Volume 8

Industrial Organization & Regulation Exams, Puzzles & Problems

Economics Reading Lists, Course Outlines, Exams, Puzzles & Problems

mpiled by Edward Tower, *Duke University*, August 1990

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NOTES TO USERS AND POTENTIAL CONTRIBUTORS

These teaching materials are drawn from both undergraduate and graduate programs at 93 major colleges and universities. They are designed to widen the horizons of individual professors and curriculum committees. Some include suggestions for term-paper topics, and many of the lists are useful guides for students seeking both topics and references for term papers and theses. Thus, they should enable faculty members to advise students more effectively and efficiently. They will also be useful to prospective graduate students seeking more detailed information about various graduate programs; to those currently enrolled in programs who are preparing for field examinations; and to librarians responsible for acquisitions in economics. Finally, they may interest researchers and administrators who wish to know more about how their own work and the work of their department is being received by the profession.

The exams, puzzles and problems include both undergraduate and graduate exams contributed by economics departments and individual professors. They should be especially useful to professors making up exams and problem sets and to students studying for comprehensive exams. They may also serve as the focus for study groups.

From time to time we will reprint updated and expanded versions. Therefore, we would welcome new or updated teaching materials, especially those which compliment material in this collection or cover areas we missed. Potential contributors should contact Ed Tower, Economics Department, Duke University, Durham, North Carolina 27706, U.S.A.

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Acknowledgement

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INDUSTRIAL ORGANIZATION & REGULATION EXAMS, PUZZLES & PROBLEMS

Contents

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U = Undergraduate **G** = Graduate
R&E = Reading Lists & Exams and/or Problems

University of Michigan U

ECONOMICS 431 (SECTION 1)
INDUSTRIAL ORGANIZATION

Professor Salant
Winter, 1990

Time and Place: Classroom: 3080 EE. Time: MWF 10-11

Readings: There is no textbook. Instead, I have assigned a collection of readings--each contained in a coursepack available at Dollar Bill's. To help you navigate in a course without a text, I have indicated on the list of "Readings" the number of weeks allocated to each topic and, in addition, have provided a detailed "Outline" of the course.

Grading: There will be a mid-term, a final, and five problem sets. Each exam will count one-third of your final grade. The problem sets will collectively account for the remaining *third*.

Problem Sets: The five problem sets are an important part of the course. They test your understanding of the lectures. Master the problem sets as you go along and you will keep up in the course and be well-prepared for the exams. Given their weight in the grade (more than ***double*** their weight in 401), responses to problem sets are to be your own work. There is to be absolutely *no collaboration*. To determine the approximate timing of the problem sets, consult their location in the list of readings.

Exams: The mid-term will be on Wednesday, February 28. The final will be on Monday, April 30 from 4-6 p.m.

Departure from Schedule: There will be no class on Friday, March 2.

Office Hours: To be arranged at our first meeting. I am very willing to help you with any problems you are having *as the course proceeds*. However, the material in this particular course is cumulative and it is *not* in your self-interest to wait until exam time to review your notes and determine what you do not know. To discourage such behavior, be advised that I will be holding *no* office hours on the week in which the mid-term falls and the week in which the final falls.

Office Location and Phone: 254 Lorch Hall, 764-2370. Please leave a message on the machine and indicate times when you are available for a return phone call.

Prerequisites: This course requires Economics 401 and first-year calculus as prerequisites. Please see me immediately if you are not adequately prepared in either subject.

Course Description: Our focus in this course will be on noncompetitive behavior by firms: manipulation of buyers and strategic interaction among sellers. The course will develop key ideas from noncooperative game theory and use them to understand the behavior of firms. For a more detailed description of the course, consult the "Course Outline" which follows the list of "Readings."

