Econ 362 - Government Regulation of Business
College of William and Mary May 1, 2012
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Final Exam - Solutions

You have until 10:30am to complete the exam, be certain to use your time wisely. Answer all questions directly on the exam. You must show all of your work to receive full credit. Non-graphing calculators may be used (no graphing calculators or phones can be used). You may leave answers as fractions. Unless a problem says otherwise, you can assume that firms can produce fractions of units and charge non-integer prices (so a firm could produce 82.4 units and sell at a price of \$5.325 per unit). Remember to put your name on the exam. Good luck!

Name: **ID Number:**

1. (15 points) Explain two different methods for calculating the value of a statistical life. Be certain to clearly discuss the types of data used to arrive at the value of a life. Which of these two approaches do you think should be used for doing cost-benefit analyses related to product or workplace safety? Be certain to fully explain your answer.

   There are several ways of calculating the value of a statistical life. Among the approaches we discussed in class are the following:

   - Lifetime earnings - Under this approach, you value a life as the discounted sum of lifetime earnings. This calculation requires knowing, or estimating, what the future wages of an individual would be and then calculating the present value of this stream of earnings. It offers a very direct way of calculating the value of a life but it fails to account for the value of health and other non-pecuniary aspects of the value of human life.
   - Survey responses - This approach entails asking people survey questions to reveal the value they place on life. You could imagine doing this in two different ways. The first would be to directly ask them to place a value on a human life. This question is particularly difficult for people to think about. An alternative is to ask a series of questions that reveals the implicit value they place on human life. For example, you could ask a series of questions about their willingness to pay to reduce the risk of death by certain amounts. The value of a life can then be backed out from this willingness to pay and the change in the probability of death. The drawback of this type of contingent valuation survey is that people often have difficulty answering questions related to mortality and low probability events. A second issue with contingent valuation surveys in general is that the way in which questions are presented can dramatically affect the responses people give.
   - Compensating differentials - This method focuses on using people's observed behavior to reveal the value they place on their life. Under this approach, you need to observe wages for jobs with varying degrees of mortality risk. If you regress wages on the level of risk and other observable job characteristics, you can get an estimate of the additional wages people require to accept higher levels of mortality risk. The value of a statistical life can be calculated based

on this estimate. This approach has the appeal that it is based on people's actual decisions in the real world. However, it still requires an assumption that people understand the risks associated with various jobs.

As to the discussion of which approach should be used, a complete answer would point out the drawbacks associated with each approach as discussed above and then make some judgement as to which drawbacks are the least problematic or which measure is likely to be the most accurate. The measure you selected is not important for receiving full credit, what matters is that you provided a valid justification for your choice.

2. (25 points) Suppose there are two polluting firms. Firm A produces 100 units of pollution if it spends no money on pollution controls. The total costs to the firm of reducing its pollution by R_A units are given by:

$$C_A(R_A) = R_A^2 \tag{1}$$

Based on this cost function, the marginal costs of reducing pollution are:

$$MC_A(R_A) = 2R_A \tag{2}$$

if the current level of pollution reduction is R_A. Firm B also produces 100 units of pollution if it spends no money on pollution controls but it has lower costs of reducing pollution given by the following total cost and marginal cost functions:

