Econ 270: Theoretical Modeling[1]

Economics is certainly not the only social science to use mathematical theoretical models to examine a particular question. But economics, since the 1960s, has evolved into the most formal of the social sciences and as a result the use of mathematical models is much more widespread than in other social sciences. This class will use both theoretical models and empirical evidence to understand macroeconomics. Because of its place in the Bates economics major, however, we will rely much more on theory than empirics. Before diving in, we will briefly discuss how theoretical modeling is done, why the field has chosen to rely so heavily on formal theory, and how we can judge competing models.

Suppose that we wish to answer a macroeconomic question. For example, suppose that we wish to understand the relationship between aggregate unemployment and taxes. A useful process is to then distinguish between *exogenous* variables and *endogenous* variables. Exogenous variables are those not being explained by the model. In our example, we may wish to treat technology as exogenous. Although technology is interesting, explaining its value is not closely related to the question at hand. Endogenous variables are those that are explained by the model. Obviously, unemployment is endogenous in this example.

An exogenous variable does not change in response to changes to other variables or parameters. If technology is exogenous, it does not change in response to monetary policy, fiscal policy, etc. This may, at first glance, seem problematic. Suppose, for example, that Congress passes a massive tax subsidy for research and development. It is reasonable to imagine that technology might change in response to such a policy. There are, however, good reasons to keep variables exogenous.

1. Simplicity. The goal of a model is to make sense of a complicated world. Exogeneity makes the model easier to work with.

2. Perhaps technology is not central to the question being asked. If I am interested in how taxes affect unemployment in the short run, then the role of technology is tangential at best. Related to the previous point, it is best to simplify such factors away so that we can better focus on the central question.

[1]These are undergraduate lecture notes. They do not represent academic work. Expect typos, sloppy formatting, and occasional (possibly stupefying) errors.

Exogenous is not, however, the same as constant. We may, for example, be interested in exploring what happens to the endogenous variables when a technological breakthrough occurs.[2]

Typically, our goal is to explain endogenous variables as a function of exogenous factors. For example, if taxes, government spending, and technology are exogenous, then we are not explaining why they equal a certain value. We are taking their values as given. But we hope to be able to say that if government spending equals \$3 trillion, and tax rates equal 30%, then unemployment equals X. We are not taking the value of unemployment as given. Because it is endogenous, its value depends on those of the exogenous factors.

Macroeconomists often use models to examine questions of interest. Formally, models use mathematics (graphs, algebra, etc.) to represent a set of assumptions about how households, firms, policy makers, and other agents behave in the economy. Perhaps we wish to make an assumption about how Congress changes tax rates in response to unemployment:

$$taxes = a + b * unemployment \tag{1}$$

where $b < 0$. This example illustrates one important way to judge the validity of a model. If its assumptions are plausible, then the model may be useful in answering the underlying question. If its assumptions are absurd, however, then the model is probably of little interest. [Note: There are many jokes about economists which are based on the idea that all economic models are based on dumb assumptions and are thus useless. For example: A physicist, a chemist and an economist are stranded on an island, with nothing to eat. A can of soup washes ashore. The physicist says, "Lets smash the can open with a rock." The chemist says, "Let's build a fire and heat the can first." The economist says, "Lets assume that we have a can-opener..."]

I propose the following three criteria to judge the quality of an economic (micro or macro) assumption.

1. Realism. Does the assumption accurately describe economic behavior. Using the example from (1), this assumption enjoys reasonable empirical support. It is probably somewhat realistic.

2. Completeness. Does the assumption capture enough of the important factors at play. Here, the assumption from (1) does poorly. Although there are good reasons to believe that

[2]On an exam, only change an exogenous variable if you are specifically asked to.

Congress responds to higher unemployment by lowering taxes, there are many other important factors as well.

3. Tractability. Is the assumption easy to work with. There is often a conflict between completeness and tractability. Adding more variables to (1), for example, may make the assumption more complete, but its also may make it harder to work with.

The relative importance of these three criteria may depend on the question being answered. Suppose, for example, that we are only interested in the effect of fiscal policy (changes to taxes and government spending) on the macroeconomy. Then we may be less concerned about the incompleteness of (1) than if we are interested in understanding how taxes respond to changes in party control of Congress, a variable neglected altogether by (1).

In macroeconomics, another criteria is often used:

4. Microfoundations. Does the behavior of households and firms result from utility maximization (for households) and profit maximization (for firms)? Macroeconomics is the aggregation of microeconomic behavior. As a result, many macroeconomists believe that macroeconomic models should assume that agents behave as discussed in your Introductory (or Intermediate) Microeconomics class. Suppose, for example, that we are studying the effect of tax changes on aggregate consumption. This criteria says that we should assume that households respond to different tax rates by choosing the response that maximizes their utility.