OUTLINE: INDUSTRIAL ORGANIZATION 431

MONOPOLISTIC PRICING STRATEGIES AND WELFARE

1. Simple monopoly pricing
    a. Inefficiency of monopoly pricing
    b. Causes of monopoly
    c. Inducing a simple monopolist to price efficiently--Loeb/Magat's subsidy scheme
2. Charging different groups different prices (third-degree price discrimination)
    a. Examples: South Africa's simultaneous gold sales to the IMF and the private market, agricultural marketing orders, international dumping at below domestic prices
    b. Arbitrage constraints
    c. Optimal third-degree discrimination given arbitrage constraints
    d. Does arbitrage always increase welfare?
3. Two-part tariffs: the optimal access fee plus price per unit when selling to a homogeneous group or set of distinguishable homogeneous groups
    a. Arbitrage constraints--one person pays access fee and resells to others
    b. Optimal pricing given arbitrage constraints
    c. Does arbitrage always increase welfare
4. Inducing self-selection when explicit discrimination is either infeasible or illegal
    a. Properties of the best single access fee and price
        i. Examples of metering: IBM, United Shoe, Xerox cases
    b. Making higher profits with a menu of quantity offerings

THEORY OF STRATEGIC INTERACTIONS

1. Game theory
    a. Description
        i. Tree representation (extensive form)
        ii. Matrix representation (normal form)
        iii. Strategies
    b. Solutions
        i. Strictly dominant strategies
        ii. Nash equilibrium
            1. Critique ("incredibility" of threats)
        iii. Nash equilibrium supported only by credible threats (require Nash equilibrium not only in the whole game but in each subgame)
            1. How to apply this restriction in
                a. Games of perfect information
                b. Games of imperfect information but with proper subgames
                c. Games without proper subgames
    c. Extended illustration: Dixit's model of entry deterrence with finite strategies
        i. Strategic moves and tactical responses: how to make threats credible
        ii. What if the strategic move is unobservable (suppose the entrant blinds himself)
        iii. What if the strategic move is reversible

STATIC OLIGOPOLY MODELS

1. Cournot (identical or different, constant marginal costs)
    a. Reaction functions
    b. Isoprofit contours
2. When joint-profit maximization induces incentives to shirk
3. Bertrand (identical or different, constant marginal costs)
4. Price competition with imperfect substitutes

a. Reaction functions

b. Isoprofit contours

ENTRY DETERRENCE, PREDATION, AND OTHER HOSTILE ACTS

1. Two-stage games

   a. Stackelberg's game (Nash equilibrium and subgame perfect equilibrium)

   b. Entry deterrence or exit promotion when entrant has fixed costs

      i. Stackelberg as benchmark--if costless precommitment to output is possible

      ii. Strategic use of inventories or expanded capacity

   c. Predatory tactics

      i. When raising one's own costs and those of one's rivals pays

      ii. Strategic deception that one's costs are low

      iii. Using the government and the courts against rivals

      iv. Other unfriendly acts

COLLUSION:

1. Tacit collusion: "Never knowingly undersold" and other facilitating practices

2. Explicit collusion

   a. Horizontal mergers and profitability

   b. Cartels and their problems

      i. Expansion of outsiders

      ii. Differential incentives to cheat on the joint profit-maximizing agreement

      iii. Conflicts based on differential cost or size in the absence of side-payments

   c. Partial solutions

      i. Enforcement by fines

      ii. Enforcement by threat of price wars

      iii. Resolving differences by voting on quotas

Prof. Salant
Winter, 1990

431 Problem Set 1

1. Four firms have the technology to produce a particular service which the public values. Each firm has a fixed cost and a constant marginal cost. Firm one has a fixed cost of \$9000 and a constant marginal cost of \$0. Firm two has a fixed cost of \$2000 and a constant marginal cost of \$20. Firm three has a fixed cost of \$800 and a constant marginal cost of \$40. Firm four has a fixed cost of \$0 and a marginal cost of \$60. Assume the inverse demand curve is $P = 100 - Q$ where P is the price and Q is the aggregate amount of the service. Each of these fixed costs can be avoided if and only if the firm produces zero output—they are what Varian dubs "quasi-fixed costs."