$$C_B(R_B) = \frac{1}{2}R_B^2 \tag{3}$$

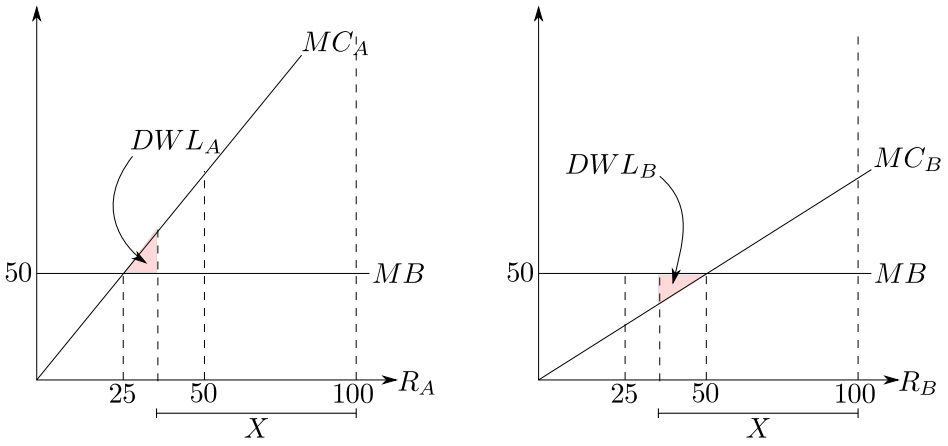
$$MC_B(R_B) = R_B \tag{4}$$

where R_B is the amount that firm B has reduced its pollution. The marginal benefits to society of a reduction in the overall level of pollution are equal to \$50 no matter what the current level of pollution is.

(a) Suppose that the regulator must set a single pollution standard. What would the most efficient single standard be? Be certain to show work to justify your answer. (Hint: It may be helpful to graph the marginal benefit and marginal cost curves to see what deadweight loss looks like under a single standard.)

Before we think about a single standard, let's actually think about the ideal situation where we could set a separate standard for each firm (something that we'll do in detail in part (b)). For the first firm, we would want the standard to be set at the point where marginal cost equals marginal benefit, which would give us R_A equal to 25. For the second firm, setting marginal cost equal to marginal benefit would give us R_B equal to 50. So ideally we would let firm A generate 75 units of pollution (100 minus R_A) and let firm B generate 50 units of pollution (100 minus R_B). If the regulator has to set a single standard, it will clearly lead to inefficient levels of pollution for at least one of the firms. The issue is how to minimize the deadweight loss from these inefficiencies.

First, note that there is no reason to set a single standard above 75 units of pollution or below 50 units of pollution. Increasing the allowed pollution above 75 units would increasing inefficiency for both firms as would decreasing it below 50 units. The question is then what level of pollution between 50 and 75 units is best. Let's consider the problem graphically. The graphs below show the marginal costs of reducing pollution for both firms and a standard, X, that is between 50 and 75 units of pollution.



Notice that we are forcing firm A to reduce its pollution too far (there are reductions being made for which the marginal costs exceed the marginal benefits) and we are allowing firm B to pollute too much (there are units of pollution that could be eliminated at a cost that is smaller than the benefits of reduction). This is generating a net loss given by the shaded areas on the two graphs. These shaded areas can easily be expressed in terms of X:

$$DWL = DWL_A + DWL_B$$

$$DWL = \frac{1}{2}(75 - X)(2(100 - X) - 50) + \frac{1}{2}(X - 50)(50 - (100 - X))$$

$$DWL = \frac{1}{2}(75 - X)(150 - 2X) + \frac{1}{2}(X - 50)(X - 50)$$

$$DWL = (75 - X)^2 + \frac{1}{2}(X - 50)^2$$

$$DWL = 5625 - 150X + X^2 + \frac{1}{2}X^2 - 50X + 1250$$

$$DWL = \frac{3}{2}X^2 - 200X + 6875$$

To find the X that makes this as small as possible, we can take the derivative with respect to X and set it equal to zero (note that full credit was given for finding an expression for the deadweight loss and recognizing that the regulator would want to make this as small as possible, doing the small bit of calculus below was not necessary for full credit):

$$\frac{dDWL}{dX} = 3X - 200$$

$$0 = 3X - 200$$

$$3X = 200$$

$$X = \frac{200}{3}$$

Notice that, as expected, this is in between the two ideal standards of 50 and 75 units of pollution. Also notice that it isn't quite halfway between the two standards. It is a little closer to the standard for firm A. The reason for this is that the marginal costs of firm A rise more quickly than those of firm B, meaning that the deadweight loss increases more quickly as you move away from the ideal standard for firm A than as you move away from the ideal standard for R_B.

(b) Now suppose that a regulator is going to set separate pollution standards for each firm. What would the efficient level of pollution be for each firm? How much has total surplus increased by switching to different standards for each firm instead of the single standard in part (a)?

