

# **HOMEWORK PROBLEMS**

## **ECONOMICS 120**

### **ECONOMICS OF THE PUBLIC SECTOR**

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*MEASURING NET ECONOMIC VALUE IN A COMPETITIVE MARKET*

Suppose that the demand for widgets is given by the following equation:

$$W = 36 - 3P$$

where  $W$  is the quantity demanded per month and  $P$  is the price (in dollars). In addition, the marginal cost of widgets is

$$MC = W/3$$

1. Determine the market values of  $P$  and  $W$  in competitive equilibrium and calculate the monthly net value created in the widget market. Also:
  - a. How much of the value created in the widget market takes the form of **consumer's surplus**?
  - b. How much of the value takes the form or **producer's surplus**?
2. For each of the following changes, determine the effect on the price of widgets and the quantity traded and compute the gain (+) or loss (-) in net value created in the widget market. (Note: a. and b. are independent. Do each part starting from the same initial competitive equilibrium.)
  - a. An innovation that cuts the marginal cost of producing widgets in half (i.e., the new marginal cost is  $W/6$ ).
  - b. A legal price ceiling which prohibits the sale of widgets for more than \$4 per unit.
3. Determine the effect on the price of widgets and the quantity traded of a tax of \$2 per unit imposed on widget producers. Also:
  - a. How much tax revenue would this tax raise for the government?
  - b. The **efficiency loss** resulting from a tax is defined as the reduction in the net value created in the market on which the tax is levied. What is the efficiency loss due to the \$2 per unit widget tax?
  - c. The **efficiency loss ratio** for a tax expresses the efficiency loss as a percentage of the tax revenue collected. What is the efficiency loss ratio for this tax?

*TWO PROBLEMS IN BENEFIT-COST ANALYSIS*

1. Zap City is considering two alternative means of supplying its citizens with electricity: It can either build a dam and generate its own electricity, or it can build a series of relay stations and import its electricity from nearby Zipville. The relay stations can be built, maintained and financed at a fixed cost of \$2.5 million per year, while the fixed costs for the dam are greater, namely, \$3 million per year. However, the (constant) marginal cost of dam-generated electricity (\$0.06 per kilowatt-hour) is only half the (constant) marginal cost of imported electricity (\$0.12 per kilowatt-hour). The average annual demand for electricity in Zap City is given by

$$E = (10 \text{ million})(1 - P)$$

where  $E$  = quantity demanded (in kw-hrs per year) and  $P$  = price (in \$/kilowatt-hour).

- a. Assuming efficient pricing of electricity in either case and access to zero cost tax revenues to make up any operating deficits, which alternative--the relays or the dam--would generate the greatest net value for the citizens of Zap city?
  - b. How would your answer above be affected if, instead of being costless, tax revenues impose a 10 percent efficiency loss ratio? (I.e., for each \$1 of taxes collected, 10 cents of net benefits are lost in the markets on which the taxes are levied.)
2. River City wants to bridge the river that runs through the center of town. There are two alternative bridge sites, site A and site B between which the city must choose. Only one bridge will be built, either at site A or at site B. Neither site would suffer from congestion. The demand for crossings at site A is estimated to be  $X_A = 20(12 - P)$  and at site B to be  $X_B = 10(18 - P)$ , where the  $X$ s are the number of crossings per day and  $P$  is the toll charged in dollars. A bridge at site A would have fixed costs of \$400 per day which it could cover, if necessary, with a toll of only \$2 per crossing, whereas a bridge at site B has fixed costs of \$450 per day, which it could cover with a toll of \$3 per crossing. If tolls are not charged, these fixed costs would have to be covered by an increase the gasoline tax, which has an efficiency loss ratio of 20%. Do a benefit-cost analysis of each of the following alternatives by calculating the net value each generates. Which of the alternatives should River City select?
- a. Build a bridge at site A and pay for it with a bridge toll.
  - b. Build a bridge at site B and pay for it with a bridge toll.
  - c. Build a bridge at site A, charge no toll, and pay for it with gasoline taxes.
  - d. Build a bridge at site B, charge no toll, and pay for it with gasoline taxes.

