Macroeconomic Theory I

Economic Growth and Business Cycles

GOALS

Our goal in this course is to understand tools, models and techniques one needs to know in order to read and write academic papers in macroeconomics. Modern macroeconomics treats an equilibrium as a sequence or, more generally, as a probability distribution over sequences for prices and quantities. The sequences are indexed by time, so that equilibrium is a probabilistic model for economic time series.

An equilibrium model provides a mapping from parameters of preferences, technologies, endowments, and *rules of the game* (parameters that are meaningful to economists) to the probability model for time series. By *inverting* this mapping, economists interpret observations on economic time series. The rigor of the logical connection between theory and observations that the mapping provides is an attractive feature of dynamic equilibrium models.

The tool now used to study business cycles and economic growth is the discipline of *quantitative dynamic general equilibrium*. In this discipline, given the question or issue at hand, an explicit model economy is written down and the answer to the question determined for that model economy. Theory, the question, and the available data dictate the choice of model economy used in application. In contrast to a long tradition of viewing business fluctuations as disequilibrium phenomena, in contemporary stochastic dynamic general equilibrium macroeconomic models the cycle emerge from the stochastic processes that are essential elements of the models. Thus random, but persistent, changes in the factors that determine the level of output give rise to fluctuations that approximate those observed in real economies.

Quantitative dynamic general equilibrium methods are needed to show that growth theory implies business fluctuations. This is not something that one can derive without the use of quantitative dynamic general equilibrium analysis. For example, Kydland and Prescott (1982) determined how big the variance of the persistence component of technology shock had to be to generate fluctuations of the magnitude observed in the United States in the 1954-1980 period. Subsequent estimates of this variance (Prescott 1986) found tat the variance was of this magnitude. This is a success for the discipline of quantitative general equilibrium and for growth theory, a theory that was developed to account for the secular movements in the aggregate time series and not to account for business cycles.

EVALUATION

Students will complete five problem sets throughout the semester which will be graded and returned. Some of the problems will require written and mathematical analysis; others will involve numerical and computational analysis. I will assign them once the appropriate material has been covered, and you will have one week to complete them. Homework problems are going to be difficult and long, and they will involve computer programming in some cases. Answers will either be provided in TA discussion sessions, or in answer guides that will be made available on my website.

I encourage you to cooperate as much as possible with your classmates and to talk to me whenever you get stuck on an assignment or have questions about the material. Intellectual interaction with other Ph.D. students is crucial for becoming a good economist. However, each problem set submitted for grading must ultimately be a student's own work. You should start learning how to use Matlab right now. You should also start reading the basic topology section of a senior-level real analysis textbook. The TA will have sessions on Matlab.

There will be a midterm examination and a final examination which is held during the regular examination period. If you cannot attend the midterm due to a verifiable medical emergency, then the weight of the midterm will be added to the final examination. Otherwise, a grade of 0 will be assigned to the midterm. If you cannot attend the final examination due to a verifiable medical emergency, then a makeup examination will be set as soon as possible. Otherwise, a grade of 0 will be assigned to the final exam.

Your final grade in the class will be determined as the following weighted average of your work throughout the semester

Problem Sets	30%
Midterm	30%
Final Exam	40%

REQUIRED REFERENCES

The required textbooks for the course are:

Acemoglu, Daron. *Introduction to modern economic growth*. Cambridge, Princeton University Press, 2009.

Ljungqvist, Lars and Sargent, Thomas J. *Recursive Macroeconomic Theory*. Cambridge, MA: MIT Press, 2004 (2nd Edition).

Stokey, Nancy L.; Lucas, Robert E., Jr. and Prescott, Edward C. *Recursive Methods in Economic Dynamics*. Cambridge, MA: Harvard University Press, 1989.

Some additional books that will prove useful are:

Cooley, Thomas F. (Eds.). "*Frontiers of Business Cycle Research*." Princeton University Press, 1995.

Heer, Burkhard and Maussner, Alfred. *Dynamic general equilibrium modeling: computational methods and applications*. Berlin; New York, NY: Springer, 2005.

Judd, Kenneth L. *Numerical methods in economics.* Cambridge, MA: MIT Press, 1998.

Kehoe, Timothy J. and Prescott, Edward C. (Eds.). "*Great Depressions of the Twentieth Century*." Minneapolis, Minnesota: Federal Reserve Bank of Minneapolis, 2007.

COURSE OUTLINE

I History of Modern Macroeconomics

Macroeconomic issues are central concerns in economics. Macroeconomics underwent a revolution in the 1970s and 1980s, due to the introduction of the methods of rational expectations, dynamic optimization, and general equilibrium analysis into macroeconomic models, to the development of new theories of economic fluctuations, and to the introduction of sophisticated methods for the analysis of economic time series.

