I. Book Overview

This book grew out of lecture notes that Prescott developed for an advanced undergraduate class at Arizona State University and that Parente developed for a Masters course at the University of Illinois at Urbana-Champaign. Their goal in these courses was to give students the opportunity and experience of using models to develop sound intuition regarding various macro questions or puzzles. Having an educated citizenry is the key to the formulation of better economic policy, a richer society, and a happier world!

In many ways, the book grew out of a frustration with the way macroeconomics has been taught at the undergraduate level, something which is inherently difficult on account that frontier research in economics is based on mathematical models most of which are far too technical for most undergraduates to handle. Graphical analysis, which was the basis for almost every undergraduate macro textbook prior to 1980, is for most part inadequate for the purpose of gaining insight into frontier research. Effective teaching of macroeconomics at the undergraduate level today requires presenting models at an appropriate level, one not devoid of mathematics, but not so involved that the student requires an advanced degree in mathematics. A basic understanding of calculus is sufficient for using this book.
Another reason graphical analysis is insufficient is that most questions that are of interest to macroeconomists are quantitative in nature. It is simply inadequate to tell policy makers that they should decrease the tax rate on capital gains, or increase the amount of infrastructure in the country. Policy makers need to know by how much taxes should be raised or lowered, or how much additional infrastructure will add to economic growth, not just the direction of the change.

This book provides quantitative answers to many important macroeconomic questions that confront us, without requiring too much statistical analysis. The quantitative analysis is based on model calibration, an approach that views the model as a sort of measuring device. In calibration, the model is treated as an input in the analysis that the researcher uses to derive the implications of theory. Calibration does not seek to find the model that is most likely to have generated the data we observe. All models, by being abstractions of reality, are necessarily false. In this sense, the calibration procedure is radically different from model estimation.

Another difference between this book and most other undergraduate textbooks in macroeconomics is that most of the chapters investigate different questions and economic puzzles. For this reason, the different chapters present different models, each tailored to the question at hand. This is again the way macroeconomists go about doing research. There is no single macro model that can be used to answer every question, and there is no pretense in the book to developing such a model, an approach that dominated macro textbooks written in the 20th Century.
II. The Evolution of Macroeconomics

Macroeconomics has undergone a dramatic transformation in the last 25 years, particularly in terms of methodology. In 1982, Finn Kydland and Edward Prescott published a paper that truly revolutionized macroeconomics, and completed a transformation that began in the early 1970s. That paper made two important contributions. First, it introduced real business cycle theory - the theory that productivity shocks accounted for a large part of the fluctuations of output over the US business cycles since the end of World War II. Second, it introduced to economics the methodology known as model calibration - a methodology that allows one to derive the quantitative implications of theory.

Over the last 30 years, model calibration has proven to be an extremely powerful tool allowing macroeconomists to test and develop all sorts of theories and to evaluate alternative policies. It has been applied to a large range of issues, some of which are outside of the field of macroeconomics. For example, this methodology has been used to study the problem of economic development. Specifically, researchers have employed this methodology to determining the factor or sets of factors account for the huge differences in living standards that currently exist across countries, and that have caused some countries such as S. Korea, Taiwan, and China to experience unprecedented growth episodes. This methodology has been also used to answer the question why Americans on average work currently more than their European counterparts whereas in the 1970’s the opposite was true. It has also been used to answer whether the stock market in the
1990’s was overvalued. It has been used to address the rise in the skill premium, the ratio of the wages of those with a college education to those of those with a high school degree or less, that started in the 1980s. It has been used to address the rise in female participation in the labor force that started in the 1970s, and trends in marriages and divorce.

Some of the questions you will address in this course are as follows: Why are some countries so much richer than others?; Why did hours worked per adult fall by one-third in Western Europe, and not in Canada and the United States, in the 1970–1995 period?; Would a higher labor tax rate in the United States raise or lower government revenues? The models and tools we develop will allow us to analyze the sustainability of social security systems in countries such as the United States, Italy, and France, and evaluate the feasibility and welfare effects of alternative systems.

Macroeconomics Before the Transformation

Prior to the transformation, macroeconomics was really a distinct field, separate from the rest of economics, with little hope of being integrated. It was mostly concerned with the short-run behavior of the economy, namely, business cycles. Business cycles refer to the upward and downward movements in output that are commonly identified with economic expansions and recessions. In the data, it is represented by the upward and downward
spikes in the plot of US output based on quarterly data.

