Introduction to Economics Dynamics

Lecture 1 of Policy and Planning Science in English

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October 1, 2021

Introduction to Economic Dynamics, the course, the instructor, and the field. The lecture continues with discussion of mathematical foundations of dynamic analysis.

Course Description

This course introduces dynamic analysis in economics. It presumes familiarity with calculus as an analytical tool, and intermediate microeconomics, using optimization theory to explain consumer and firm behavior as a foundation for analysis of economic interactions, primarily via markets.

It is a fairly pure lecture course, with evaluation based on examinations and out-of-class problem sets. By request of the curriculum committee, the primary language of instruction is **English**. Lectures and course materials will be in **English**. Class discussion and questions may be in English or Japanese at your convenience. Out-of-class assignments should be written in English, but may be written in Japanese *with prior approval from the instructor*. Expect substantial delays in evaluation of work written in Japanese *without approval*.

Evaluation

40%	**Research proposal:** Identify a question in social science that involves dynamics in some important way. Explain the relation of dynamics to the question. Propose to study the issue using methods of economic dynamics.
20%	**Presentation:** Present your proposal in a recorded, short speech of 2–3 minutes.
40%	**Homework:** Problem solving. (See test bank on old website.)

Experience shows that my grading of submitted assignments is not biased by my feelings about students, but when assigning course grades you will *not* get a worse grade if I can associate your name with a face. You may get a better grade, specifically if you are at or near the cutoff, if I feel your participation has contributed to the other students.

Primary Course Resources

- Resources are linked from the *Economic Dynamics Home Page* (`https://turnbull.sk.tsukuba.ac.jp/Teach/Dynamics/`). I may occasionally provide links or urgent information via Manaba or Teams, but the *Economic Dynamics Home Page* is authoritative.
- Ronald Shone [2001], *Introduction to Economic Dynamics*, Cambridge, UK: Cambridge U. Press is **recommended but optional**. The bookstore won't handle foreign texts unless at least 75 students are expected. It can be ordered from Amazon but it's pretty expensive.
- Some *secondary resources* can be found in the University library or you may use my personal copies in my office by appointment.

Secondary Course Resources: Background

- Nishimura, Kazuo [1995]. *Mikurokeizaigaku Nyuumon*, 2d ed. (Japanese). Tokyo: Iwanami Shoten. (This is a good textbook in Japanese.)
- Varian, Hal R. [2014]. *Intermediate Microeconomics: A Modern Approach*, 9th ed., New York: Norton. (This is the best textbook in English. For this class, any edition will do.)
- Bergstrom, Theodore, and Hal R. Varian [2014]. *Workouts in Intermediate Microeconomics*. (Companion to Varian [2014].)
- Hirsch, Morris W., Stephen Smale, and Robert L. Devaney [2013]. *Differential Equations, Dynamical Systems, and an Introduction to Chaos*. Waltham, MA: Academic Press. (For more information about the mathematics of dynamical systems. Not easy.)
- Intriligator, Michael. *Mathematical Optimization and Economic Theory*. (For more information about optimization and control theory. Not easy.)

Secondary Course Resources: Theory

- Gandolfo, Giancarlo [2009]. *Economic Dynamics*, 4th ed., Berlin: Springer. (Currently the encyclopedic resource on economic dynamics.)
- Lucas, Robert and Nancy L. Stokey. *Recursive Methods in Economic Dynamics*.
- Shone, Ronald [2002]. *Economic Dynamics: Phase Diagrams and their Economic Application*, 2nd ed., Cambridge, UK: Cambridge U. Press. This is the long version on which *Introduction to Economic Dynamics* is based.
- Stokey, Nancy L. *The Economics of Inaction*. (A text on the most recent advances in stochastic dynamics.)