This is a much simpler task for the regulator. The regulator will want to have each firm reduce pollution up to the point where the marginal cost of an additional reduction is just equal to the marginal benefit of another reduction, ensuring that all of the units of pollution for which the benefits of reduction exceed the costs are eliminated and the units of pollution for which the costs of reduction exceed the benefits remain. Setting up these equations will give us the standards for each firm (denoted below as S_A and S_B):

$$MC_A(R_A) = MB(R_A + R_B)$$

$$2R_A = 50$$

$$R_A^* = 25$$

$$S_A = 100 - R_A^*$$

$$S_A = 75$$

$$MC_B(R_B) = MB(R_A + R_B)$$

$$R_B^* = 50$$

$$S_B = 100 - R_B^*$$

$$S_B = 50$$

As for the increase in total surplus, we can just use the expression we found for deadweight loss in part (a) based on the shaded areas in the graph above. Plugging in the original standard of $\frac{200}{3}$ into this expression gives us:

$$DWL = \frac{3}{2}\left(\frac{200}{3}\right)^2 - 200 \cdot \frac{200}{3} + 6875$$

$$DWL = \frac{625}{3}$$

So when moving from the single standard to the separate standards, we eliminate a deadweight loss of (and therefore increase total surplus by) $\frac{625}{3}$.

(c) Suppose that the regulator creates 100 pollution permits and divides these permits evenly between the two firms. Assuming that the firms are allowed to buy and sell permits to each other, what will the final distribution of permits between the two firms be? Is this distribution efficient? Be certain to justify your answers.

The firms will continue to trade permits as long as the marginal costs of reducing pollution differ between the two firms. As long as those marginal costs differ, there is a price in between the two marginal costs at which the firm with the higher marginal cost would be willing to by a permit to avoid paying its high costs of reducing pollution and the firm with the lower marginal costs would be willing to sell a permit since the price is above what it will cost the firm to reduce pollution by another unit. This means the firms will trade up to the following point:

$$MC_A(R_A) = MC_B(R_B)$$
$$2R_A = R_B$$

So permits will be traded until the pollution reductions for firm B are twice as large as the pollution reductions for firm A. To pin down the exact values of R_A and R_B, we can use the fact that total reduction must equal 100 (the total pollution without reductions minus the total number of permits):

$$R_A + R_B = 100$$

Plugging in the equation we obtained from setting the marginal costs equal gives us:

$$R_A + 2R_A = 100$$
$$3R_A = 100$$
$$R_A = \frac{100}{3}$$
$$R_B = 2R_A = \frac{200}{3}$$
$$permits_A = 100 - R_A = \frac{200}{3}$$
$$permits_B = 100 - R_B = \frac{100}{3}$$

So firm A will end up with two thirds of the permits and firm B will end up with one third of the permits. We can quickly show that this is not an efficient outcome. At an R_A of $\frac{100}{3}$, the marginal cost of an additional unit of pollution reduction is $\frac{200}{3}$ which is larger than the marginal benefit of an additional unit of pollution reduction, so firm A is being forced to reduce units of pollution for which the costs of reduction exceed the benefits, generating a net loss to society. Firm B also has marginal costs of reduction that exceed the marginal benefit of reductions. The problem here is that we started with an inefficient total number of permits. Making the permits tradeable led to the most efficient distribution of permits given the total number of permits but it won't lead to the efficient outcome unless the total number of permits is efficient to begin with.

3. (20 points) Use the graphs on the next page to answer the following questions. The top graph shows the total costs and total benefits of spending on research and development related to developing new drugs for a pharmaceutical company. The horizontal axis measures the level of research and development. Costs and benefits are measured on the vertical axis. The bottom graph shows the marginal cost and marginal benefit curves for research and development implied by the top graph.

   (a) Show on both graphs what the firm's profit-maximizing level of research and development will be.

