

# What Econ720 is About

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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 Your Undergraduate Macro Courses Were Not That Useful

Or:

Macro is Micro

# Macro Before Lucas

A macro model before Lucas

- ▶ developed “top down”

Goods market primitives:

- ▶ Aggregate demand identity:  $Y = C + I + G$ .
- ▶ Consumption function:  $C = C_0 + cY$ .
- ▶ Investment function:  $I = I_0 - bi$ .

IS curve:

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

# Macro Before Lucas

Money market primitives:

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

LM curve:

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

This looks very different from a micro model.

# Key Features

**Aggregate relationships** are taken as primitives

- ▶ such as the demand for goods or money
- ▶ their functional forms are based on **introspection**

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.

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?

Related: 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

(Then what is the difference between macro and micro?)

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  $p_2$ .

## Econ101 question

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**:

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

## 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 **Lagrangian**:

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

- ▶ 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

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

- ▶ The multiplier  $\lambda$  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  $(c_1, c_2, \lambda)$  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  $\lambda$ .
- ▶ The ratio of the FOCs implies

$$u_2/u_1 = p \quad (2)$$

- ▶ 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:

$$S_i = \sum_{h=1}^N e_i = N e_i \quad (3)$$

Aggregate demand:

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

Market clearing:

$$c_i = e_i \quad (5)$$

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.

## Econ201 question

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?<sup>1</sup>

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<sup>1</sup>They may well be, but not because they write down models without money.

# What is a good model?

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# 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.

Hopefully up to date links to unpublished texts are in the syllabus. Let me know if you can't find something.

## References

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