Secondary Course Resources: Applications

- Arthur, W. Brian [1994]. *Increasing Returns and Path Dependence in the Economy*, Ann Arbor, MI: U. of Michigan Press.
- Axelrod, Robert [1997]. *The Complexity of Cooperation: Agent-Based Models of Competition and Collaboration*, Princeton, NJ: Princeton U. Press.
- Dasgupta, Partha, and Geoffrey Heal. *Economic Theory and Exhaustible Resources*.
- Jones, Charles. *Economic Growth Theory*.
- Kleinberg, Jon & David Easley. *Networks, Crowds, and Markets*.
- Resnick, Mitchel [1994]. *Turtles, Termites, and Traffic Jams: Explorations in Massively Parallel Microworlds*, Cambridge, MA: MIT Press.

Instructor information

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Office (rarely)	3F1234, tel: (029) 853-5091
Lab (occasionally)	3E406

Course information

Economic Dynamics (FH27041)	
Prerequisites	Microeconomics and elementary calculus.
Time & room	Fri 1&2, Teams
Home page	`http://turnbull.sk.tsukuba.ac.jp/Teach/Dynami`
Lecture notes	Linked from course home page
Contact email	`dynamics-help@turnbull.sk.tsukuba.ac.jp` `Subject: Dynamics help: …`
Homework submission	`dynamics-hw@turnbull.sk.tsukuba.ac.jp` `Subject: Dynamics (FH27041) HW #: …`
Teams Team	(Linked from course home page)

Dynamics are important

- The novel virus *SARS-CoV-2* and the disease it causes called *COVID-19* have *warped our lives*. When I first wrote this passage in September 2020, as far as I knew, I didn't know anyone who has had COVID-19. Do you remember the first time you or someone you know had it?
- In fact, at that time in Japan only a few tens of thousands of cases have occurred, less than 0.1% of the population. Of those, only a couple thousand deaths, about 0.01% ot the population. That's not good—it's a very serious disease. But it's not enough to have a huge effect on the economy and the whole society by itself.
- What makes COVID-19 so important are its *dynamics*. Left to itself in a business-as-usual society, the number of cases would double every few days. It could infect every person in this country in a few weeks at that pace. That is terrifying, especially since in the early days we knew nothing about immunity, precise mechanism of transmission, and long-term effects of COVID.

Models are important

- We saw that the *exponential model* (unconstrained doubling) was not a good model. It eventually predicts the impossible, and doesn't describe the historical fact well.
- So we modified that model, to account for more and more facts about the disease.
- We discovered that (in combination with some facts about public health) the disease is quite frightening despite the fact that it seems to be controlled, justifying severe policies (though we don't know how severe policies are actually needed, yet) until we have good vaccines and better treatments available.

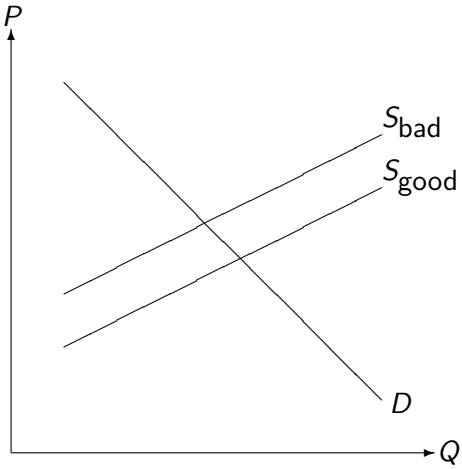
The Dynamic World

What is the subject of economic dynamics? While many economic problems have a "parametric static solution" that can be applied repeatedly in several periods, in many problems linkage must be considered over time. Decisions made now create constraints or opportunities for decisions in future periods.
Dynamic analysis has always been considered important:

- "The uncertainty of life itself casts a shadow on every business transaction into which time enters." (Irving Fisher, *The Theory of Interest*, Ch. IX, p. 216.)
- "Time ... is the centre of the chief difficulty of almost every economic problem." (Alfred Marshall *Principles of Economics*, Preface to the First Edition.)

Generic static solution

- What do we mean by a "parametric static solution"?
- A typical example is the market for rice. The economic problem is who decides to produce rice? Who gets to consume it?
- The market disseminates a price, and if the buyers at that price want as much as the sellers, there is equilibrium.
- But supply depends on the weather, the parameter.