a. Verify that there exists no price such that the demand at that price equals the supply which would be provided by price-taking, profit maximizing firms. Hence a competitive market cannot be counted on to provide this service.

b. Suppose a social planner (a maximizer of consumer plus producer surplus) is well-informed about the demand curve and the cost function of each firm. Moreover, she can decide which technology or technologies to operate and can operate any at a level of her choice. Verify that it is never sensible to use more than one technology. [Hint: assume she considered operating more than one technology at a positive output and show that the same aggregate output could be produced at lower cost by shutting down all but one of the technologies.]

c. To maximize consumer plus producer surplus, which technology should be operated and at what output?

d. Suppose a regulator wanted to maximize consumer plus producer surplus and could identify the firm with the technology referred to in (c). Assume the regulator has the power to designate that firm as the monopolist but cannot subsidize the firm and cannot direct its behavior. Assume the firm operates as a standard monopolist (does not price discriminate). How much–if anything–would that firm produce? What would be the resulting sum of consumer plus producer surplus? Is the resulting total surplus maximized?

e. Suppose instead a regulator wanted to maximize consumer plus producer surplus (by implementing the solution in (c)) but *did not know* the cost function of any of the firms. He plans to let the four firms bid at an auction for the right to monopolize the market and agrees to pay the winning firm an aggregate subsidy dependent on the price the firm chooses to charge. Suppose the subsidy if P is charged equals the net consumer surplus at price P. Compute the subsidy function offered to the winning firm.

f. In deciding how much to bid at the auction, each firm determines how much

winning would be worth and bids that full amount. For each of the four firms, calculate the price it would charge if it were the subsidized monopolist and the total proceeds per year which would result: government subsidy + revenue from consumers—variable costs—fixed costs. To simplify, assume that the monopoly will last only one year and that the demand and cost functions are in annual terms (i.e. there is no need to compute discounted net benefits in future years). How much would each of the four firms bid? Assuming the firm bidding the most wins the auction, which firm would be the winner? What price does he charge? How much does he produce? What subsidy does he receive?

2. According to the February 1982 Consumers Reports (p.106), the Navel Orange Administrative Committee of California-Arizona (one of numerous volume-restricting Federal agricultural marketing boards which is exempt from antitrust enforcement) succeeded in the 1980-81 crop year in diverting so much California-Arizona produce to the concentrate market that the price of fresh navels was driven up to ten times the price of oranges sold for juice! Assume that in doing so the Committee was maximizing profits by third-degree price discrimination.

a. Assume that the price of concentrate is set in Florida (which in fact supplies 98% of oranges used to make concentrate) and is unaffected by the Navel Committee's decisions. Compute the elasticity of demand in the fresh market at the prevailing price.

b. If the elasticity of demand in the concentrate market were instead *less* than infinitely elastic, what can be said about the *range* of possible price elasticities of demand in the fresh market at the prevailing price? (What is the smallest magnitude of price elasticity and the largest magnitude consistent with third degree price discrimination theory and the data reported in this question)?

3. A firm with zero costs sells to consumers in two separate markets. The demand curve in each market is linear. The slope of the demand curve in the first market is twice the slope of the demand curve in the second market. But the steeper inverse demand curve cuts the vertical axis at a higher price.

a. If the most profitable common price is charged in both markets and that price elicits positive demand in each market, which market will have the higher price elasticity of demand? Explain.

b. If the firm is allowed to set different prices in the two markets (but no access fees) and maximizes profit, in which market will he set the higher price? Explain.

c. In the presence of price discrimination, are the firm's profits higher? Is the net consumer surplus of the consumers in the first market higher? Is the net consumer surplus of the consumers in the second market higher?