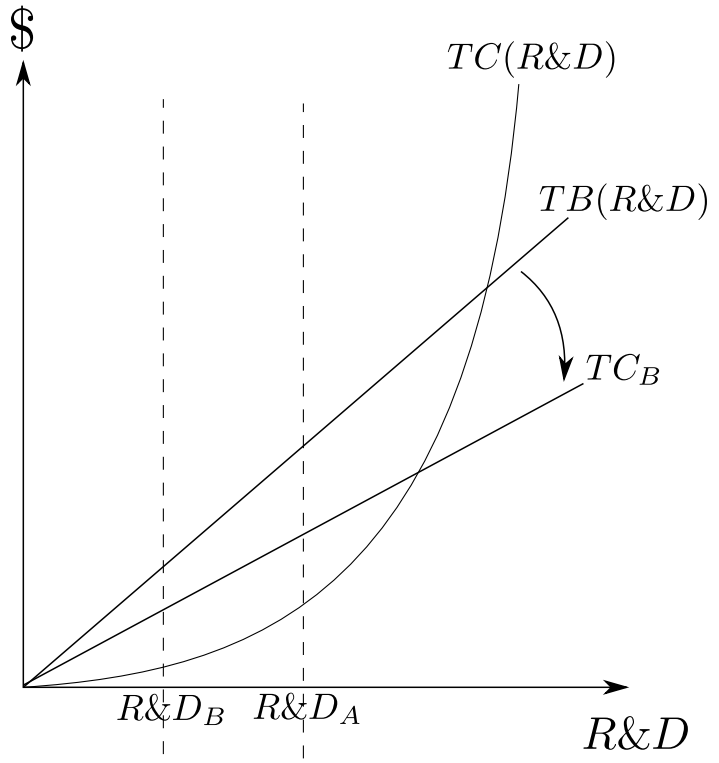
   The firm will seek to maximize profits by engaging in the level of research and development at which the benefits exceed the costs by the largest amount. On the upper graph, this is where the gap between benefits and costs is largest. On the lower graph, this is where marginal benefits are equal to marginal costs (to the left of this point, marginal benefit is greater than marginal cost so profits are increasing, to the right of this point marginal benefit is less than marginal cost so profits are decreasing). This level of research and development is labeled as $R\&D_A$ on the graph.

   (b) Now suppose that the FDA changes the rules for generics such that generics no longer need to prove that they are bioequivalent to name brand drugs, making it less costly for generics to enter the market when the name brand drug's patent expires. Use the graphs to show the effect that this will have on the optimal level of research and development from the firm's perspective.

   This policy will not have any effects on the research and development costs associated with developing new drugs. However, it will reduce the benefits of developing those drugs because the manufacturers will now face greater competition once their patents run out, driving down profits. This will lower the total benefits curve and the marginal benefits curve. This is depicted on the graph as a rotation of the total benefits curve down and to the right to TC_B and a corresponding downward shift in the marginal benefits curve to MB_B (there are other ways to draw the changes, the key is that benefits should be lower now). This leads to the new, lower profit-maximizing level of research and development $R\&D_B$.

   (c) Explain one reason why the change in policy described in part (b) may increase economic efficiency in the market for prescription drugs. Explain one reason why the change in policy may decrease economic efficiency in the market for prescription drugs.

   Economic efficiency may be increased because the increased competition from generics will drive price down closer to marginal costs after patents expire, bringing the equilibrium quantity closer to the efficient quantity where marginal cost intersects the demand curve. Economic efficiency may decrease because of the reduced incentives to innovate leading to firms deciding to not develop drugs that would have a net benefit to society.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TC(R&D)
TB(R&D)
TC_B
R&D_B
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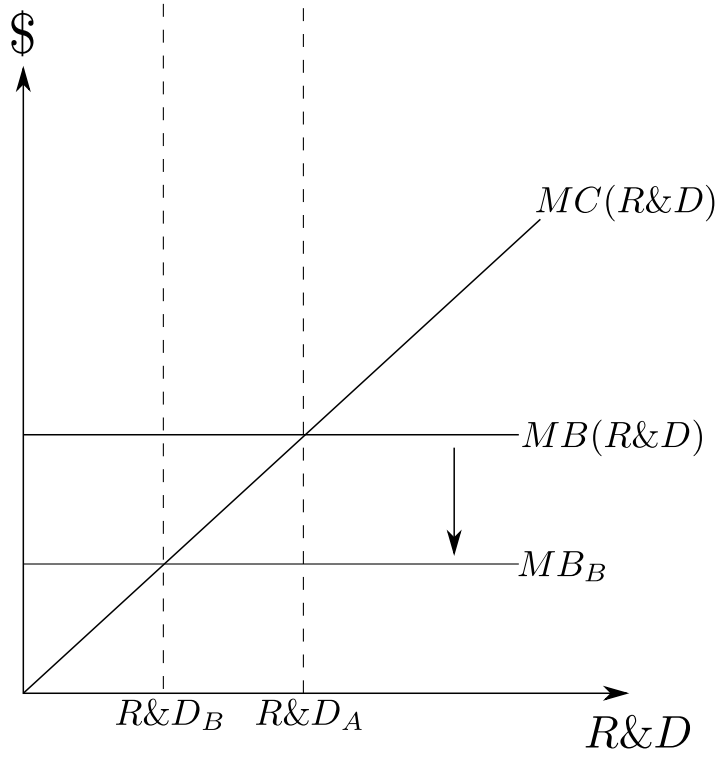
R&D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MC(R&D)
MB(R&D)
MB_B
R&D_B
R&D_A
R&D