Is Comparative Statics Enough?

- Elementary microeconomics compares *equilibrium states*, using the technique of *comparative statics*.
- Before and after? Maybe, maybe not.
  Comparative statics cannot be thought of as "before and after."
  Two different equilibria are based on contemporary conditions.
  Returning to the "before" equilibrium is trivial.
  In dynamic problems, however, the conditions *evolve* over time, and reversing the process is usually not possible. (Arthur [1994] on "path dependence", Gandolfo [2009] on "irreversibility in dissipative nonlinear systems and chaotic systems".) Resetting policy to the original state is *not* enough to reset all environmental conditions.
- Thus continuing change is central, and not only must evolution of physical conditions be considered but persistent changes in the *expectations* held by market participants.

Anticipation and Demand

- Several times in the last decades the government of Japan has increased the consumption tax rate (including the introduction of the tax, which we think of as raising the rate from 0% to 3%).
- The static equilibrium analysis shows that consumers perceive this as a price increase (*zei-komi kakaku*) and firms as a price decrease (*zei-nuki kakaku*). The burden is shared according to the ratio of price elasticities of supply and demand.
- However, when the consumers and firms anticipate the tax increase, there is an additional effect of anticipatory purchasing: consumers change their plans to buy large durables (houses, cars, refrigerators) to complete purchase *before* the tax increase. That is, the announcement induces a rightward shift in demand in the pre-tax-increase period (*kake-komi juyou*), and a leftward shift in the post-tax-increase period.
- This mitigates the decrease in sales over the long term, and reduces the tax revenue, compared to the static analysis.

Complex Dynamics

- The "classical" dynamic models are aggregate models. They treat markets (with hundreds or thousands of traders reduced to price and quantity), or populations (reduced to the number of members), or whole national economies (reduced to GDP and population).
  - Mathematically we say they are of *low dimension*, that is, they have few variables.
  - They also tend to be either monotonic or cyclic according to a sine wave.

  These two properties make them "simple".
- "Complex" dynamics arise when either property fails.
  - With low-dimensional nonlinear systems, *chaos* can arise.
  - In systems with many interrelated variables (such as "agent simulations"), the dimensionality itself creates complexity as changes ripple back and forth "across" the "population" (from one agent's variables to other agents' variables).

"Classical" Dynamic Topics in Economics

- *Economic growth theory* can help us to understand the context of Japan's current economic discomfort better – and predict that Korea, Taiwan, and China will experience similar discomfort.
- *Technological innovation* is at the core of modern growth theory; we'll take a look at dynamics of innovation.
- Do *limitations on natural resources* necessarily imply "limits to growth"? We will look at the economics of exhaustible resources, like oil, and renewable ones, like fish.
- Why are markets so *volatile*, with a persistent but irregular business cycles and financial bubbles that end in "meltdowns"? *Stability analysis* can distinguish inherent instability from external randomness.
- The theory of *pricing of derivative assets* necessarily involves time (as Irving Fisher said).

Basic Ideas of Economic Dynamics

- Dynamics studies an evolving process of change.
- Dynamics often involves irreversibilities.
- Commodities consumed at different *dates* are considered to be different commodities. *E.g.*, "storage" is *production*. Consumers are considered to have *time preference*, or *discounting*.
- Dynamic processes can be very complex, since tomorrow's outcome of an action today may be outweighed by later outcomes depending on that action. Irreversibility makes it possible to consider simple "endgames", and analysis works back from there.
- Dynamic optimization may also focuse on *steady states* where the decision-maker's problem does not change. *I.e.*, the decision in each period recreates the original conditions for the next one.

Microeconomics and Dynamics

- Economic dynamics is a branch of microeconomics. Microeconomics is a science:
  - quantitative, and
  - logically correct.
- Microeconomics guides "social engineering,"
  - as chemistry guides chemical engineering.
- Rigor (logical correctness) is costly, requiring
  - abstraction (modeling), and
  - explicit statements of the relationships that are important.
  - *Ad hoc* accounting for "other factors" is unscientific.
  - Instead, change the model, and re-solve from the beginning.

