EC 224: Intermediate Microeconomics

Practice Problems and Handouts

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Bentley University

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Textbook: Nicholson & Snyder, *Microeconomic Theory: Basic Principles and Extensions*

Contents:

- Consumer Theory (Chapters 2–3)
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Contents

1 Utility and Consumer Choice I

Chapter 2: Utility and Choice — Key Concepts

Topics covered: Utility functions, budget constraints, utility maximization, indifference curves, marginal rate of substitution (MRS), Cobb-Douglas preferences, perfect substitutes, perfect complements.

Key equations:

- Budget constraint: $P_X \cdot X + P_Y \cdot Y = I$
- MRS: $MRS = \frac{MU_X}{MU_Y} = \frac{P_X}{P_Y}$ at optimum
- Cobb-Douglas utility: $U(X, Y) = X^a Y^b$

Problem 1: Cobb-Douglas Utility Maximization

Suppose a consumer has $8.00 to spend on only apples and bananas. Apples cost $0.40 each and bananas cost $0.10 each. The consumer's preferences for apples (A) and bananas (B) are given by:

$$U(A, B) = \sqrt{A \times B}$$

(a) Write down the algebraic equation for this person's budget constraint and graph it.

(b) Calculate the utility for $A = 5$ and $B = 80$.

(c) If $A = 10$, what would be the amount of B to provide the same level of utility?

(d) Find the utility maximizing pair of apples and bananas under the budget constraint.

Problem 2: Perfect Substitutes

A consumer enjoys coffee (C) and tea (T) according to the following utility function:

$$U(C, T) = 3C + 4T$$

(a) Draw the indifference curves for $U = 12$ and $U = 16$. What does the indifference curve imply for the relationship between tea and coffee consumption?

(b) If coffee and tea both cost \$3 each and the consumer has \$12 to spend on these products, how much coffee and tea should he buy to maximize his utility?

(c) Draw the graph of his indifference curve, the budget constraint, and the optimal consumption point.

(d) Would the consumer buy more coffee if he had more money to spend?

(e) How would the consumption change if the price of coffee fell to \$2?

Problem 3: Perfect Complements

Each time you go to a movie, you buy 2 bags of pop-corn. Your utility function can be expressed as $U(M, C) = \min(2M, C)$. The price of pop-corn is \$2.50 and the price of a movie ticket is \$10. You have \$30 to spend on these activities.

(a) Draw the utility functions for $U = 2$ and $U = 4$.

(b) Find the optimal consumption that yields the maximum utility.

2 Utility and Consumer Choice II

Chapter 2-3: Taxation and Demand — Key Concepts

Topics covered: Effects of taxation on consumer choice, income vs. substitution effects, price elasticity of demand, total revenue and elasticity relationship.

Key insights:

- An income tax that raises the same revenue as a specific tax leaves the consumer better off (no substitution effect distortion).
- Price elasticity: $\varepsilon = \frac{\%\Delta Q}{\%\Delta P} = \frac{dQ}{dP} \cdot \frac{P}{Q}$
- When $|\varepsilon| > 1$: elastic demand; $|\varepsilon| < 1$: inelastic demand

Problem 1: Taxation and Consumer Welfare

Kate enjoys drinking coffee and soda. Both cost $1 each, and she allocates $150 to spend on these beverages alone each month. Her utility function is $U = \sqrt{C \times S}$ with $MRS = \frac{S}{C}$.

(i) Find the equilibrium demand for both goods and calculate her utility.

(ii) Suppose government imposed a $0.60/unit tax on soda. Find Kate's new optimum consumption under the new budget constraint. Calculate the government revenue.

(iii) Suppose an alternative policy of imposing a tax on income. How much should the tax be for the government to collect the same revenue? Find the new equilibrium for Kate.

Problem 2: Price Elasticity and Total Revenue

Suppose that the market demand curve for garbanzo beans is given by:

$$Q = 20 - P$$

(i) Calculate the demand for $P = 10$.