## TARIFFS AND PRODUCER RENTS

Suppose that the demand for and domestic supply of widgets are given by the following:

$$\text{Demand: } Q_d = 60 - 4P$$

$$\text{Supply: } Q_s = 6P$$

Also suppose that foreign widgets are available at a constant supply price of \$3 per unit.

1. Calculate the equilibrium price and quantity and net value created in the widget market when there are no restrictions on widget imports.
  - a. How much of the quantity is produced domestically and how much is imported?
  - b. Calculate the domestic producers' and consumers' surpluses.
2. Calculate the new equilibrium price and quantity when widgets are subject to a \$2 per unit tariff.
  - a. How much of the new quantity is produced domestically and how much is imported?
  - b. Calculate the new domestic producers' and consumers' surpluses and the amount of tariff revenue generated for the government. Use this information to calculate the net value created in the widget market.
  - c. How much additional economic rent do domestic producers earn as a result of the tariff? How much of this rent is transferred from consumers to producers?
  - d. What is the deadweight loss due to the tariff?

## BUREAUCRATS' PARK

1. The Greenville Municipal Park Department (GMPD) has asked the Greenville City Council to supply budgetary funds for the construction of a 150 acre park. The marginal value and marginal cost of new park space (which are known only to the expert bureaucrats at the GMPD) are given, respectively, by:

$$MV = 1500 - 6A, \text{ and } MC = 9A$$

where A is the number of acres in the new park.

- a. How much new budgetary funding does the GMPD need to build the proposed 150 acre park?
- b. Before it will approve the funding, the City Council has asked the GMPD to conduct a benefit-cost study to demonstrate that its proposed park is worth building. Specifically, it wants to be sure that the benefit/value of the park is at least as great as the cost. What will be the results of the GMPD's study? I.e., what are the benefits (value), the costs, and the bottom line (net value) for the 150 acre park? Does this suggest that the GMPD's proposal will be approved?
- c. What is the largest possible park that the GMPD could propose, and the corresponding increase in its budget, and still not fail the City Council's benefit-cost test?
- d. What is the optimal size for the new park and what net benefits (value) would it create? How big a budget increase would the GMPD receive if it proposed to construct the optimal size park?

*SUPER EXTERNALITY*

Suppose that the demand for kryptonite is given by the following equation:

$$K = 180 - 3P$$

where  $K$  is the number of tons of kryptonite demanded per week and  $P$  is the price per ton (in dollars). Producers of kryptonite incur marginal costs equal to

$$MC = K/6.$$

Unfortunately the production and use of kryptonite has a negative external effect on one Mr. Superman. In particular, the "man of steel" turns to the "man of jello" in the presence of kryptonite. In an exclusive interview with the Daily Planet, Superman has revealed that the marginal external cost to him depends upon the amount of kryptonite produced and is equal to

$$E = K/18.$$

Use this information to answer the following questions:

1. Assuming the market for kryptonite is competitive, what is its price, the quantity produced per week, and the net benefit generated by the kryptonite market?
2. What is the economically efficient production rate for kryptonite, and what net benefits would this efficient rate of production generate? What is the efficiency loss in the competitive market for kryptonite?
3. Appearing before Congress, Superman has argued that his predicament warrants a tax on the production of kryptonite. Impressed by his cute blue tights and big red "S", Congress agrees. What should the kryptonite tax be in dollars per ton?
4. The man of steel has also argued that the tax proceeds should be turned over to him to compensate him for any external costs he still bears. If Congress goes along with this, will Superman's compensation be inadequate, more than adequate, or just sufficient to offset his costs?