4. (15 points) The graph below shows the total cost of water pollution to society ($C_{poll}(y)$) as a function of factory output (y). Suppose that factories exhibit constant returns. In other words, if you double the size of a factory, you double the amount of output produced by the factory and the factory's total costs (not including the environmental costs of the pollution).

   (a) Use the graph and a written explanation to demonstrate whether it is more efficient to have one factory producing 200 units of output or two factories each producing 100 units of output.

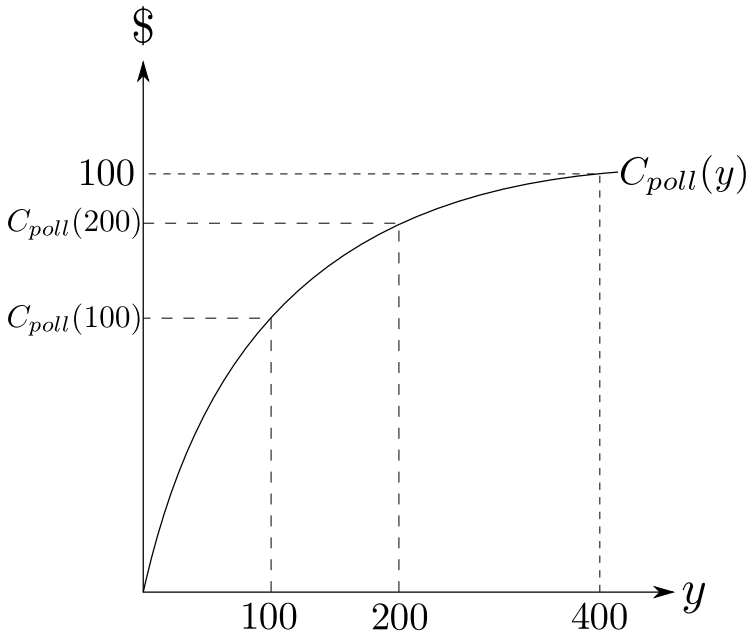
   On the graph, the environmental costs of a factory producing 200 units of output and a factory producing 100 units of output are labeled on the vertical axis. Notice that the environmental costs of a factory producing 200 units of output are less than double the environmental costs of a factory producing 100 units of output. This is due to the concave shape of the cost curve. What this means is that the total environmental costs of producing 200 units of output at one factory will be less than the total costs of producing those 200 units of output at two separate factories ($C_{poll}(200) < 2 \cdot C_{poll}(100)$). Total firm costs will be the same in each case because of the constant returns to scale and consumer surplus will be the same because the same level of output is being produced. The only difference is the environmental costs. Therefore it will be most efficient to go with the approach with lower environmental costs: a single factory should be used.

   (b) Suppose that a regulator decides to restrict the number of factories to the efficient number you discussed in part (a). Explain why issues of equity may make this regulation unpopular. You can assume that there are two counties of voters. If there are two factories, each county gets one of the factories. If there is one factory, only one county is subjected to the factory's pollution.

   The regulator will be restricting production to a single factory for the reasons described in part (a). This means that one county will be exposed to pollution and the other county will not. This raises equity concerns because the county with the factory shoulders a disproportionate burden of the pollution (all of it) while individuals in both counties presumably benefit the same from consuming the output of the factory (or sharing in the profits from the factory).

   (c) Propose a way to redistribute surplus to address the equity issues raised in part (b).