(ii) Calculate the price elasticity of demand for $P = 10$ and $P = 15$. Calculate the total revenue at both price levels and explain the relationship between elasticity and total revenue.

(iii) Calculate the price and quantity level for which total revenue is maximized.

(iv) Suppose that the demand for beans shifted to $Q = 40 - 2P$. Graph the new demand curve and calculate the price and quantity that would yield the highest expenditure level.

3 Demand Curves

Chapter 3: Individual and Market Demand — Key Concepts

Topics covered: Derivation of individual demand curves, income and substitution effects, market demand aggregation, consumer surplus.

Key relationships:

- Individual demand derived from utility maximization
- Market demand = horizontal sum of individual demands
- Consumer surplus = area below demand curve, above price

Problem 1: Deriving Demand from Utility

Suppose a person has $20 and likes both rap music (R) and country music (C) with a set of preferences so that $U = C^{1/2}R^{1/2}$. Suppose that the iTunes price of a rap music song is $P_R = 2$ and the price of a country music song is $P_C = 1$.

(a) What is the highest level of utility that is affordable?

4 Uncertainty and Risk

Chapter 4: Uncertainty — Key Concepts

Topics covered: Expected value, expected utility, risk aversion, certainty equivalent, risk premium, fair insurance, diversification.
Key equations:

- Expected value: $E[X] = \sum p_i \cdot x_i$
- Expected utility: $E[U] = \sum p_i \cdot U(x_i)$
- Risk premium = Expected income $-$ Certainty equivalent
- Fair insurance premium = probability of loss $\times$ amount of loss

Risk attitudes:

- Concave utility function $\Rightarrow$ Risk averse
- Linear utility function $\Rightarrow$ Risk neutral
- Convex utility function $\Rightarrow$ Risk loving

Problem 1: Risk Aversion and Gambling

Assume that you receive diminishing marginal utility from income, which can be described as:

$$U = \sqrt{\text{Income}}$$

(a) Show the relationship between Income and Utility.

(b) Calculate the utility from $35,000 certain income and show it on the graph.

(c) Calculate the expected income from having $35,000 of income and taking a fair gamble with a 50:50 chance of winning or losing $5,000.

(d) Calculate the expected utility from the uncertain income outcomes described in (c).

(e) Calculate the expected income from taking a fair gamble with a 50:50 chance of winning or losing $15,000.

(f) Calculate the expected utility from the uncertain income outcomes described in (e).

(g) Calculate how much you would be willing to pay to avoid the risk associated with gambling in (f).

Problem 2: Insurance

Using the utility function $U = \sqrt{\text{Income}}$ and an income of $35,000/year, suppose there is a 50% chance you will incur medical bills of $15,000.

(a) Calculate the fair insurance premium.

(b) Calculate the unfair (market) insurance premium.

Problem 3: Portfolio Diversification

Using $U = \sqrt{\text{Income}}$, calculate the expected income and expected utility of the following investment choices:

(i) Investing all your money in company A and company B.

(ii) Diversifying your portfolio.

5 Game Theory

Chapter 5: Game Theory — Key Concepts

Topics covered: Normal form games, Nash equilibrium, dominant strategies, mixed strategies, sequential games, subgame perfect equilibrium, backward induction.

Key concepts:

- Nash equilibrium: No player can improve by unilaterally changing strategy
- Mixed strategy: Randomization over pure strategies
- Subgame perfect equilibrium (SPE): Nash equilibrium in every subgame
- Backward induction: Solve sequential games from the end

Classic games: Prisoner's dilemma, Battle of the sexes, Coordination games, Chicken

Problem 1: Battle of the Sexes

A husband and wife are trying to decide where to go for an evening out. Whilst apart they must choose either to go to a boxing match, or the ballet. Both players would rather go anywhere together but given this, the man prefers the boxing and the woman the ballet.

(a) Find the pure Nash equilibrium or equilibria by the underlining method.

(b) Draw the best response function of the wife if the husband's probability of choosing ballet is h.

(c) Draw the best response function of the husband if the wife's probability of choosing ballet is w.