Readings:

Blanchard, Olivier. "What Do We Know about Macroeconomics that Fisher and Wicksell Did Not?" *Quarterly Journal of Economics,* November 2000, 115(4), pp. 1375-1409.

Blanchard, Olivier. "The State of Macro." *Annual Review of Economics*, 2009, 1, pp. 209-228.

Kydland, Finn E. "Quantitative Aggregate Economics." *American Economic Review,* December 2006, 96(5), pp. 1373-83.

Phelps, Edmund S. "Macroeconomics for a Modern Economy." *American Economic Review*, June 2007, 97(3), pp. 543-61.

Woodford, Michael. "Revolution and Evolution in Twentieth-Century Macroeconomics." Unpublished Manuscript, 1999.

Woodford, Michael. "Convergence in Macroeconomics: Elements of the New Synthesis." *American Economic Journal: Macroeconomics*, January 2009, 1(1), pp. 267-79.

II Optimal Growth

The centerpiece of the theory of economic dynamics is the classical optimal growth model. It consists of a central planner maximizing the sum of discounted utilities of consumption subject to a convex one-sector production set. These premises, resting largely on convexity assumptions, yield a simple and elegant model explaining many aspects of capital accumulation. In particular, there is a unique optimal growth path which, independent of the initial stock of capital, converges to the unique steady-state equilibrium level of capital. Furthermore, the convexity assumptions, in preferences and in production, imply that the necessary first-order conditions, i.e., the Euler equation and the transversality condition, are also sufficient for optimality.

Readings:

"Economic Growth and Economic Development: The Questions", **Acemoglu**, Chapter 1

"The Solow Growth Model", **Acemoglu**, Chapter 2

"The Solow Model and the Data", **Acemoglu**, Chapter 3

"Foundations of Neoclassical Growth", **Acemoglu**, Chapter 5

"The Solow–Swan Model", **Barro and Sala-i Martin**, Chapter 1

"A Deterministic Model of Optimal Growth", **Stokey and Lucas**, Chapter 2.1

Jones, Charles I. and Scrimgeour, Dean. "A New Proof of Uzawa's Steady-State Theorem." *Review of Economics and Statistics*, February 2008, 90(1), pp. 180-182.

Uzawa, H. "Neutral Inventions and the Stability of Growth." *Review of Economic Studies*, February 1961, 28(2), pp. 117-124.

III Dynamic Programming under Certainty and Stochastic Models

To analyze dynamic equilibrium models, we must first be able to characterize solutions to dynamic optimization problems since the behavior of agents in these models will be determined by the solutions to such problems. We will consider a technique for solving dynamic optimization problems that fall into a particular class called *stationary discounted dynamic programming* problems.

Readings:

Markov Chains

"Markov Chains", **Ljungqvist and Sargent**, Chapter 2

"Markov Processes", **Stokey and Lucas**, Chapter 8

Flodén, Martin. "A Note on the Accuracy of Markov-Chain Approximations to Highly Persistent AR (1) Processes." *Economics Letters*, June 2008, 99(3), pp. 516-520.
Matlab code

Tauchen, George. "Finite State Markov-Chain Approximations to Univariate and Vector Autoregressions." *Economics Letters*, 1986, 20(2), pp. 177-181.

Applications

"Stochastic Dynamic Programming", **Acemoglu**, Chapter 16

"Stochastic Growth Models", **Acemoglu**, Chapter 17

"Sequential Problems", **Ljungqvist and Sargent**, Chapter 3.1

"Stochastic Control Problems", **Ljungqvist and Sargent**, Chapter 3.2

"Practical Dynamic Programming", **Ljungqvist and Sargent**, Chapter 4

"Dynamic Programming under Certainty", **Stokey and Lucas**, Chapter 4

“Applications of Dynamic Programming under Certainty”, **Stokey and Lucas**, Chapter 5

“Stochastic Dynamic Programming”, **Stokey and Lucas**, Chapter 9

“Applications of Stochastic Dynamic Programming”, **Stokey and Lucas**, Chapter 10

IV Competitive Equilibrium

The fundamental concept that markets are interrelated and therefore the equilibrium of the economy is characterized by simultaneous equality of supply and demand on all markets is due to Walras (1874). The concept as further developed and expounded by Pareto (1896, 1909). The case that equilibrium exists was made plausible by showing that the number of equations equaled the number of unknowns. The optimality of the competitive equilibrium was argued by both Walras and Pareto. General equilibrium theory describes the equilibrium and disequilibrium arising from the interaction of all economic agents in all markets.

The principal objective of general equilibrium (GE) theory is to study the allocation of resources via system of markets. If all activity in an economy could be viewed as taking place in a single period then it would perhaps be reasonable to assume that markets are complete; that is, there is a market and associated price for each good. This is the environment of the classical theory resource allocations which finds its most elegant synthesis in the Arrow-Debreu theory.