   A simple solution would be institute some manner of transfer payments from the county without the factory or consumers of the factory's product to the county with the factory. The basic idea is that if the single factory increases total surplus, there should be a way to redivide that increase in total surplus, shifting the big gains in surplus from the county without the factory to the county with the factory, such that everyone is better off. In this case, that might take the form of taxing the product produced by the factory and using those taxes to provide payments to the residents in the county with the factory (effectively transfering consumer and producer surplus to the residents suffering from the negative externality of the pollution). There are a variety of other mechanisms you could have described.


$
100
$C_{poll}(200)$
$C_{poll}(100)$
$C_{poll}(y)$
100
200
400
y

5. (10 points) Answer one and only one of the questions below. You may not choose a question based on your own group presentation.

   (a) Explain one reason the federal government may want to regulate Google's use of user information (essentially mandating that Google adhere to a very strict privacy policy). Your reason should be focused on economic efficiency.

   A correct answer needs to provide an argument focused on economic efficiency. This means that your answer should not focus on things along the lines of whether it is fair for Google to use private information, whether consumers should get a portion of the profits from the use of that information, and so on. Your answer should be focused on why total surplus would be increased by the government requiring a strict privacy policy. The most plausible argument would be one focused around asymmetric information. Essentially, consumers are unaware of the extent to which Google uses their information and would choose to not use Google if they were aware. So the consumers are mistakenly choosing a product that is reducing their consumer surplus. Preventing Google from freely using that information without the customers knowledge will prevent consumers from making those choices that actually reduce their surplus.

   (b) Explain why there may be a greater role for government regulation of automobile safety when it comes to behavioral standards than for manufacturing standards. You answer should focus on economic efficiency as the main goal of regulation.

   A typical answer to this question centers around the role of externalities. Many of the manufacturing standards relate to the safety of the driver and the passengers in the driver's car. The market will potentially lead to the efficient level of safety because people ought to be willing to pay for the level of safety they want. If people want to drive cars that provide them with little protection because those cars cost less, this is presumably the choice that maximizes the consumers' utility and doesn't necessarily require regulation. Behaviors, however, tpyically have externalities associated with them. A person speeding or texting while driving may have decided they are willing to accept the additional risk to their own safety. However, their actions also increase the risk for other cars and pedestrians and this negative externality isn't being accounted for in the decision making process. In this case, government regulation is required to take the negative externalities into account and reduce risk to the socially efficient levels.

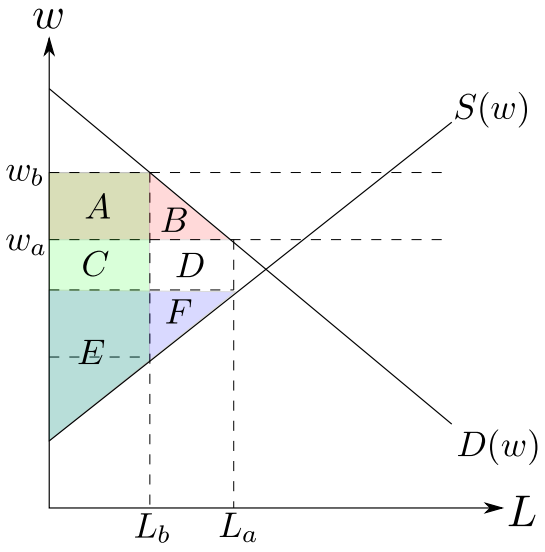
   (c) Discuss the economic rationale for labeling organic food products and the main issues regulators face with determining what content to include on labels and the design of those labels.

   Much like the question about Google's privacy policy, the main issue here is that consumers require complete information to make proper choices and maximize utility. Labels provide the consumers with the information about their food that allows them to make informed decisions, allowing them properly determine what their marginal benefit is which is essential if we want the market to reach the efficient outcome where marginal benefit equals marginal cost. When it

comes to label content and design, it is essential to provide the information that is truly necessary for consumers to make their decisions and to present it in a clear format that the consumer will notice and will be able to easily find the crucial information (too much information can be as bad as too little).

(d) Use a graph to show the economic impact of living wage legislation on worker and firm surplus in the labor market. Be certain to clearly label all key elements of the graph. Assume that a minimum wage is already in place before the living wage legislation is passed and that the living wage is higher than the previous minimum wage.

