EE320 Ch.1 Introduction

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Outline

Economics need Mathematics - Espinosa, Rondon, and Romero (2012) found that

"... we provide concrete measures of mathematization in Economics. Furthermore, we found that the use and training in mathematics has a positive correlation with the probability of winning a Nobel Prize in certain cases. It also appears that being an empirical researcher as measured by the average number of econometrics outputs has a negative correlation with someone's academic career success ..."

Economics need Mathematics - Admission to Top Universities

PhD Economics at MIT:

"... Successful candidates whose prior background is primarily in economics have typically excelled in advanced undergraduate or graduate courses and taken math at least through **linear algebra**. Many have taken **real analysis** or some other **advanced proof-oriented course**, though this is not necessary. For candidates who were not economics concentrators we look for evidence of exceptional performance in their prior field of study, **strong technical skills**, and some economics background. It would be unusual for us to accept a student who had not taken intermediate microeconomics.

Economics need Mathematics - Admission to Top Universities

PhD Economics at UC Berkeley:

"... Applicants must have knowledge of **multivariate calculus**, **basic matrix algebra**, and **differential equations**; completion of a two-year math sequence, which emphasizes **proofs and derivations**. Some knowledge of statistics and elementary probability is highly desirable, as is additional coursework in **algebra and real anaysis** ..."

Economics need Mathematics - Admission to Top Universities

PhD Economics at Cornell University:

"...The student must have a minimum of four semesters of **calculus and linear algebra** and at least two semesters of advanced mathematics including a course in **analysis**. This is an absolute minimum and is rarely seen as competitive for a financial aid offer. There is a strong admissions and financial aid bias towards students with more mathematics: **differential equations, real or complex analysis, mathematical probability and statistics, optimization, topology, and stochastic differential equations**, among many others. Many successful applicants are double majors in economics and mathematics ..."

Why do economists need mathematics?

- Economists are fastinated in the Economy
- They try to explain the economic phenomena, but it is too complex.
- Therefore, economists simplify the economy:
  - Create Economic Model
  - State Assumptions
  - Generate Conclusion
  - Test it with real data
  - Make a Prediction

Example: Money Multiplier

Setting: How much money does banking system create?
Minimum Legal Reserve Requirement = 10%
Banks can lend = 90 %
Assume that

1. Banks lend all excess cash
2. One must deposit all of his or her money

Bank	Deposit	Legal Reserve	Excess Cash Reserve/Loan
1	1,000	100	900
2	900	90	810
3	810	81	729
⋮	⋮	⋮	⋮
Total	?	?	?

$$\begin{aligned} P &= \text{initial cash deposit} \\ rr &= \text{minimum legal reserve requirement} \\ A &= \text{excess cash reserve} = P(1-rr) \\ D &= \text{demand deposit created by banking system} \end{aligned}$$

$$\begin{aligned} D &= P(1-rr) + P(1-rr)^2 + P(1-rr)^3 + \dots \\ D &= P(1-rr)\Big(1 + (1-rr) + (1-rr)^2 + (1-rr)^3 + \dots\Big) \\ D &= P(1-rr)\Big((1-rr)^0 + (1-rr)^1 + (1-rr)^2 + (1-rr)^3 + \dots\Big) \\ \therefore D &= \frac{P(1-rr)}{rr} = \frac{A}{rr} \end{aligned}$$

Note: Geometric Series $\sum_{n=0}^{\infty}(r^n) = \frac{1}{1-r}; |r| < 1$

Bank	Deposit	Legal Reserve	Excess Cash Reserve/Loan
1	P	rrP	$P(1-rr)$
2	$P(1-rr)$	$(rr)(1-rr)P$	$P(1-rr)^2$
3	$P(1-rr)^2$	$(rr)(1-rr)^2P$	$P(1-rr)^3$
$\vdots$	$\vdots$	$\vdots$	$\vdots$
Total	$\frac{P}{rr}$	P	$\frac{P(1-rr)}{rr} = \frac{A}{rr}$

Bank	Deposit	Legal Reserve	Excess Cash Reserve/Loan
1	1,000	100	900
2	900	90	810
3	810	81	729
⋮	⋮	⋮	⋮
Total	10,000	1,000	9,000

Economics-Major Students need Maths

Explanation of Math Requirement at Columbia University:
"... Economics problems often involve functions of several variables. For example, living in New York City, I can choose from a wide variety of entertainments, such as movies, concerts, plays, etc., but I don't have an infinite amount of money to spend on my entertainment (nor an infinite amount of time to enjoy all of these activities). Indeed, I must decide how to allocate my budget among these many variable choices where I must think about giving up one good (e.g., a concert) in order to get more of another (e.g., a play). In order to choose the best allocation of my budget for me, I must solve a problem of several, variables. Fortunately, we can extend the results from the calculus of one variable to that of several variables to solve these more complicated economics problems. Calculus III will teach you how to solve these types of problems ..."