(d) Indicate the mixed-strategy Nash equilibrium.

(e) Calculate the expected total payoff for each of the Nash equilibria in this game.

(f) Indicate the symmetric Nash equilibrium.

Problem 2: Sequential Battle of the Sexes

Now assume that the game is played sequentially with perfect information. Wife plays first (either ballet or boxing) and husband has 4 contingent strategies: (i) always choose ballet, (ii) choose the same as wife, (iii) choose the opposite of wife, (iv) always choose boxing.

(a) Show the solution in normal form and identify the Nash equilibria. Discard the non-stable ones that include non-credible threats.

(b) Find the subgame perfect equilibrium (SPE) by using the extensive form and backward induction method.

Problem 3: Cuban Missile Crisis

During 1962, the Soviet Union installed nuclear missiles in Cuba. When the US found out, President Kennedy discussed the options: (i) do nothing, (ii) air strike on the missiles, (iii) a naval blockade of Cuba. JFK decided on the naval blockade. Negotiations ensued, and Khrushchev threatened to escalate the situation.

First, Khrushchev must decide whether to place the missiles in Cuba or not. If the missiles are in place, JFK must decide on (i) nothing, (ii) air strike, or (iii) blockade. If JFK decides on air strike or blockade, Khrushchev must decide whether to acquiesce or escalate.

Utility ranking for Khrushchev: missiles allowed $>$ status quo $>$ acquiesce to blockade $>$ acquiesce to air strike $>$ escalate after air strike $>$ escalate after blockade.

Utility ranking for JFK: blockade and acquiesce $>$ air strike and acquiesce $>$ status quo $>$ allow missiles $>$ Khrushchev escalates after blockade $>$ Khrushchev escalates after air strike.

(a) Find the subgame perfect Nash Equilibrium.

Problem 4: Tragedy of the Commons

Game involves two shepherds: A and B, who graze their sheep on a common land. Let s_A and s_B be the number of sheep each graze, chosen simultaneously. Because the common only has a limited amount of space, if more sheep graze, there is less grass for each one, and they grow less quickly. The benefit A gets from each sheep (mutton and wool) equals $120 - s_A - s_B$ and there is no cost of raising sheep.

(a) Calculate the **total** benefit of shepherd A and B from owning a flock of s_A sheep.

(b) Calculate the **marginal** benefit and **marginal** cost for shepherd A and B from owning an additional sheep.

(c) Graph the best response functions of shepherd A and B and indicate the Nash equilibria (mutual best responses to each other).

(d) Calculate the total benefit for A and B at the Nash equilibrium. Calculate the total benefit if both raised 30 sheep. Explain why the game is called a tragedy of commons.

6 Production and Costs

Chapters 6-7: Production and Costs — Key Concepts

Topics covered: Production functions, isoquants, returns to scale, short-run vs. long-run costs, cost minimization, marginal product, average and marginal costs.

Key equations:

- Returns to scale: $f(tK, tL)$ compared to $t \cdot f(K, L)$
- Short-run total cost: $STC = FC + VC(q)$
- Average cost: $AC = \frac{TC}{q}$; Marginal cost: $MC = \frac{dTC}{dq}$
- Cost minimization: $\frac{MP_L}{w} = \frac{MP_K}{r}$

Efficient scale: Output level where AC is minimized (where $MC = AC$)

Problem 1: Linear Production Function

Suppose that artichokes are produced according to the production function $q = 100K + 50L$, where q represents pounds of artichokes produced per hour, K is the number of acres of land devoted to artichoke production, and L represents the number of workers hired each hour to pick artichokes.

(a) Does this production function exhibit increasing, constant, or decreasing returns to scale? Graph the isoquants for $q = 100$ and $q = 200$. Calculate the capital and labor input for capital only, labor only, and a mixed production.

(b) What does the form of this production function assume about the substitutability of L for K?

(c) Give one reason why this production function is probably not a very reasonable one.