Prior to the transformation, business cycles theory was devoid of capital theory, and separate from growth theory. The theory of the business cycle that dominated in this period was attributed to John Maynard Keynes. Substantively, Keynesian economics viewed fluctuations of output, namely, the business cycle as a demand driven phenomenon. A key feature of this theory is that not all prices were free to adjust clearly so as to clear markets. On account of this “price stickiness”, a situation of involuntary unemployment – at the current prices, the quantity supplied of a labor exceeded the quantity demanded by firms- could arise and persist.
Keynesian models were represented by a system of structural equations. They are called structural for the reason that they describe the structure of the economy. Mathematically, a structural equation states the relation between a set of endogenous variables and a set of exogenous variables. An endogenous variable is one whose value is to be determined within the system. In contrast, an exogenous variable is one whose value is taken to be determined outside the system. In addition, a structural equation contains parameters, which relate endogenous and exogenous variable. Parameters differ from variables in that their values are viewed to be invariant to any changes in the model, including changes in exogenous variables.

An example of a structural equation in the Keynesian model is the consumption function, which states that the total amount that private citizens eat in the economy, $C$, is a linear function of aggregate income, $Y$, less taxes, $Tx$. More specifically,

$$C = a + b(Y - Tx),$$

The letter $a$ is a structural parameter and equals the amount that people would consume in the case they had no income. The letter $b$ is another structural parameter of the model and represents the increase in consumption associated with an additional increase in
after tax income, the so called marginal propensity to consume. The endogenous variables in this equation are consumption and income whereas the exogenous variable is taxes.

With the system-of-equations approach, each equation in the system is determined up to a set of parameters. The simple prototype system-of-equations Keynesian macro model has an investment equation, i.e., the amount of machines, and structures, and houses firms and household’s buy, a money demand function, and a Phillips curve, (i.e., a negative relationship between unemployment rate and the inflation rate first noted by William Phillips in 1958) in addition to a consumption function. Behind each of these equations, there was a rich empirical literature and, in the case of the consumption function, money demand function, and investment equation, some serious theoretical work. The theoretical work, however, examined each equation separately. This is to say, for example, that the theoretical underpinnings for the consumption function was neither considered nor derived in the context of money demand.

The final step was to use the tools of statistical estimation theory to select the parameters that precisely define the structural equations. In model estimation, the output of the exercise is the model itself. In effect, the macroeconomist’s job was to “identify” the model that was the one most likely generated by the data. Using econometric techniques, macroeconomists estimated the structural parameters of the model. Lawrence Klein at the

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1 Milton Friedman and Franco Modigliani were each awarded the Nobel Prize for their theoretical work on the consumption function, Friedman in 1976 and Modigliani in 1985. James Tobin was awarded a Nobel Prize in 1981 for his work on money demand, and Trygve Haavelmo was awarded the Nobel Prize in 1989 for his work on the investment equation.
University of Pennsylvania, who was awarded the Nobel Prize in economics in 1980, was important in pioneering this approach and developing the Keynesian macroeconometric models of this period.

There were numerous problems with this approach. First, the models even in the short-run performed poorly in forecasting the path of the economy. Another problem was identified by Robert E. Lucas, another Nobel Prize recipient in economics. A key assumption in the system-of-equations approach is that the equations are \textit{policy invariant}. In the context of the consumption function written above, this meant that the autonomous consumption parameter, \( a \), and the marginal propensity to consume parameter, \( b \), do not change in response to policy. Lucas’s insight was that this assumption was inconsistent with dynamic economic theory. His criticism, which has come to be known as the \textit{Lucas Critique}, states that it is impossible to define arbitrary decision rules, such as the consumption function or the investment function that remained unchanged to changes in the rest of the economy’s structure. Lucas’s concluded that the Keynesian approach could not be saved with a few alterations, and that an entirely different approach was called for.

\textbf{Macroeconomics after the Transformation}

The transformation of macroeconomics started in the 1970’s and initially was termed the “\textit{Rational Expectations Revolution}” on account that it introduced the assumption of rational expectations into macroeconomics. At a non-technical level, the assumption of rational expectations is that people take all available information into account in making
decisions, and act in a way that is consistent with those decisions. The concept of rational expectations was introduced by John Muth in a paper he wrote in 1960.

Initially, this revolution was seen as the start of a new school of economic thought – New Classical Economics – that was based on the assumptions of market clearing and rational expectations. Today this revolution is seen simply as the start of an alternative approach to macroeconomics, one that advocates dynamic general equilibrium models with strong microeconomic foundations, and that uses the calibration methodology. This approach is heavily used today in macroeconomics.