After stating the models underlying assumptions, the next step is to solve the model using mathematics, consisting of logic, graphs, algebra, or something else. *Solving a model* means understanding how endogenous variables respond to exogenous shocks (changes to exogenous variables or random events). For example, "a 1% increase in worker productivity increases GDP by X%, all else equal." The "all else equal" phrase is important. It means that we are isolating the effect of a single event.

By solving the model, we are able to obtain a set of predictions. Here lies an important intersection between theoretical macro and empirical macro. Modern macroeconomic theory is motivated by data. The predictions of a model are judged against those observed (sometimes controversially) in the data. If a model predicts that higher taxes increase unemployment, we compare that prediction to the observed behavior of unemployment in response to tax changes. A good model will match the most important features of the data.

Simulations

Suppose that we have used the preceding criteria to determine that our model of taxes and unemployment is good. We can then use this model to conduct simulations. One especially interesting type of simulation is a policy change. For reasons that we will discuss later in the course, it is extremely difficult to empirically estimate the effect of a policy that has never actually been in effect.[3] But if the model fits the empirical reality of policies that actually have been in effect, then it may be reasonable to hope that it will do a good job predicting the effects of those that have not been enacted.

Suppose, for example, we want to examine the effect of a flat income tax rate of 15% on the economy. Because this policy has never been in effect in the U.S., we can't do so using only empirical methods. But if we are happy with a model, then it may be simple to plug this tax rate into the model and see what happens to national income, inflation, income inequality, etc.

Institutions such as the Congressional Budget Office, the Federal Reserve, etc. frequently issue forecasts that influence policy makers. When such a forecast examines the effects of a hypothetical policy, it is likely that they are based on a theoretical model that has been judged a good fit with the actual data.

Why Use Models at All?

The economics profession is not unanimous in the belief that models should be used to analyze economic questions. Some traditions, known as heterodox schools of thought, reject this approach and prefer a narrative approach. They argue that the world is too complex to be represented by a model consisting of a workable set of equations. The best known examples are Marxists and Austrians. The vast majority of the profession, however, feels that models are important. Here are a few of their reasons:

1. Simplification. Often, an economist wishes to understand how policies or events affect certain variables. But in reality, variables are typically affected by countless variables. The mind is simply unable to process all of these factors or isolate their individual effects. A model simplifies the real world by limiting the analysis to a comprehensible level.

Again consider the example of unemployment and taxes. Suppose that Congress cuts taxes and then the unemployment increases. It cannot be said that the change to taxes caused the change in unemployment. it may instead have resulted to changes in government spending,

[3]This is intuitive. If a policy has never been in effect, then there exists no data which were generated by that policy.

productivity, or some other intervening event. A model may allow us to identify logically coherent causal relationships. Perhaps tax cuts incentivizes households to work more, thus reducing unemployment. Hopefully, this is a mechanism that may be tested using data.

2. Identify Core Areas of Dispute. Consider another example. In 2009, Congress passed, and President Obama signed, the American Recovery and Renewal Act. This stimulus package included over hundreds of billions of dollars in government spending. Most economists believe that increased government spending increases output and reduces unemployment in the short run (assuming that the economy is below potential output). An important minority, however, believe that this effect is not significant.

Both of these groups use models that yield predictions about the effect of government spending. The use of models allows us to identify the core source of their disagreement, rather than resorting to banter or childish namecalling. It turns out that often times, the source of this particular disagreement is whether or not prices adjust efficiently to economic events. If they do, then government spending is ineffective (at least in the short run). If prices respond sluggishly, then government spending may work in the short run. This difference may be analyzed, debated, and tested. Hopefully, this debate will be less ideologically driven than a debate about government spending that relies on no models.

3. Falsifiability. An important component of a scientific theory is falsifiability. There must exist some hypothetical set of observations that would convince a rational and fair minded scientist that their theory is wrong (of course, if the theory is correct, then such evidence will not actually exist). Models, however, are testable. If one believes that government spending is effective as a matter of sheer conviction, then her belief is likely not falsifiable. But using the previous example, if she is shown clear empirical evidence that firms rapidly adjust their prices, then she may be convinced that her theory is incorrect.

4. Avoiding Storytelling. Consider the following argument. "Raising taxes will not help reduce the nation's large budget deficit because business will respond by reducing hiring, slowing growth, and reducing tax revenues." Or : "Cutting spending in the midst of a slow economy will not help our budget deficit because doing so will slow growth and reduce tax receipts." Both statements are superficially reasonable. By insisting on models, however, we are able to identify the core assumptions needed to generate these results. We are further able to to see that these assumptions enjoy virtually no empirical support.

5. Minimizing bias. This is a side effect of #1-4. The study of economics ideally compels

students to challenge their initial beliefs and support their views with logically coherent mechanisms and/or empirical support. Without models, however, there is a tendency for economics to instead validate, rather than challenge, the students' initial views. It would be dishonest to claim that the use of models eliminates this bias (indeed, there is a tendency for students who initially are suspicious of government intervention to read the empirical results as supporting this position, while those more open to government intervention view these same results differently). But I believe that models introduce rigor to the field that at least discourages this bias.