

# Contents: *Economics with Calculus*

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## Chapter 1: Introduction

The introductory chapter provides a crisp explanation of the scope of economics and the topics to be covered in this text. The table listing one week's research output by National Bureau of Economic Research Associates reveals the range of topics studied by academic economists. Charts and tables show how the phenomenal growth of the US economy has been interrupted by bouts of inflation and unemployment. A chart contrasts the behavior of fixed versus flexible exchange rates.

- 1.1 Economics defined
- 1.2 The scope of economics
- 1.3 Allocating resources
- 1.4 Adam Smith and the invisible hand of free enterprise
- 1.5 Economic performance: an overview
  - 1.5.1 Economic growth
  - 1.5.2 The Transformation of Agriculture
  - 1.5.3 Unemployment
  - 1.5.4 Inflation
  - 1.5.5 Foreign Exchange Rates
  - 1.5.6 Inequality
- 1.6 Prospectus

## Chapter 2: Production Possibilities

The second chapter introduces the production transformation curve and puts it to work by using the model to explain opportunity cost, the gains from trade, efficient resource allocation and the principle of comparative advantage. As the first application of maximization behavior, I show how relative prices determine the output choice for a revenue-maximizing producer.

Because I think it is essential to give concrete applications of theoretical constructs, I use GDP data in developing a rough estimate of the production transformation curve revealing the remarkable mobilization of the US economy for World War II. As a second application, I present Alan Manne's linear programming analysis of the allocation of petroleum resources in the Korean War.

I postpone the traditional introductory chapter discussion of economic methodology until the end of this chapter in order that I can clarify basic concepts by referring to the production transformation curve model and the analysis of maximizing behavior.

- 2.1 Overview
- 2.2 The Production Transformation Curve
  - 2.2.1 Hypothetical Numerical Example
  - 2.2.2 Production Transformation - Mobilizing for World War II
- 2.3 Opportunity Cost and the MRT
  - 2.3.1 Marginal Rate of Transformation (MRT)
  - 2.3.2 A Simple Supply Function
- 2.4 Linear Programming
  - 2.4.1 Introduction
  - 2.4.2 Simplified Example
  - 2.4.3 Linear Programming - Korean War
- 2.5 The Gains from Trade
  - 2.5.1 Introduction
  - 2.5.2 Numerical Example:
  - 2.5.3 Market Forces Achieve Efficiency

- 2.6 Conclusions
- 2.7 Methodological Note
- Appendix 2.1: Alternative proof of a fundamental proposition

## Chapter 3: Supply and Demand: Where do Prices Come From?

Chapter 3 explains how prices are determined in a competitive marketplace. There are numerous applications. The extended discussion of tax incidence reveals the power of the analytical techniques developed in this chapter. In the concluding section I contrast market allocation with democratic decision-making and introduce Hotelling's median voter model.

This chapter introduces the essential concept of partial derivative, which is *not* covered in the standard Calculus Advanced Placement Course.

- 3.1 Overview
- 3.2 The Middletown housing market, a parable
- 3.3 The Econoland corn market
  - 3.3.1 Crop failure
  - 3.3.2 Consumer surplus
- 3.4 Demand and supply curve shifters
  - 3.4.1 Some demand curve shifters
  - 3.4.2 Some supply curve shifters
  - 3.4.3 Recapitulation
  - 3.4.4 Functions of several variables and partial derivatives
- 3.5 Taxes and subsidies
  - 3.5.1 Tax incidence
  - 3.5.2 Maximizing tax revenue - the Laffer curve
  - 3.5.3 Consumer surplus, producer surplus, and the excess burden
- 3.6 Elasticity
  - 3.6.1 Arc-elasticity
  - 3.6.2 Point elasticity
  - 3.6.3 Price versus income elasticity
  - 3.6.4 Some elasticity estimates
- 3.7 Applications
  - 3.7.1 Paradoxes Resolved
  - 3.7.2 The Minimum Wage
  - 3.7.3 Farm price supports
  - 3.7.4 Tariffs, quotas and the gains from trade
  - 3.7.5 Foreign exchange rates
- 3.8 Markets versus the ballot box

## Chapter 4: Maximizing Satisfaction

The economic analysis of consumer behavior disappoints the student preparing for a career in marketing while raising intriguing issues for the more philosophically inclined. I gradually strengthen the student's skill at solving constrained maximization problems. I start the analysis of consumer maximization with the simplest case of two consumers and one good, contrasting Bentham's greatest happiness principle with Rawls argument for maximizing the position of the least advantaged. I discuss Sen's objection to Utilitarianism. Then I explain consumer maximization and find the demand curve generated with a Cobb-Douglas utility function. I also develop indifference curves and generate the box diagram.