Dani Rodrik wrote in his blog

"... if you are smart enough to be a Nobel-prize winning economist maybe you can do without the math, but the rest of us mere mortals cannot. We need the math to make sure that we think straight–to ensure that our conclusions follow from our premises and that we haven't left loose ends hanging in our argument. In other words, we use math not because we are smart, but because we are not smart enough."

Noah Smith also said

"... So why should we use math in economics? Well, I can think of a number of reasons:

- 1. We may want to make precise predictions about what will happen in a market.
- 2. We may want to make precise predictions about the conditions under which things will happen in a market.
- 3. Precise statements often help resolve debates, avoiding the phenomenon of "talking past each other".
- 4. Precise statements often lead to unintuitive but logically inescapable results.
- 5. It is usually easier to check sets of precise statements for logical inconsistencies ..."

To conclude, Mathematical Economics is then ...

- an approach (or tool) for economic analysis
- as a language to state problems and to derive a set of conclusions or theorems from a given set of assumptions.

Economic Theory

Keynes postulated that

"The fundamental psychological law ... is that men [women] are disposed, as a rule and on average, to increase their consumption as their income increases, but not as much as the increase in their income."

In short, he stated about **Marginal Propensity to Consume**

Mathematical Economics

From that economic theory stating the relationship between consumption and income, we have:

$$C = f(Y) = a + bY; b \in (0, 1)$$

Marginal Propensity to Consume = b

Econometrics

Collect real data and **Test** the relationship between consumption and income, whether it holds true in reality.

Mathematical Economics Vs Econometrics

Mathematical Economics:

- applies mathematics to the purely theoretical aspects of economic analysis
- uses deductive reasoning

Econometrics:

- deals with the study of empirical observations resorting to statistical methods of estimation and hypothesis
- uses inductive reasoning

Economic Model

What is an economic model?

- an economic model is a deliberately simplified analytical framework, used as a rough presentation of the actual economy
- economic models are usually written as mathematical models, involving a set of equations and a number of variables

Variables, Constants and Parameters

Variable is something that can take on different values and must be represented by a symbol.

- Endogenous (dependent) variables are solution values of a certain set of variable that can be solved from an economic model.
- Exogeneous (independent) variables are variables which are assumed to be determined by external forces of the model and whose magnitudes are accepted as given.

Constant is a magnitude that does not change and is the opposite of the variable

Parameter is a constant in an equation that varies in other equations of the same general form.

Example:

1. $y = \ln(3x^3)$
2. $Q^d = a - bP$
3. $Q_1^d = 2 - 7P_1 + 4P_2 - 4P_3$
4. $DAE = C + I + G + X - M$
5. $C = C_0 + cY$
6. $Q = f(K, L)$
7. $TC_1 = \alpha_0 + \alpha_1 Q_1 + \alpha_2 Q_1^2$
8. $M^d = f(M_t^d, M_p^d, M_s^d)$
9. $M_s^d = \beta_0 - \beta_1 r$
10. $I = I_0 - \gamma_1 r$
11. $B = p_1 x_1 + p_2 x_2$
12. $Q = A_0 K^\beta L^\alpha$

Equations and Identities

Definitional Equation sets up an identity between two alternative expressions that have exactly the same meaning. The symbol $\equiv$ (identical-equality sign) is used between the two expression.
Ex. $\pi \equiv Revenue - Cost$

Behavioral Equation specifies the manner in which a variable behaves in response to changes in other variables.
Ex. $TC = 80 + 20Q$
Ex. $C = a + bY$

Conditional Equation states a requirement to be satisfied. Ex. Equilibrium Condition $Q^d = Q^s$
Ex. Break-even Condition $\pi = TR - TC = 0$

Read CW Chapter 1