Problem 2: Short-Run and Long-Run Costs

A firm producing hockey sticks has a production function given by:

$$q = 2\sqrt{K \times L}$$

In the short run, the firm's amount of capital is fixed at $K = 100$. The rental rate for

K is $v = \$1$ and the wage rate for L is $w = \$4$.

(a) Calculate the firm's short-run total cost function. Calculate the short-run average cost function. Express both in output unit q.

(b) The firm's short-run marginal cost function is given by $SMC = q/50$. What are the STC, SAC, and SMC for the firm if it produces 25 hockey sticks? Fifty hockey sticks? One hundred? Two hundred?

(c) Graph the SAC and the SMC curves for the firm. Indicate the points found in part (b).

(d) Where does the SMC curve intersect the SAC curve? (Efficient scale).

(e) Calculate the long-run cost-minimizing K and L input levels if the firm is producing 200 hockey sticks.

7 Profit Maximization and Supply

Chapter 8: Profit Maximization — Key Concepts

Topics covered: Profit function, revenue and cost analysis, first-order conditions for profit maximization, supply curve derivation.

Key equations:

- Profit: $\pi = TR - TC = P \cdot q - C(q)$
- Profit maximization condition: $MR = MC$
- For price takers: $P = MC$ (supply curve)
- Total revenue: $TR = P \cdot q$; Marginal revenue: $MR = \frac{dTR}{dq}$

Problem 1: Cost Analysis (Review)

A firm producing hockey sticks has a production function given by:

$$q = 2\sqrt{K \times L}$$

In the short run, the firm's amount of capital is fixed at $K = 100$. The rental rate for K is $v = \$1$ and the wage rate for L is $w = \$4$.

(a) Calculate the firm's short-run total cost function. Calculate the short-run average cost function. Express both in output unit q.

(b) The firm's short-run marginal cost function is given by $SMC = q/50$. What are the STC, SAC, and SMC for the firm if it produces 25 hockey sticks? Fifty hockey sticks? One hundred? Two hundred?

(c) Graph the SAC and the SMC curves for the firm. Indicate the points found in part (b).

(d) Where does the SMC curve intersect the SAC curve? (Efficient scale).

(e) Calculate the long-run cost-minimizing K and L input levels if the firm is producing 200 hockey sticks.

Problem 2: Profit Maximization for a Price Taker

Consider a firm that is selling in a competitive market with $p = \$20$ for each unit independent of how much the firm sells (firm is a price taker). The total cost function for the firm is given as $TC = 50 + 10q + 0.1q^2$.

(a) Derive the total revenue and marginal revenue functions.

(b) Derive the fixed cost, variable cost, average total cost, and marginal cost functions.

(c) Write down the profit function, derive the first-order condition for profit maximization, and calculate the output that maximizes the firm's profit.

8 Perfect Competition

Chapter 9: Perfect Competition — Key Concepts

Topics covered: Characteristics of perfect competition, short-run supply, shutdown condition, long-run equilibrium, zero economic profit.
Key conditions:

- Many buyers and sellers, homogeneous product, free entry/exit
- Firms are price takers: $P = MR$
- Short-run profit max: $P = MC$ (where MC is upward sloping)
- Shutdown condition: $P < AVC$
- Long-run equilibrium: $P = MC = AC$ (zero economic profit)

Problem 1: Marginal Revenue for a Monopolist (Comparison)

Consider a firm with the following demand curve $p = 10 - q$.

(a) Derive the total revenue curve.

(b) Derive the marginal revenue curve.

(c) Graph the demand and the marginal revenue curve on the same graph.

Problem 2: Short-Run Supply Decision

The short-run total cost curve and the marginal cost curve associated with a price-taker firm in a competitive industry is given by:

$$STC = 0.1q^2 + 10q + 250$$

$$MC = 0.2q + 10$$

(a) Derive the short-run average cost curve and calculate the efficient scale output level for which the short-run average cost is minimum.

(b) Calculate the profit-maximizing quantity, short-run average total cost, and the profit if the market price for the product is \$18.