4. An opera house is considering price discriminating on the basis of age but

plans to charge at most two distinct prices. Assume such discrimination is legal and cannot be evaded. Assume costs are zero.

For the evening show, an equal number of 40, 30, and 20 year-olds would be interested in attending. The reservation price for each 40 year-old is \$100. The reservation price for each 30 year-old is \$80. The reservation price for each 20 year old is \$45. For simplicity assume there are 100 people in each age group.

a. The opera house first considers charging one price to people over 39 and a second price to people who are younger. Calculate the profit-maximizing price to each group and the resulting profits.

b. As an alternative, it considers charging one price to people over 29 and a second price to people who are younger. Calculate the profit-maximizing price to each group and the resulting profits.

c. As a final option, it considers charging the same price to everyone. Calculate the profit-maximizing (simple monopoly) price and the resulting profits.

d. Of the previous options, which is the most profitable to the opera house? As a separate matter, which generates the largest social surplus (i.e. sum of consumer plus producer surplus)?

5. A Swedish car manufacturer faces more elastic demand at home and relatively inelastic demand in the U.S. Specifically the home demand curve has a price intercept of \$10,000 and a slope of \$1 per car, while the U.S. demand curve has a price intercept of \$20,000 and the same slope. Suppose production occurs at a constant marginal cost of \$4000. What price should the company charge U.S. buyers if countless U.S. yuppies would flock to Europe and purchase the cars there (for resale or own use in the U.S.) whenever the U.S. price exceeds the European price by more than \$2000. In answering, assume that–regardless of the pricing strategy of the Swedish manufacturer–other car manufacturers can safely be assumed not to react in a way which affects either demand curve faced by the Swedish car manufacturer.

Prof. Salant
Winter, 1990

Answers to 431 Problem Set 1

1. a. If a firm has a strictly positive fixed cost, a constant marginal cost and takes price as given, it will shut down to avoid the fixed cost if the price is less than or equal to its constant marginal cost but will provide infinite supply at any larger price. This discontinuous behavior results in no price which equates supply and demand.

In the example given, firm four has a zero marginal cost and hence would supply infinite at any strictly positive price. This insures that the sum of the supplies of the four firms is infinite at any strictly positive price—which exceeds the finite demand of the consumers at that price. On the other hand, consider a price of zero. Each price-taking firm (including firm four) would then supply zero. Hence the aggregate supply would be zero—which is smaller than the demand at that price. Thus at no price does the market clear. Competitive equilibrium fails to exist.

b. Suppose the contrary. Suppose it were sensible to use more than one technology at a positive level of output. Since the different technologies have different marginal costs, the planner could provide the same output to the same consumers at a lower resource cost (and hence a larger total surplus) simply by reducing output by one unit at the technology with higher marginal cost and increasing output by one unit at the technology with lower marginal cost. But since the marginal costs are constant, this trick can be repeated until the higher marginal cost technology is shut down completely. At that point the planner gets a bonus—the fixed cost of operating the technology he shut down is also saved.

c. If a technology of marginal cost c_i and fixed cost F_i is chosen, then it should be operated where $100 - Q_i = c_i$ or $Q_i = 100 - c_i$. This will generate a profit of $-F_i$ and a consumer surplus of $.5(100 - c_i)^2$. Hence the net surplus is $.5(100 - c_i)^2 - F_i$. Plugging in the marginal and fixed costs for firm i ($i = 1, \ldots, 4$), we find that the maximum surplus for firm 1 is -4000, firm 2 is 1200, firm 3 is 1000, and firm 4 is 800. Hence, total surplus is maximized by operating firm 2 at $Q_2 = 80$.

d. Suppose firm two were selected by a regulator and could set its price to maximize profits. Then it would produce at the point where marginal revenue equals marginal cost: $100 - 2Q = c \Rightarrow Q = 40$. *If* it operated, the firm could do no better than a loss (profit$=-400$). To avoid this, the firm would shut down and total surplus would be zero—far below the surplus of 1200 if the firm is operated efficiently.