I use the method of substitution rather than Lagrangian multipliers when solving constrained maximization problems in the text because most students whose background in the calculus is limited to an AP course or the equivalent find learning Lagrangian multipliers a time consuming struggle. The appendix explains Lagrangians for the interested reader.

- 4.1 Introduction
  - 4.2 One good and two consumers
    - 4.2.1 Utilitarianism
    - 4.2.2 Marginal utility
    - 4.2.3 Maximizing total satisfaction
    - 4.2.4 Amartya Sen's complaint
    - 4.2.5 John Rawls - the position of the least advantaged
  - 4.3 Two goods and one consumer
    - 4.3.1 Consumer graphics - indifference curves
    - 4.3.2 Analytical solution
    - 4.3.3 Application - compensating for inflation
    - 4.3.4 General statement of the two commodity problem
    - 4.3.5 Diminishing marginal utility and the law of demand
    - 4.3.6 Inflation, consumption, and homogeneity
  - 4.4 Indifference curve applications
    - 4.4.1 Income effect versus the substitution effect
    - 4.4.2 Inferior goods
    - 4.4.3 Giffen goods
    - 4.4.4 Work-leisure tradeoff
    - 4.4.5 Saving and the rate of interest
  - 4.5 The box diagram - two goods and two consumers
    - 4.5.1 Equity versus efficiency
    - 4.5.2 The gain from trade
    - 4.5.3 The contract curve
    - 4.5.4 Competitive equilibrium
- Appendix 4.1: Lagrangian multipliers

## Chapter 5: The Business Enterprise: Theory of the Firm

This chapter starts with an institutional discussion of different forms of business organization. The extended discussion of accounting (the language of business) is more relevant than ever, thanks to the Enron and Arthur Andersen scandals.

I use the Cobb-Douglas production function extensively in this and subsequent chapters, rather than getting involved with more complicated functional forms. I derive the short and long run cost functions from the production function and show that a profit maximizing monopolist will set output where marginal cost equals marginal revenue.

The discussion of optimal lot size and just in time shows how the theory of the firm can be applied to solve practical business problems.

- 5.1 Introduction
- 5.2 Organization of the firm
  - 5.2.1 Types of organizations
  - 5.2.2 How the modern corporation works
- 5.3 Profits and accounting
  - 5.3.1 The balance sheet
  - 5.3.2 The income statement
  - 5.3.3 Taxing complications
  - 5.3.4 Creative accounting
  - 5.3.5 Accounting versus economic profit
- 5.4 The technological constraint
  - 5.4.1 Total product curve: one variable input
  - 5.4.2 The law of diminishing returns
  - 5.4.3 Multiple inputs and the production function

- 5.5 Maximizing profit
  - 5.5.1 The cost function
  - 5.5.2 Short-run profit maximization
  - 5.5.3 Least-cost input mix - costs in the long run
  - 5.5.4 Constant returns to scale (homogeneity of degree 1)
  - 5.5.5 Pricing to maximize profit
- 5.6 Management Science illustrated: OLS & JIT
  - 5.6.1 Optimal lot size formula (OLS)
  - 5.6.2 Just in time

## Chapter 6: Market Structure

I start with an explanation of how competitive markets work, going behind the supply curve of Chapter 3. Then I investigate the efficiency of competition and the deadweight loss of monopoly and move on to discuss the theory of monopolistic competition and oligopoly. The chapter concludes with a terse discussion of antitrust policy.

- 6.1 Overview
- 6.2 Competitive markets
  - 6.2.1 Key features of competitive markets
  - 6.2.2 The behavior of the competitive firm, given price
  - 6.2.3 Industry supply
- 6.3 Monopoly versus competition: efficiency issues
  - 6.3.1 Inefficient monopoly versus marginal cost pricing
  - 6.3.2 Pollution and other externalities
  - 6.3.3 Innovation, patents and dynamic efficiency
  - 6.3.4 Product differentiation and price discrimination.
- 6.4 Monopolistic competition
  - 6.4.1 Demand in a monopolistic competitive industry
  - 6.4.2 Equilibrium under monopolistic competition
  - 6.4.3 Is monopolistic competition efficient?
- 6.5 Oligopoly
  - 6.5.1 Case 1: Duopoly with identical products
  - 6.5.2 Case 2: Duopoly with product differentiation
  - 6.5.3 Game theory
- 6.6 Antitrust action

## Chapter 7: Distribution: Who Gets What?

This chapter examines a host of distributional issues. I start with a review of evidence on income inequality, explaining the construction of Lorenz curves and the calculation of the Gini coefficient. Then I move on to the marginal productivity theory of wages. I show how labor's share is determined if the aggregate production function is Cobb-Douglas. Then I discuss how government transfer programs and tax policy affect the distribution of income.