Classical GE theory as synthesized by Arrow-Debreu has the property of being theoretically the most elegant part of the economic theory. It is elegant, because within the context of a precisely formulated set of hypotheses it leads to a clear and simple explanation of how an idealized system of markets allocates resources and achieves what amounts to a best possible solution to the problem of resource allocation. GE crystallizes a classical tradition in economic theory that has its origin in Adam Smith’s theory of the invisible hand, by which a competitive system with market prices coordinates the otherwise independent activities of consumers and producers acting purely in their self-interest.

Readings:

“Pareto Optima and Competitive Equilibria”, **Stokey and Lucas**, Chapter 15

“Applications of Equilibrium Theory”, **Stokey and Lucas**, Chapter 16

“Recursive (Partial) Equilibrium”, **Ljungqvist and Sargent**, Chapter 7

“Equilibrium with Complete Markets”, **Ljungqvist and Sargent**, Chapter 8

“Recursive Competitive Equilibrium”, **Ljungqvist and Sargent**, Chapter 12

“Recursive Methods for Computing Equilibria in Business Cycle Models”, **Hansen and Prescott**

V Real Business Cycle Models

The real business cycle (RBC) approach to macroeconomic fluctuations seeks to explain the main stylized facts of the business cycle by building stochastic artificial economy models in which economic equilibria are the outcomes of the interaction of rational agents who solve explicit intertemporal maximization problems. The first generation of RBC models typically specified a closed economy with a single production sector and in which shocks to aggregate production function were the only type of random disturbance. These simple models were consistent with many aspects of the cyclical behavior of industrialized economies. More recently, researchers have focused their attention on two major discrepancies between the properties of simple RBC models and the U.S. data, both of which are related to the labor market.

First, total hours worked are much more volatile compared to average labor productivity in the data than in the simple RBC models. Second, simple RBC models predict a high correlation between hours worked and average labor productivity which is absent from the data. These two stylized facts of the labor market constitute a puzzle which RBC models have had trouble solving. Various modifications have been proposed to the baseline RBC model in order to generate predictions which are more compatible with the data. As illustrated in a unified framework by Hansen and Wright (1992), RBC models can be made to generate a higher volatility of hours either by introducing preferences that are nonseparable between leisure in different time periods as in Kydland and Prescott (1982) or by introducing indivisibilities in the labor-leisure tradeoff as in Hansen (1985) and Rogerson (1988).

Readings:

"Economic Growth and Business Cycles", **Cooley and Prescott**

"Real Business Cycles", **Ellen R. McGrattan**
(The note has been prepared for The New Palgrave Dictionary of Economics, 2nd edition)

Hodrick, Robert J. and Prescott, Edward C. "Postwar U.S. Business Cycles: An Empirical Investigation." *Journal of Money, Credit and Banking,* February 1997, 29(1), pp. 1-16.

Prescott, Edward C. "Theory Ahead of Business-Cycle Measurement." *Carnegie-Rochester Conference Series on Public Policy,* Autumn 1986, 25, pp. 11-44.

Rebelo, Sergio. "Real Business Cycle Models: Past, Present and Future." *Scandinavian Journal of Economics,* June 2005, 107(2), pp. 217-238.

Williamson, Stephen D. "Real Business Cycle Research Comes of Age: A Review of Essay." *Journal of Monetary Economics,* August 1996, 38(1), pp. 161-170.

VI OLG Models

Competitive equilibria in economies of overlapping generations are different from competitive equilibria in economies that extend over finitely many periods, finite economies for short. These differences concern the properties of competitive equilibria, such as existence, optimality and determinacy or local uniqueness; and the phenomena compatible with competitive equilibria, such as net aggregate debt or fiat money with a positive price. Ever since the introduction of the model of overlapping generations by Allais (1947) and Samuelson (1958), economic theories have striven to isolate the reasons for the differences between this model and the definitive model of a finite economy elaborated by Arrow (1951), Debreu (1951, 1970) and Arrow and Debreu (1954).

The OLG model of Allais and Samuelson retains the methodological assumptions of agent optimization and market clearing from the Arrow-Debreu model, yet its equilibrium set has different properties: Pareto inefficiency, indeterminacy, positive valuation of money, and a golden rule equilibrium in which the rate of interest is equal to population growth (independent of impatience). The OLG model is used to analyze bubbles, social security, demographic effects on stock returns, the foundations of monetary theory, Keynesian vs. real business cycle macro models, and classical vs. neoclassical disputes.

Readings:

"Overlapping Generations Models", **Ljungqvist and Sargent**, Chapter 9
Geanakoplos, John. "Overlapping Generations Models of General Equilibrium." Cowles Foundation Discussion Paper No: 1663, Yale University, May 2008.

"Intertemporal General Equilibrium Models", **Timothy J. Kehoe**

"Growth with Overlapping Generations", **Acemoglu**, Chapter 9