e. The Loeb-Magat subsidy would be $.5(100 - P)^2$.

f. Faced with that subsidy, each firm—if it monopolized the market—would set

its price equal to its marginal cost and would earn consumer surplus minus the fixed cost. In part c we determined how much each firm would anticipate earning as the monopolist and hence how much each firm would bid: firm 1 would bid -4000, firm 2 would bid 1200, firm 3 would bid 1000, and firm 4 would bid 800. Hence, firm 2 would win the auction. It would then charge a price of 20 and would produce 80 units. Given the price, the firm would earn a subsidy of 3200 which—after payment of the 2000 fixed cost—would leave a surplus of 1200.

2. a. $P_c = P_f(1 - 1/|n_f|)$, where P_c is the price in the concentrate market, P_f is the price in the fresh market and $|n_f|$ is the magnitude of the elasticity of demand with respect to price in the fresh market. Since $P_f/P_c = 10$, the equation implies that $|n| = 10/9$. .

b. If demand in the concentrate market were not perfectly elastic, then marginal revenue in the concentrate market would instead be $P_c(1 - 1/|n_c|)$. At an optimum, this would equal marginal revenue in the fresh market:

$$P_c(1 - 1/|n_c|) = P_f(1 - 1/|n_f|) \geq 0.$$

Since the price in the fresh market was 10 times the price in the concentrate market, we obtain:

$$1/|n_f| = .9 + .1/|n_c|.$$

Since $|n_c| \geq 1$, it follows that $1 \leq |n_f| \leq 10/9$.

3. a. The linear inverse demand curve which cuts the vertical axis at a higher price was shown in class to have the smaller price elasticity—regardless of whether it has the smaller or the larger slope. To derive this result, first show (see class notes) that the elasticity at price P is equal to the ratio of the price to the distance between the price and the vertical intercept of the inverse demand curve. Using this fact, we then note that—at any price—the numerator of that ratio is the same and the denominator will be larger for the inverse demand curve with the larger intercept. Hence, the magnitude of the elasticity must be smaller at any price for the inverse demand curve with the larger vertical intercept.

b. The firm will set the higher price in the market with the inverse demand curve which is the more inelastic at any price—the market where the linear inverse demand curve has the higher intercept. Suppose the contrary. Suppose the profit-maximizing firm set the higher price in the market which at any common price had the higher magnitude of elasticity. Then since the magnitude of elasticity rises as one moves up the inverse demand curve, the magnitude of the point elasticity in the higher price market *at the price chosen* would be higher than the corresponding magnitude in the other market. But then the equation relating price, marginal revenue and elasticity implies that the marginal revenue (the product of two factors

each of which is larger) in the high price market must exceed the marginal revenue in the low price market. This in turn implies that hence profits could be increased by selling one less unit in the low marginal revenue market and selling it instead in the high marginal revenue market. We have contradicted our assumption that profits were maximized. Hence, it must optimal to charge a higher price in the market which—at any common price—has the lower magnitude of elasticity at any common price.

4. a. If 40 and over defines the aged, then only one group fits in that category and its members will be charged their reservation price—$100. The "juniors" market consists of the 30 year olds and the 20 year olds. Since it is better to serve two buyers at $45 than to serve only one at $80, the price in the other market will be $45 and the profits in that market will be ($90+$100)100=19000.

b. If 30 and over defines the aged, then two groups fit in that category and the monopolist must compare selling two units at $80 instead of one at $100. Hence, he will sell two units at $80 and will earn in that market $160(100). In the other market, the 20 year olds are isolated and will be charged their full reservation price, $45(100). Hence the total profit will be $205(100)=20500.

c. If a single price is charged to everyone, the monopolist can serve 1 customer at $100, 2 at $80 per customer or 3 at $45. It is most profitable to charge $80. This results in a profit of 2(100)(80)=16000. Note that—in this case—the 20 year olds are priced out of the market.

d. The most profitable age break at the opera house is at 30 and over (case b). The resulting payoff is (20500).