*Micro-Based Models:* Economic models after the transformation are grounded in strong microeconomic theory. Models after the transformation are dynamic, fully articulated model economies in the general equilibrium sense of the word *economy*. Model people maximize utility given the price system, policy, and their consumption possibility set; firms maximize profits given their technology set, the price system, and policy; and markets in some sense clear. Preferences, on the one hand, determine what people choose from a given choice set. Technology, on the other hand, specifies what outputs can be produced given the inputs. In Macroeconomics after the Transformation, *preferences and technology are policy invariant*. They are the data of the theory and not the equations as in the system-of-equations approach. With the general equilibrium approach, empirical knowledge is organized around preferences and technology, in sharp contrast to the system-of-equations approach, which organizes knowledge about equations that specify the behavior of aggregations of households and firms. For example, it is often assumed
that people have preferences over consumption and leisure and that these preferences are given by a log-log utility function of the form, \( \log(c) + \alpha \log(\ell) \). The letter \( \alpha \) is a parameter that determines how much the individual enjoys leisure.

**General Equilibrium** - Modern macroeconomics employs general equilibrium analysis. This type of analysis requires that all markets in the economy must simultaneously be in equilibrium. This is in contrast to partial equilibrium analysis that considers a single market and examines how a change in the economy, possibly policy related, changes the equilibrium in the market, ignoring all other markets and feedbacks between them. With general equilibrium, these feedbacks are taken into account. This is important, especially when examining the effects of policy changes on an economy. In general, the effect of any change will be smaller when considered in a general equilibrium context.

**Model Calibration** – Modern economics employs model calibration as the main tool for quantitative analysis. The calibration procedure views a model as an input or tool. More specifically, a model is seen as a measuring device to
derive the quantitative implications of theory. In a certain sense, a model is like a
thermometer; just as a thermometer measures the temperature of some location or thing, a
model measures the effect of a policy or the implications of some feature of the economy.

There are five steps to the Calibration methodology. They are

1. *Pose a question.* Questions can be of two varieties. First, they can be of
   the type that is used to test and develop theory. The second variety is of the type
   that explores the consequences of various policies.

   **Type I Questions: Test and Develop Theory**
   
   a. What accounts for the huge disparity across countries?
   b. Was the stock market overvalued in the 1990s?
   c. Why do Americans work more than Europeans?
   d. What accounts for the business cycle?

   **Type II Questions: Policy Evaluation**
   
   a. What would be the effect lowering the tax rate on
capital gains?
   b. What would be the effect on welfare of making the
social security system a fully funded system rather than
a pay as you go system?

2. *Choose a good measuring device* – The second step in the process is to choose
a model, or measuring device. In this step, both theory and data interact to choose
the device. In most of the quantitative studies taken up in this book, the measuring device is the Neoclassical Growth (or Solow Growth model, the difference being that in the Solow model, people do not choose savings optimally). The reason for this choice is two-fold. First, it is simple enough to be presented at the undergraduate level, yet rich enough to address a large number of questions. Second, it qualitatively and quantitatively, matches the stylized growth facts pertaining to the United States and other similarly industrialized countries since the turn of the 20th Century.

3. Define Consistent measures. All models are abstractions of realities and hence necessarily false. The point of a model after all is to strip away those features of the world that the modeler does not deem as important in order to concentrate on those features that are believed to be potentially important. The consequence of this is that a model will not have predictions for all the variables that are listed in the national income and product accounts. And yet we will need to make comparisons between the model and the data. For instance, for many questions and those addressed within this course, the assumption that is made is that the model is one of a closed economy. Hence, there is no international trade. Some output of the US economy is sold to foreigners, and some goods bought by US citizens and firms are produced abroad. A closed model economy has no exports or imports. To be able to make comparisons between the model economy and the actual US economy, we must make certain adjustments to the data, in this example to the net export category in the National Income and Product accounts.
For this reason, it is critical that we understand both the income and product side of the national accounts.

4. **Assign Parameter Values** - Here, we restrict parameters of the model so that equilibrium properties of the model match observations. Having chosen a model, we need to assign parameters of the model so as to derive its quantitative implications. This we do so that the equilibrium quantities and prices of the model match their counterparts for the US economy. In effect, we know the values we want for the equilibrium outcome. What we do, therefore, is to assign values to the parameters that give us that equilibrium outcome. In the context of the Neoclassical growth model, we will assign the parameter values so that the equilibrium of the model matches the US long-run growth observations over the twentieth century. With the model restricted in this way, we will explore its quantitative implications for a host of other issues such as international income differences, business cycles, and changes in labor hours.