(c) Is the firm better off by shutting down its business or should it continue to operate at the current output level? Explain using the concepts of fixed and variable cost.

9 Economic Efficiency and Taxation

Chapter 9: Welfare Economics — Key Concepts

Topics covered: Consumer surplus, producer surplus, total surplus, deadweight loss, tax incidence, efficiency of competitive markets.

Key equations:

- Consumer surplus = $\int_0^{Q^*} D(q)\,dq - P^* \cdot Q^*$
- Producer surplus = $P^* \cdot Q^* - \int_0^{Q^*} S(q)\,dq$
- Total surplus = CS + PS (maximized at competitive equilibrium)
- Deadweight loss from tax = Lost surplus not captured by anyone

Tax incidence: Burden falls more heavily on the more inelastic side of the market.

Problem 1: Tax Incidence and Deadweight Loss

Suppose the supply of a good is given by the equation $Q_S = 240P - 480$, and the demand for the good is given by the equation $Q_D = 640 - 80P$, where quantity (Q) is measured in millions of units and price (P) is measured in dollars per unit.

The government decides to levy an excise tax of $2.00 per unit on the good, to be paid by the seller.

(a) Calculate the equilibrium price and quantity without the tax.

(b) Calculate the equilibrium price and quantity after the tax.

(c) Calculate the consumer, producer, and overall surplus before the tax.

(d) Calculate the consumer and producer surplus after the tax.

(e) Calculate the government revenue from the tax as well as the amount of tax paid by buyers and sellers.

(f) Calculate the deadweight loss of the tax.

10 Monopoly

Chapter 11: Monopoly — Key Concepts

Topics covered: Sources of monopoly power, profit maximization under monopoly, price discrimination, welfare effects of monopoly, deadweight loss.
Key differences from perfect competition:

- Monopolist faces downward-sloping demand: $MR < P$
- Marginal revenue: $MR = P + q \cdot \frac{dP}{dq} = P(1 - \frac{1}{|\varepsilon|})$
- Profit max: $MR = MC \Rightarrow P > MC$ (markup over cost)
- Results in deadweight loss compared to competitive outcome

Problem 1: Monopoly vs. Perfect Competition

A monopolist can produce at constant average and marginal costs of $AC = MC = 5$. The firm faces a market demand curve given by $Q = 53 - P$. The monopolist's marginal revenue curve is given by $MR = 53 - 2Q$.

(a) Calculate the profit-maximizing output and price combination for the monopolist. Also calculate the monopolist's profits and consumer surplus.

(b) On a graph, indicate the monopoly equilibrium and compare it to the perfect competition equilibrium.

(c) Calculate the producer and consumer surplus under monopoly. Compare them to the case under perfect competition, and finally calculate the deadweight loss associated with the monopoly.

11 Oligopoly and Strategic Behavior

Chapter 12: Oligopoly — Key Concepts

Topics covered: Cournot competition, Stackelberg leadership, Bertrand competition, collusion, entry deterrence.

Cournot model:

- Firms choose quantities simultaneously
- Best response functions: $q_i^* = f(q_j)$
- Nash equilibrium: Intersection of best response functions

Stackelberg model:

- Leader moves first, follower responds
- Solved by backward induction
- Leader has first-mover advantage

Problem 1: Stackelberg Competition

Consider the Cournot market setup with two firms (A & B) with the following market demand:

$$P = 120 - q_A - q_B$$

and zero marginal and average costs, where the Nash equilibrium in the simultaneous game was each firm producing 40 units and making $1,600 profit.

Now assume that the firms decide on their production sequentially. Firm A commits to an output first and Firm B decides on her output after Firm A.

(a) Find the best response function for Firm A.

(b) Find the best response function for Firm B.

(c) Find the sequential Nash equilibrium, profit for each firm, and compare it with the simultaneous Nash equilibrium.

(d) Assume that there is a fixed entry cost to the market, which is $785. Find the entry-deterring strategy for Firm A and conclude if the strategy is better than the one in which Firm B enters and both maximize their profit.

End of Practice Problems