Modern Macro

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What Econ720 is about

Macro is built around a small number of workhorse models:

1. Overlapping generations
2. "Standard growth" in continuous and discrete time
3. Stochastic growth
4. Endogenous growth
5. Search and matching models

We study basic versions of the **models** and the **tools** needed to analyze them.

What is not covered

Computational issues

- see Econ821 (sometimes)

Empirical issues

How to take models to data?

We will talk about empirical applications later in the semester (and in Econ721).

Modern Macro

(Special Advertisement Section)

Or:

Why Most of Your Undergraduate Macro Courses Were Useless

Modern macro

Let's start by talking about how macroeconomists approach questions.

The main point is:

Macro is micro.

Macro Before Lucas

Goods market primitives:

- Consumption function: $C = C_0 + cY$.
- Investment function: $I = I_0 - bi$.
- Identity: $Y = C + I + G$.

IS curve:

$$(1-c)Y = C_0 + I_0 + G - bi$$

Money market primitives:

- Money demand: $L = L_0 + kY - di$.
- Money supply: M/P.

LM curve:

$$M/P = L_0 + kY - di$$

Key Features

Aggregate relationships are taken as primitives

- such as the demand for goods or money

The **parameters** inside the aggregate relationships are taken as primitives

- such as C_0 or the marginal propensity to consume c
- these parameters are thought of as (more or less) constant

Expectations are taken as given

- in dynamic versions of the model

What is Missing?

1. Constraints:
   Where are the budget constraints of consumers and the government?
2. Responses to changing government policies:
   E.g., consumption should depend on government debt.
3. Expectations
   What happens in the future matters for today's decisions.
   E.g., saving depends on the solvency of social security.
4. Expectations have to be consistent with actions

   This cannot be right!

Modern Macro

Modern macro builds models bottom-up (**micro-foundations**).

A model is an **artificial economy**.

- Agents interact in markets.
- Aggregate outcomes result from individual decisions.

The primitives are the "physical" environment and agents' preferences.

Model Primitives

An economy is described by

- the list of **agents**,
- their **demographics**,
- their **preferences**,
- their **endowments**,
- the **technologies** they have access to
- the **markets** in which they can trade.

Important note: every model description should start with these elements.

- You are not allowed to analyze anything until you have described these model elements.

How agents behave

Individual behavior is the result of an **optimization problem**.

- e.g., maximize utility subject to budget constraints

Agents have **rational expectations**.

- They understand how the economy works.
- Their expectations are the best possible forecasts.

Digression

Are people really this rational?

Digression

What is economics?

Competitive Equilibrium

Once we put all the pieces together and let agents interact in markets, we get a Competitive Equilibrium.

A key skill we will learn:

How to translate the description of an economy into a set of equations that characterize the **competitive equilibrium**.

Definition

A competitive equilibrium is an **allocation** (a list of quantities) and a **price system** (a list of prices) such that
- the quantities **solve all agents' problems**, given the prices;
- all **markets clear**.

How to Set Up a Competitive Equilibrium

Steps:

1. Describe the economy
2. Solve each agent's problem
3. State the market clearing conditions
4. Define an equilibrium

All of this is really mechanical.

The hard part is to say something about what the equilibrium looks like.

(Ask your computer.)

Step 1: Describe the Economy

1. List the agents (households, firms).
2. For each agent define:
   - **Demographics**: e.g., population grows at rate n.
   - **Preferences**: e.g., households maximize utility $u(c)$.
   - **Endowments**: e.g., each household has one unit of time each period.
   - **Technologies**: e.g., output is produced using $f(k)$.
3. Define the **markets** in which agents interact.
   - E.g., households work for firms; households purchase goods from firms.

Step 2: Solve Each Agent's Problem

Write down the maximization problem each agent solves.

Derive a set of equations that determine the agent's choice variables.

- E.g.: A consumption function, saving function.
- We call these **policy functions** or **decision rules**.

Example

A household chooses c and s to maximize utility, subject to a budget constraint.
Policy rules: $c = f(y, p)$ and $s = g(y, p)$

Step 3: Market Clearing

For each market, calculate supply and demand by each agent.