- 7.1 Overview:
- 7.2 Measuring inequality
  - 7.2.1 Measuring Inequality
  - 7.2.2 Lorenz Curves
  - 7.2.3 International comparisons
  - 7.2.4 Gini coefficients
- 7.3 Rewards: wages, productivity, exploitation and monopsony
  - 7.3.1 Wage Determination
  - 7.3.2 Monopoly, monopsony and exploitation
  - 7.3.3 Labor's share and the Cobb-Douglas production function
  - 7.3.4 The minimum wage and union bargaining

- 7.4 Government and the distribution of income
  - 7.4.1 Transfer programs
  - 7.4.2 Measuring poverty
  - 7.4.3 Tax Policy
- 7.5 Public Goods

## Chapter 8: Monitoring Economic Performance

I postpone until this chapter the explanation of the distinction between micro and macroeconomics because it is much easier for students to understand once they have been exposed to microeconomics.

I discuss at length how unemployment and inflation are measured because I find that students with quantitative interests often find the details intriguing. I motivate the discussion by presenting considerable historical data.

The appendix reviews compound interest and discusses the pricing of bonds.

- 8.1 Overview
- 8.2 An economic report card
- 8.3 Unemployment
  - 8.3.1 Estimating unemployment
  - 8.3.2 Fuzz on the data:
  - 8.3.3 Okun's law, the GDP gap and the costs of unemployment
- 8.4 Inflation arithmetic
  - 8.4.1 Inflation compounds like money in the bank
  - 8.4.2 Plotting inflation:
  - 8.4.3 Manipulating price indices:
  - 8.4.4 Measuring price movements
  - 8.4.5 The index number problem:
- 8.5 How to live with inflation
  - 8.5.1 The real wage
  - 8.5.2 The real rate of interest
  - 8.5.3 The mortgage twist
- 8.6 Business cycles
  - 8.6.1 Identifying business cycle peaks and troughs
  - 8.6.2 Forecasting with Leading economic indicators
  - 8.6.3 Forecasting business cycles ~ econometric models
  - 8.6.4 Consumer Sentiment

### Appendix 8.1: Compound interest

## Chapter 9: GNP Accounting and the Multiplier

This chapter could be subtitled "Depression Economics." After discussing basic national accounting concepts we consider the government spending multiplier. Using an admittedly simplified model we find that the magnitude of the multiplier depends on both the marginal propensity to consume out of disposable income and on leakages between GDP and disposable income – taxes, corporate retained earnings, depreciation, etc. Scatter-plot parameter estimates for the United States suggest that the multiplier is about 3.45. We then find that this preliminary (strawman?) estimate is much too large because the oversimplified multiplier model neglects such complications as the life-cycle/permanent income hypothesis. I point out that the analysis also neglects capacity constraints and the influence of monetary policy and other complications that will be analyzed in subsequent chapters. I explain that a much smaller estimate of the multiplier is generated with a Federal Reserve Board econometric model.

- 9.1 Overview
- 9.2 GDP, disposable income and consumption spending
  - 9.2.1 Defining GDP

- 9.2.2 What's not in GDP
- 9.2.3 Real GDP and the implicit price deflator:
- 9.2.4 The composition of GDP:
- 9.2.5 Measuring welfare
- 9.2.6 From GDP to disposable income, consumption and saving
- 9.2.7 Two empirical relationships
- 9.3 The simple multiplier: depression economics
  - 9.3.1 Rounds of induced expenditure - the Kahn multiplier
  - 9.3.2 A family of multipliers
  - 9.3.3 The multiplier, a graphical approach
  - 9.3.4 Saving and the paradox of thrift
- 9.4 A Simple model of the business cycle
- 9.5 Critique and qualifications - shrinking multipliers
  - 9.5.1 Modifications of the Consumption Function
  - 9.5.2 Capacity constraints and the inflationary gap:

## Chapter 10: Money, Prices and Output

This chapter presents a sequence of macro-models. Starting with the multiplier, we move on to the IS curve and then to the IS-LM model. Next we derive the short-run aggregate demand curve from IS-LM, given the nominal money supply. Finally, we explain that if wages and prices are flexible in the long run then the aggregate supply curve is vertical and money is a veil. Table 1 summarizes the sequence of models and tallies the endogenous and exogenous variables.

