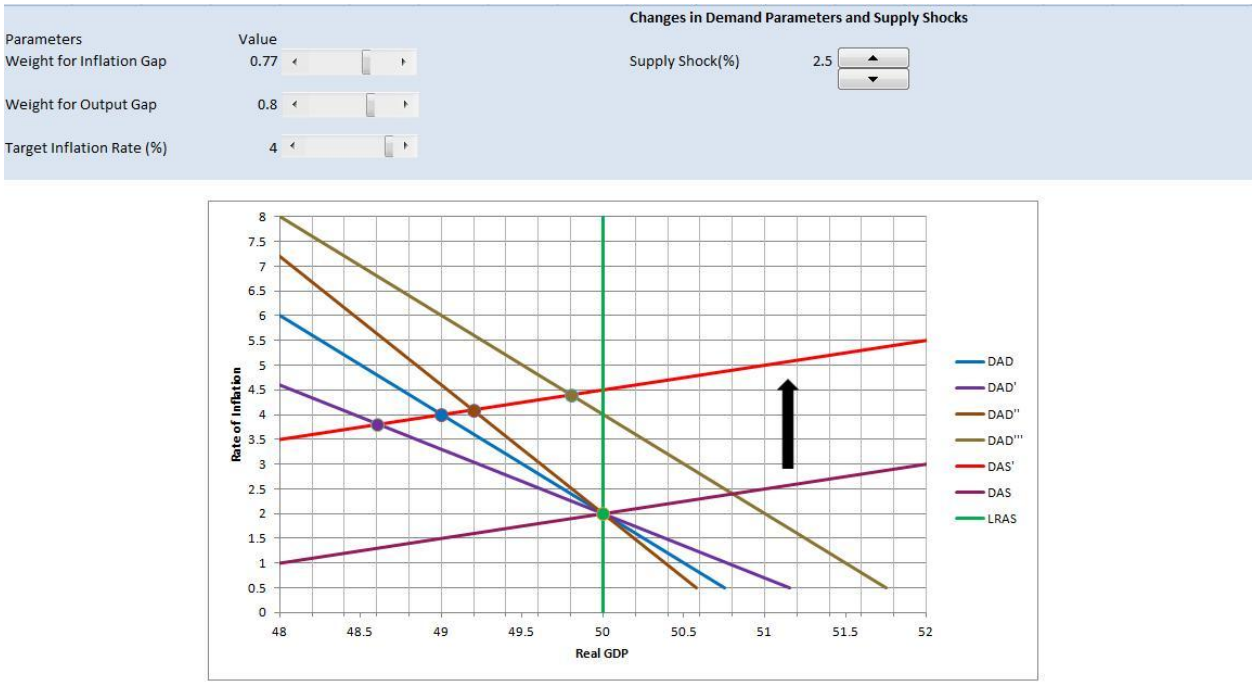
We finally consider the effects of Fed's policy changes that influence the DAD curve. As per our formulation of the monetary policy rule, there are three policy parameters of interest: θ_1, the weight for inflation adjustment, i.e., the responsiveness of the Fed to inflation's deviation from its target, θ_2, weight for output gap, i.e., the responsiveness of the Fed to the output gap and π^*, the target rate of inflation. As it is evident from our discussion of the DAD curve (13) and its slope, changes in any of these parameters affect the DAD curve and consequently influence the impact of a shock. Figure 5 illustrates the effects of the changes in these parameters on the DAD curve and the resulting impact of an adverse supply shock.

In order to examine the impacts of these parameter changes we incorporate three scrollbars on our worksheet. Each scrollbar controls one of the three parameters. For the purpose of these simulations we use the same baseline model for the monetary policy rule that we have used for the baseline model for the DAD curve of equation (15). Specifically, the baseline for the monetary policy rule of (10) is given by:

$$i_t = 2 + r_n + .5(\pi_t - 2) + .5(Y_t - 50) \qquad (16)$$

Using the format control we set the ranges for θ_1 and θ_2 from .1 to 1 with an increment of .01 and the range for π^* from 1 to 4 percentage point with an increment of .1. As with all other scrollbars the sliders control the values of the linked parameter. In figure 5 we begin with the initial baseline DAD curve and the DAS curve. As before they intersect at the longrun equilibrium position with $Y = Y_n = 50$, $\pi = \pi^* =$ 2%. The adverse supply shock as described

Figure 5



in our earlier simulation causes the DAS curve to shift upward to DAS'. Figure 5 illustrates the impact on the DAD curve as each scrollbar is adjusted and the parameter values are increased.

As θ_1 is increased, the central bank puts more emphasis on inflation control than on managing output gap and the DAD curve becomes flatter. The resulting DAD curve is shown by DAD'. As shown in figure 5, the adverse supply shock leads to less inflation but greater loss of output. When θ_2 is increased, the DAD curve becomes steeper, as shown by DAD'', since the centarl bank's responsiveness to output gap increases and output falls by a smaller amount after an adverse supply shock, but at the cost of higher inflation. The increase in the target rate of inflation, π^*, is constituted as a loose monetary policy and the DAD curve shifts to the right to DAD'''. The accommodative monetary policy limits the output loss but inflation increases significantly.

4. Conclusion

In spite of growing interest in active learning strategies such as simulations, experiments etc., most instructors of undergraduate economics courses still devote much of their class time to traditional lectures. In this paper we have shown how we have developed spreadsheet based simulation models to teach economic adjustments in dynamic aggregate supply-aggregate models. We have expanded the simple simulations described in the paper to incorporate other

expectation forming structures as well as active policies following the demand and supply shocks.

Furthermore, since instructors and students are familiar with Excel spreadsheets, these simulations can be further expanded and modified by instructors to suit their needs. Thus, these spreadsheet based simulations can be easily integrated with alternative teaching styles. We usually assign the simulations to students as class assignments or even as home works before we discuss the topics rigorously in class. We have found that since students actively control the models and generate the graphs, they become more interested in the topic and generally retain the material better. Once they understand the mechanics of the graphs by working through the simulations, we can spend more time in class discussing the economic principles underlying these models. We plan to discuss the assessment results of these and other simulations that we have used in a future paper.

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