Consumer surplus is equal to the sum of the reservation prices of the customers served minus their payments. Producer surplus is—since costs are zero—simply equal to the payments of the consumers. Hence, total surplus is equal to the sum of the reservation prices of the customers served (the payment from consumers to the firm is a transfer which nets out when calculating the change in the total surplus). In case a, the sum of the reservation prices of the served customers is 100(100+80+45)=22500. In case b, the sum of the reservation prices of the served customers is 100(100+80+45)=22500. In case c, however, the customers with the reservation prices of $45 are not served and the sum of the reservation prices of the served customers is only 100(100+80)=18000. Note in this case that what is most profitable for the third–degree price discriminator (case b) generates more total surplus than single–price monopoly (case c).

5. We first investigate how our Swedish monopolist would behave if he was free to set prices in the two markets and did not have to worry about the yuppie arbitrageurs. If it turns out that the prices he would choose do not differ by enough

to induce arbitrage, the problem is solved; otherwise, he would set the two prices so that they differed by \$2000 and the problem must be re-analyzed to determine the levels of the two prices.

In the absence of arbitrageurs, this is merely a problem in third degree price discrimination. The monopolist would set output in the two markets so that the marginal revenue in each was equal to \$4000, the common marginal cost. It is easy to verify that selling 3000 cars in Europe and 8000 cars in the U.S. generates a marginal revenue of \$4000 in each market. The price which would induce this demand in Europe is \$7000 per auto, while the corresponding price in the U.S. is \$12000 per auto. Unfortunately, if the monopolist tried to set these prices, he would make no sales in the U.S. since the price differential would be more than enough to induce massive arbitrage.

The best the monopolist could do in this situation would be to set the U.S. price \$2000 higher than the Swedish price. But what should be the Swedish price? Let it be denoted p. Then the monopolist will want to set p to maximize

$$pD_s(p) + (p + 2000)D_{us}(p + 2000) - 4000(D_s(p) + D_{us}(p + 2000)).$$

Differentiating and setting the derivative equal to zero, we obtain:

$$D_s(p) + pD'_s(p) + (P_s + 2000)D'_{us}(p + 2000) + D_{us}(p + 2000) - 4000(D'_s + D'_{us}) = 0.$$

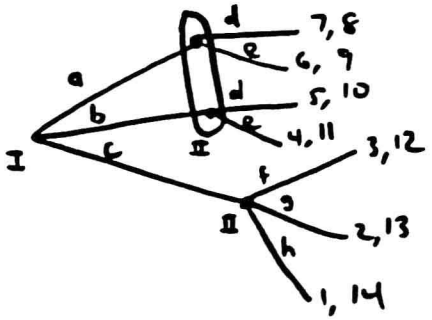
Since $D_s(p) = 10000 - p$ and $D_{us}(p) = 20000 - p$, it is easily shown that profit is maximized when the Swedish price is set equal to \$8500 and the U.S. price is set \$2000 higher.

Economics 431, section 2
Professor Salant
Due: February 13, 1989

PROBLEM SET 2

Payoff Conventions: In extensive-form trees, the payoff of the player who moves first is listed first at the ends of the tree. In normal-form matrices, the first payoff in each payoff pair goes to the row player.

1. Reduce the following extensive form game to normal form:



2. In the following normal form game, which strategies for the row player are strictly dominated?

	L	R
U	10, 15	5, 2
D	8, -11	18, -16

3. In the following normal form game, which two strategy pairs form a Nash equilibrium?

	L	R
U	10, 3	60, 40
D	14, 14	0, 7

4. True or false: if a strategy of one player is strictly dominated, it can never be part of a Nash equilibrium.