*CLEANING UP MURKY LAKE*

Two local firms, Aquasludge and Hydrogunk, are responsible for all of the pollution in Murky Lake. Currently, Aquasludge emits 8 tons of noxious pollutants into the lake each year and Hydrogunk emits 6 tons for a total of 14 tons of pollutants. The EPA's SuperDuperFund has targeted Murky lake for clean up. Specifically, the EPA wants to reduce the total amount of pollutants in Murky lake by 10 tons per year, i.e., reduce the amount of pollutants from the current 14 tons down to only 4 tons. The marginal costs of clean up for the two polluters are given respectively by:

$$MC_A = 75 + 20X_A \quad \text{and} \quad MC_H = 125 + 30X_H$$

where the MCs are the marginal costs and the Xs are the number of tons of pollutants eliminated per year.

Use this information to answer the following questions.

1. If the EPA simply orders each polluter to eliminate 5 tons of pollutants per year, what will be the cost -- for each polluter and in total -- of cleaning up Murky Lake?
2. Suppose the EPA were to use an effluents tax approach to cleaning up the lake.
  - a. At what dollar amount per ton of pollutants should the tax be set?
  - b. How many tons of pollutants would be eliminated by each polluter and at what cleanup cost? What would the total cost of the clean up be?
  - c. How much tax revenues would the EPA collect?
3. Suppose that the EPA decides to auction pollution permits, each allowing the holder to emit one ton of pollutants into Murky Lake each year. Because it wants to limit the amount of pollutants to 4 tons, it limits the number of permits to 4. Anyone who emits pollutants into the lake without a permit is subject to the death penalty!
  - a. What is the most that Aquasludge and Hydrogunk, respectively, would offer for the first permit auctioned off? Who would buy it?
  - b. Do the above analysis for the second, third and fourth permits. How many does each polluter buy? How much pollution does each eliminate?
  - c. What is the cost of the pollution clean up using the permit approach?
4. Suppose that, before the permit auction takes place, Aquasludge and Hydrogunk convince the EPA that the most equitable way to allocate the permits is to give each of them 2. If the two polluters can bargain costlessly, will this equal allocation be stable, or will it be modified? Explain.

*THE COMMUNITY PARK*

Suppose that we are dealing with a community of only five individuals who are considering the provision of a public good, namely, a park. Each acre of park space can be purchased and maintained at a constant marginal cost of \$20 per week. (With only five individuals, we can assume that there are no congestion costs.)

The marginal valuations (i.e., demands) of the five individuals for park space, as a function of the size of the park in acres ( $G$ ), are as follows:

Alphonse:  $MV_A = 26 - 3G$

Bertha:  $MV_B = 15 - 2G$

Carlisle:  $MV_C = 18 - 2G$

Durwood:  $MV_D = 24 - 3G$

Ernestine:  $MV_E = 21 - 2G$

These marginal values are measured in dollars per week and they are relevant only where positive.

1. What is the efficient size of park for this community and what would be its total net value to the community.
2. What are the Lindahl tax shares for each of the five individuals and what would be their respective consumer's surpluses if a Lindahl tax system were implemented?
3. What would be the consumer's surplus of each of the five individuals if the same (i.e., the efficient) size park is provided but financed by *equal* tax shares of \$4 per acre per week for each person?
4. Suppose that Carlisle acts as a free rider, contributing nothing to the provision of the park while all others contribute according to their true preferences. What size of park would be provided and what will be the community's net benefits? What will be Carlisle's consumer surplus?

*VOTING ON THE COMMUNITY PARK*

Suppose that we are dealing with the same community of five individuals who were considering the provision of a public park in Homework #4. As was the case in that problem, each acre of park space can be purchased and maintained at a marginal cost of \$20 per week and the marginal valuations (i.e., demands) of the five individuals for park space, as a function of the size of the park in acres ( $G$ ), are the same as before, namely,

Alphonse:  $MV_A = 26 - 3G$

Bertha:  $MV_B = 15 - 2G$

Carlisle:  $MV_C = 18 - 2G$

Durwood:  $MV_D = 24 - 3G$

Ernestine:  $MV_E = 21 - 2G$

These marginal values are measured in dollars per week and they are relevant only where positive.