Review of Microeconomic Modeling

- Abstraction eliminates "unimportant" details.
- Analysis is easier and more transparent.
  - Classroom models emphasize "easy to study."
  - Policy models emphasize computation of accurate predictions.
  - Theoretical models need high degrees of abstraction.
- Loss of realism is a necessary cost,
  - of complexity of individual decision-making and interaction.
  - Our models are less robust than those used by engineers,
  - and less emotionally satisfying (to laymen and to many "political economists") than a careful verbal analysis.
- Are they realistic enough?

A Definition of Microeconomics

Microeconomics: *the social science that studies interactions among allocations of scarce resources to competing ends by rational agents.*

science Science is organized, quantitive study using *models*. "Quantitative" means measurement and mathematics.

model A *model* simply states that certain facts and relationships are important, and others will be ignored. Discussing other facts and relationships *violates* the model.

social science A *social* science is one that deals with *interactions* within groups, of animals, organizations, or even machines. Explicit description of interactions is why microeconomics is "micro". Macroeconomics, on the other hand, concentrates on overall flows of resources rather than decisions.

scarce resources A *resource* is anything that might ever be useful to somebody. A resource is *scarce* when someone would be able to use a little bit more of it. A resource is *free* if nobody anywhere has any use whatsoever for more of it.

competing ends An *end* is a use, goal, or purpose. Two ends *compete* when they both could use the same scarce resource.

allocation *Allocation* is simply a fancy word that means to make a decision. In particular it refers to a decision about for which purpose to use a particular resource.

rational agent *Agent* simply means "decision maker." *Rational* simply means "purposeful" or "goal-oriented." An agent may be considered to have *immoral* or *crazy* goals, but if those goals are clear and the agent's resources are used for those purposes they are considered *rational*.

Dimension of variables

- In formulating and interpreting a dynamic model, it is important to keep track of the dimensions (units) of various quantities.
- Algebra "doesn't care" what variables and numbers you combine, but in economics most combinations don't make sense.
- The most important task of the economic theorist is checking that the model equations make sense, or revising them so that they do make sense.
- The classic saying is that "you can't add apples and oranges." That is true, in one sense, but that would make it impossible to do macroeconomics. The macroeconomist revises the model to "count" apples and oranges in terms of their *values*, and adds those up to get *GDP*.
- In the same way, microeconomists summarize all of the expenditures of production in a *cost function*, or give different items a *quality index* without explaining why one is "better" than another.

Stock *vs.* flow

- The most important dimensional distinction in economic dynamics is that of *stock vs. flow*.
- In economics and accounting, the *stock* of a good is the amount that exists at a given time. A stock has a dimension of physical units: number of apples, kilos of rice, carats of diamonds, and so on.
- A *flow* is a *rate of change* in a stock. Therefore it is measured as a ratio: physical units per time unit.
  - It is *not* the change in a stock. It needs to be multiplied by time; if the flow exists only for an instant, the stock doesn't change. The longer the flow exists, the bigger the change in stock.

Stock *vs.* flow: example

- For example, it makes sense to say one has a *wealth* of 10,000,000 yen. It does *not* make sense to say one has an *income* of 10,000,000 yen, because it means very different things depending on the unit of time.
- A person with an income of 10,000,000 yen *per month* is *very* fortunate.
- An income of 10,000,000 yen *per year* is pretty good (but well within reach: a senior professor acting as Dean of Shako makes about that much).
- An income of 10,000,000 yen *per lifetime* is extreme poverty (based on an average lifetime of 75 years).

Higher-order dimensions

- In mechanics, we are familiar with higher-order units. For example, *acceleration* has units "distance per time squared."
- Such units are less common in economics, but they occasionally show up in highly dynamic fields such as finance and macroeconomics.