- Aggregate supply $= \sum$ individual supplies.
- Aggregate demand $= \sum$ individual demands.

Market clearing is simply:

- Aggregate supply $=$ aggregate demand.

Tip

The market clearing condition for apples contains only quantities of apples.

- If there are prices or bananas, it's wrong.

Step 4: Define the Equilibrium

From steps 2-3:

Collect all endogenous objects

- e.g., consumption, output, wage rate, ...

Collect all equations

- first order conditions or policy functions
- market clearing conditions

You should have N equations that could (in principle) be solved for N endogenous objects

- prices
- quantities (the allocation)

What do we gain from this approach?

Consistency:

- Aggregate relationships by construction satisfy individual constraints.
- Example: the aggregate consumption function cannot violate any person's budget constraint.

Transparency:

- The assumptions about the fundamentals are clearly stated.

What do we gain from this approach?

Non-arbitrary behavior:

- In old macro, results depend on the assumed behavior.
- In modern macro, behavior is derived.

Expectations:

- Expectations are endogenous.
- They are automatically consistent with the way the economy behaves.

What do we gain from this approach?

Welfare:

- It is possible to figure out how a policy change affects the welfare (utility) of each agent.

Testing:

- Models can be tested against micro data.

Micro and macro become the same thing.

Static example

Static Example

- We study a very simple one period economy.
- There are many identical households.
- They receive **endowments** which they eat in each period.
- Nothing interesting happens in this economy - it merely illustrates the method.

Step 1: Describe the Economy

Demographics:

- There are N identical households.
- They live for one period.
- For now, there are no other agents (firms, government, ...).

Preferences:

- Households value consumption of two goods according to a utility function $u(c_1, c_2)$

Step 1: Describe the Economy

Endowments:

- Each agent receives endowments of the two goods (e_1, e_2).

Technology:

- There is no production. Endowments cannot be stored.
- Resource constraint: $Ne_1 = Nc_1$ and $Ne_2 = Nc_2$.

Tip

A technology is always described by a **resource constraint** that equates how much stuff is made with how much stuff is used. Resource constraints usually become market clearing conditions in equilibrium.

Step 1: Describe the Economy

Markets:

- There are competitive markets for the two goods
- The prices of the two goods are p_1 and p_2.

What are prices denoted in?

Step 2: Solve each Agent's Problem

There is only one agent: the household.

Households maximize $u(c_1, c_2)$ subject to a budget constraint.

State variables the household takes as given:

- market prices for the two goods, p_1 and p_2.
- endowments e_1 and e_2.

The **choice variables** are c_1 and c_2.

- We can normalize the price of one good to one (numeraire): $p_1 = 1$.
- Call the relative price $p = p_2/p_1$.

Household problem

Budget constraint: Value of endowments = value of consumption.

The household solves the **problem**:

$$
\begin{aligned}
& \max u(c_1, c_2) \\
s.t.\ c_1 + p\ c_2 &= e_1 + p\ e_2
\end{aligned}
$$

Solving the household problem

- A solution to the household problem is a pair (c_1, c_2).
- To find the optimal choices set up a **Lagrangean**:

$$\Gamma = u(c_1, c_2) + \lambda \ [e_1 + p\ e_2 - c_1 - p\ c_2]$$

- It would actually be easier to substitute the constraint into the objective function and solve the unconstrained problem

$$\max\ u(e_1 + p\ e_2 - p\ c_2, c_2)$$

but the Lagrangean is instructive.

Household first-order conditions

- The **first order conditions** are

$$\partial\Gamma/\partial c_i = u_i(c_1, c_2) - \lambda p_i = 0 \tag{1}$$

- The multiplier λ has a useful interpretation: It is the marginal utility of relaxing the constraint a bit, i.e. the marginal utility of wealth.
- The solution to the household problem is then a vector (c_1, c_2, λ) that solves
  - 2 FOCs
  - the budget constraint.