Suppose the size of the park is to be determined by a vote of the five individuals.

1. Assume that the tax burden is to be divided equally among the five citizens, and that they all know this in advance.
  - a. What size park will each of the five individuals prefer?
  - b. What size of park will be selected, if any, if a *plurality* voting rule is used? Briefly explain.
  - c. If *majority* rule voting is used to vote on incremental additions to the park, what size park will ultimately be chosen? Briefly explain.
2. Now assume that each individual is to vote for a particular park size, and that the size chosen will be the average of these.
  - a. If all persons vote in accordance with their true preferences, what size park will be chosen?
  - b. If Ernestine is confident that her fellow citizens will vote in accordance with their true preferences, what size park should she vote for in order to maximize her own welfare?

*THE CONGESTED PARK*

Suppose that the city of Alto Palo is considering the provision of a public park. The *total* weekly value of the proposed park to the local community would be

$$V = 1600G - 600G^2 + 10XG - 0.045X^2$$

where  $G$  is the size of the park in acres and  $X$  is the average number of visits to the park each week. The *marginal* values of additional park space ( $MV_g$ ) and additional visits ( $MV_x$ ) are given by the respective partial derivatives of total value, namely,

$$MV_g = 1600 - 1200G + 10X \quad \text{and} \quad MV_x = 10G - 0.09X$$

(Note that the marginal value of additional park space depends positively on the number of visits, and the marginal value of an additional visit is positively related to the size of the park.)

The weekly cost of building and maintaining the park will depend upon both the size of the park and the number of visitors, and is given by

$$C = 400G + 0.004X^2.$$

In addition to the building and maintenance costs, there would be (external) congestion costs equal to

$$E = 0.001X^2.$$

The *total social costs* associated with the park would therefore be

$$S = C + E = 400G + 0.005X^2$$

where the corresponding *marginal social costs* of additional acreage ( $MC_g$ ) and additional visits ( $MC_x$ ) are given by:

$$MC_g = 400 \quad \text{and} \quad MC_x = 0.01X$$

Use the above information to answer the following questions:

1. What would be the optimal size and number of weekly visits for this park, and what weekly net benefits would be associated with this optimum?
2. If the optimal size park were provided and exclusion is possible, what admission price should be charged to park visitors? Accordingly, how much of the weekly building and maintenance costs should be financed by admission fees and how much by general tax revenues?
3. If exclusion is not possible, how many visitors would use the park each week (round to the nearest whole number) and what would be the weekly efficiency loss due to over congestion?

*REGULATING A CABLE TV FRANCHISE*

Gotham City is considering the grant of an exclusive franchise to Prime Time Cablevision to provide Gotham citizens with cable TV programming. The demand for cable TV is given by

$$X = 60,000 - 4000P$$

where  $X$  is the number cable subscribers and  $P$  is the monthly charge for the service. The total cost of the service is given by

$$C = 80,000 + 3X$$

where \$80,000 is the monthly fixed cost of maintaining the cable system and \$3 is the marginal cost per subscriber. (Note: The marginal cost is a constant \$3 per subscriber, not \$3X.)

For each of the following methods of regulating Prime Time, determine the resulting monthly charge(s), the number of subscribers, and the monthly net benefits for the citizens of Gotham City.

1. Require Prime time to charge a single, marginal cost price and make up any operating deficit out of Gotham City tax revenues, which generate a 15 percent efficiency loss.
2. Allow Prime Time enough revenues to cover all of its costs, but prevent it from practicing any form of price discrimination.
3. Allow Prime Time to use a two-part pricing structure that raises enough revenues to cover all of its costs and leads to the economically efficient level of service.
4. Allow Prime Time to charge any price it wants, so long as it shares any profits with Gotham City.