5. **Compare data generated with model with actual data** – As many of the applications of the calibration method in these notes are by way of tests of theory, we need to compare the predictions of the model to the data. What is important in this stage is that the dimensions of the data that are being compared to the model’s predictions cannot be the ones used in step 4 of the calibration procedure. By assignment of the parameters, the model trivially matches the set of observations used in Step 4 of the calibration. The test has to be along
dimensions of the data not used in step 4 to assign parameter values of the model. For deterministic environments, we compare the actual path of the model with actual data. For stochastic environments, that is model worlds where there is some uncertainty and randomness, the process is more involved, requiring comparing a moments for a sampling distribution.

*Calibration and Mercury Thermometers.*

The analogy of a model as a thermometer is really not such a stretch in the calibration procedure. A thermometer can be used to answer a number of questions, such as does my child have a fever, or should I wear a jacket? Most thermometers today are of the digital variety, but earlier ones used mercury liquid. You might not have realized this, but those old mercury thermometers had been “calibrated” to the freezing points and boiling points of water. The maker of these thermometers simply indicated on the glass tube the 0 degree Celsius point (32 degree Fahrenheit) by determining the height of the mercury liquid when it was stuck in a bowl of ice water. The 100 degree Celsius/212 degree Fahrenheit point on the glass tube was marked by sticking the thermometer in a pot of boiling water and noting the line of the mercury. The temperature marks in between were based on the theory that mercury expands linearly with temperature. Note how uninteresting it is to use the thermometer to measure the temperature at which water freezes or boils; by the way the points are marked on the thermometer water freezes at 0 degrees and boils at 100 degrees Celsius. The thermometer, just as the economic model, by step 4 of the calibration exercise trivially matches the boiling and freezing points. This is not a test of the thermometer.
III. Book Outline-

The book is divided into two parts. The first part of the book concentrates on the problem of economic development and growth, namely, why some countries are so rich and others are so poor. These are Chapters 2-5. The models presented in these chapters are not fully modern in that they do not derive consumer savings by solving a household utility maximization problem. Instead, the savings rate is treated as a model parameter. The models do, however, do include profit maximizing firms and are general equilibrium in their analysis. The advantage of treating the savings rate as a parameter is that the analysis is extremely simple. Despite not being fully micro-founded, these models nevertheless offer much insight into one of the most fascinating questions in macroeconomics-why some countries are so much richer than others.

The next part of the book does not skimp on the microeconomics. These chapters present models with utility maximizing consumers. As the problem of utility maximization is complex, we first start with a model in which consumers choose how much to work and how much to eat. The world lasts only one period, so there is no reason to save. The model, is thus static in nature. We use this model to study the issue of work hour differences between countries. The average working age person living in the G-7 nations used to work a lot more than the US counterparts. Today, this pattern has been reversed. This is Chapter 6 of the book.
Chapters 7 and 8 study the household savings decision and how it relates to important macroeconomic issues such as social security and government debt. These chapters consider dynamic models, i.e., models in which there is multiple period so as to study the savings decision of households. A key component of the household savings problem is its intertemporal budget constraint, and wealth. Chapter 7 derives the household’s intertemporal budget constraint. It also derives an intertemporal budget constraint for the government, and uses this constraint to make sense of the current sovereign debt crises faced by many nations and individual US states. Having derived the household’s intertemporal budget constraint, it derives the utility maximizing conditions for savings. Chapter 8 then considers the saving decision and government policy in the context of studying retirement. The chapter employs the overlapping generations model developed by Paul Samuelson (1957) to show how government pension systems improve households’ welfare and compares the difference between a pay as you go system and fully financed pension system. Although not central to the Chapter 8’s topic, the chapter does contain an appendix that adds money in the overlapping generation model.

The last part of the book takes up the study of business cycles. This is the most difficult topic to teach at this level. We begin with a chapter that documents the business cycle regularities. This is Chapter 9. We then follow this with a presentation of the neoclassical growth model, i.e., the growth model with savings optimally determined. Chapter 10 assumes that households do not care about leisure, so there is no labor-leisure decision to consider. Chapter 11 adds this feature, and then uses the model to assess the
importance for productivity shocks for accounting for the US business cycle via a standard calibration exercise.