- 10.1 Overview
- 10.2 Investment and the IS curve
  - 10.2.1 Review of the multiplier (Model A)
  - 10.2.2 The IS relationship (Model B)
  - 10.2.3 Plotting the IS curve
  - 10.2.4 Government spending shifts the IS relationship
  - 10.2.5 IS: saving = investment and goods market equilibrium
- 10.3 The Money Supply
  - 10.3.1 Measuring the money supply
  - 10.3.2 How central banks control the supply of money and credit
- 10.4 Money and interest rates
  - 10.4.1 Quantity theory of money
  - 10.4.2 IS-LM curve interaction (Model C)
  - 10.4.3 International complications
  - 10.4.4 IS-LM analysis of demand pull inflation
- 10.5 Aggregate demand - aggregate supply analysis
  - 10.5.1 Derivation of the aggregate demand curve (Model D)
  - 10.5.2 Aggregate demand and supply interaction (Model E)
  - 10.5.3 Long run aggregate supply and demand interaction (Model F)
  - 10.5.4 The classical dichotomy and the neutrality of money
- 10.6 Monetarists versus Keynesians

## Chapter 11: Dynamics, Expectations and Inflation

How markets adjust to equilibrium is the central theme unifying this chapter's discussion of micro and macro issues. After a brief look at the cobweb model and a discussion of options, speculation and hedging, we examine the stock market. Then we take a detailed empirical look at the Phillips curve explanation of the rate of inflation. We show how changes in the rate of productivity growth shift the Phillips curve and explain that the simplest version of the relationship failed because it neglected the role of expectations. We show that under rational expectations the Phillips curve is vertical and explain the Lucas supply function. Finally, we examine the Taylor

Rule and look at fiscal and monetary policy simulations generated by a Federal Reserve Board econometric model.

- 11.1 Introduction
  - 11.2 Market dynamics
    - 11.2.1 The cobweb model
    - 11.2.2 The corn story: government stabilization versus speculation
    - 11.2.3 Options, forward markets and hedging
    - 11.2.4 The stock market
  - 11.3 Inflation, unemployment and the Phillips curve
    - 11.3.1 The promised tradeoff
    - 11.3.2 The Phillips curve in practice
    - 11.3.3 The Phillips curve boomerang
    - 11.3.4 Productivity, labors share, and the Phillips curve
    - 11.3.5 Anticipated Inflation Shifts the Phillips curve
    - 11.3.6 A vertical long run Phillips curve:
  - 11.4 Rational expectations:
    - 11.4.1 Rational expectations and the Phillips curve
    - 11.4.2 The Lucas aggregate supply function
    - 11.4.3 Policy Ineffectiveness
    - 11.4.4 The Lucas aggregate supply function
  - 11.5 Labor market dynamics
  - 11.6 What should central bankers do?
    - 11.6.1 Rules versus discretion
    - 11.6.2 Leaning against the wind ~ Taylor rules
    - 11.6.3 Simulating policy with econometric models
- Appendix 11.1 Solving first order linear difference equations

## Chapter 12: Growth and Development

After a brief discussion of Malthus, we consider a classical growth model in which the law of diminishing returns coupled with the subsistence theory of wages generates an unhappy stationary state. The rest of the chapter addresses various shortcomings of the classical model. I analyze a neoclassical growth model in the spirit of Solow but complicated by diminishing returns; we determine the conditions under which long run decay rather than growing living standards will prevail. I look more deeply at the way in which the rate of population growth responds to rapidly rising living standards and use a simplistic overlapping generation model to explore how declining population growth affects the demand for teachers, the dependency ratio, and the savings rate. Then I turn to Hotelling's analysis of the way in which the market allocates exhaustible resources over time. Finally, a model of renewable resources shows how the absence of appropriately assigned property rights can lead to over-fishing and the collapse of the fish population.

- 12.1 Introduction
- 12.2 Malthusian population dynamics
- 12.3 A classical growth model, simplified
- 12.4 Growth accounting - The sources of economic growth
- 12.5 A neo-classical model of the growth process
  - 12.5.1 Assumptions
  - 12.5.2 Analysis
  - 12.5.3 Growth or stagnation?
  - 12.5.4 Convergence?
  - 12.5.5 Real business cycles
- 12.6 Population trends
  - 12.6.1 The demographic transition
  - 12.6.2 A simple overlapping generation model

- 12.7 Exhaustible resources
  - 12.7.1 Two numerical examples
  - 12.7.2 Analysis
  - 12.7.3 Moral
- 12.8 Renewable resources - over-fishing
  - 12.8.1 Balance of nature
  - 12.8.2 Fishing
  - 12.8.3 Market equilibrium

Appendix: Further Reading

Appendix: Web Sites