Some tips

- Always explicitly state what variables constitute a solution and which equations do they have to satisfy.
  - This makes it easy to keep track of the pieces that go into the competitive equilibrium.
- You should have a FOC for each choice variable and all the constraints.
- Make sure you have the same number of variables and equations.
- When you write down an equation, pause and **think**.
  - Make sure you understand what the equation says in words.
  - If you cannot make sense of it, it's probably wrong!

Simplify the optimality conditions

- It is useful to substitute out the Lagrange multiplier λ.
- The ratio of the FOCs implies

$$u_2/u_1 = p \tag{2}$$

- This is the familiar tangency condition: marginal rate of substitution equals relative price. [Graph]
- Now the solution is a pair (c_1, c_2) that satisfies (2) and the budget constraint.
- Note: I can keep the Lagrange multiplier or drop it. If I keep it, I also need to keep another equation (e.g., the FOC for c_1).

Log utility example

- Assume log utility:

$$u(c_1, c_2) = \ln(c_1) + \beta \ln(c_2)$$

- Then the problem can be solved in closed form:

$$\frac{u_2}{u_1} = \beta \frac{c_1}{c_2} = p$$

- Substitute this back into the budget constraint:

$$\begin{aligned} c_1 + \beta\ c_1 &= W = e_1 + p\ e_2 \\ c_1 &= \frac{W}{1+\beta} \\ c_2 &= \frac{\beta W}{1+\beta} \end{aligned}$$

Log utility example

- Tip: This is a peculiar (and often very useful) feature of log utility: the expenditure shares are independent of p. The reason is exactly the same as that of constant expenditure shares resulting from a Cobb-Douglas production function: unit elasticity of substitution.
- Tip: Recall that taking a monotone transformation of u doesn't change the optimal policy functions. In particular, we can replace u by

  $$u(c_1, c_2) = c_1 \ c_2^{\beta}$$

  Convince yourself that this yields exactly the same consumption functions.

Step 3: Market Clearing

There are two markets (for goods 1 and 2).

- Why isn't there just 1 market where good 1 is traded for good 2?

Each agent

- supplies the endowments e_i and
- demands consumption c_i in those markets.

Goods are traded for **units of account**.

I don't use the word **money** because there is no such thing in this economy.

Market Clearing

The market clearing condition is

"aggregate supply = aggregate demand."

Aggregate supply is simply the sum of individual supplies:

$$S_i = \sum_{h=1}^{N} e_i = N\ e_i \tag{3}$$

Aggregate demand:

$$D_i(p, e_1, e_2) = \sum_{h=1}^{N} c_i = N\ c_i(p, e_1, e_2) \tag{4}$$

Market clearing:

$$c_i = e_i \tag{5}$$

Everybody eats their own endowments.

Definition of Equilibrium

A **competitive equilibrium** is an allocation (c_1, c_2) and a price p that satisfy:

- 2 household optimality conditions (FOC and budget constraint).
- 2 goods markets clearing conditions.

Now we count equations and variables.

- We have $2N+1$ objects: $2N$ consumption levels and one price.
- We have $2N$ household optimality conditions and 2 market clearing conditions.

Why do we have one equation too many?

Recap of key points

1. A macro model consists of exactly these parts:
   1.1 Demographics
   1.2 Preferences
   1.3 Endowments
   1.4 Technologies
   1.5 Markets
2. A competitive equilibrium is an allocation (think quantities) and a price system such that
   2.1 all agents solve their optimization problems, given prices;
   2.2 markets clear.
3. Market clearing conditions only contain quantities of one good (no prices!).
4. Prices are in units of account that can be chosen arbitrarily at each trading date.
5. Walras' law allows you to drop one market clearing condition **or** one budget constraint.

Where Is the Money?

We just wrote down a model without money.

The vast majority of macro models have no money.

But money is important ... are macroeconomists crazy?[1]

[1] They may well be, but not because they write down models without money.

Reading

There is a remarkable shortage of discussions on how to properly set up a model in textbooks. But see

- Krusell (2014), ch. 2 describes the ingredients of modern macro models.
- Ch. 5 talks about Arrow-Debreu versus sequential trading.

References

Krusell, P. (2014): "Real Macroeconomic Theory," Unpublished.