The graph below shows the change in worker surplus and the change in firm surplus from increasing minimum wage from w_a to the living wage w_b assuming that the original minimum wage was binding (above what the equilibrium wage would be in the absence of a minimum wage). Notice that the equilibrium number of employed workers falls from L_a to L_b. The surplus of workers is given by the area above the supply curve below the wage up to the equilibrium number of works. The change in the surplus of workers is therefore the area A (the gain in surplus for workers still employed and now earning higher wages) minus the area $D + F$ (the surplus lost by workers who became unemployed as a result of the wage increase). The surplus of the firms is the area under the labor demand curve above the wage up to the equilibrium number of workers. The change in the surplus of firms is therefore the area $A + B$ (this is a loss in surplus).



(e) Would allowing a la carte channels (letting consumers pay for just the channels they want) make the market for cable television more or less efficient? Would it make the market more or less equitable? Be certain to fully explain you answers.

There are a variety of possible answers you could give for this question. One possible direction to go with an answer is to think of unbundling channels as

allowing the cable company to price discriminate. Having the ability to price discriminate can actually help achieve the efficient outcome but does so by transfering consumer surplus to producer surplus (the cable company has the incentive to provide a channel to a customer as long as marginal benefit exceeds marginal cost because the company can capture any net surplus through higher prices). This transfering of surplus could be deemed inequitable.

6. (15 points) The graph below shows the market for gasoline. The demand curve is labeled as $D(p)$. The marginal costs to firms of producing an additional gallon of gasoline are constant and given by the curve MC_{firm}. The curve MC_{env} shows the marginal costs of the pollution from an additional gallon of gasoline. This marginal cost is not taken into consideration by either the consumers or producers in the industry. The total marginal costs of a gallon of gasoline including both the firm's costs and this negative externality from pollution are given by the curve MC_{social}.

   (a) Label the quantity of gasoline that will be produced in the absence of any government regulation. You can assume that the market for gasoline is competitive and that average costs for the firm are constant and equal to marginal costs.

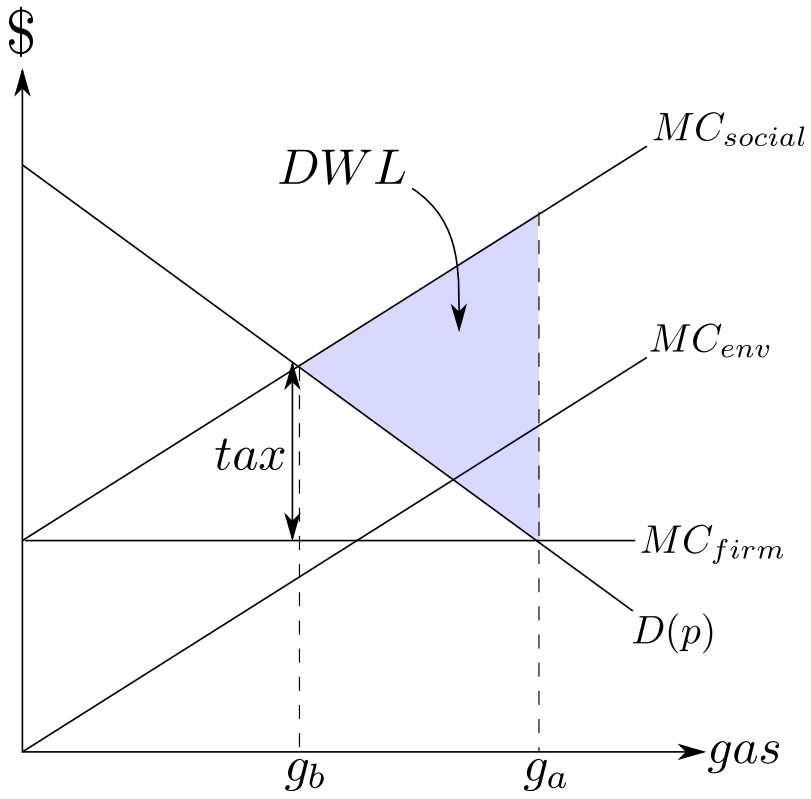
   Given that the market is competitive, price will be driven down to the point where it is equal to the firms' marginal costs. The quantity of gasoline at which this occurs is given by g_a on the graph, the quantity at which the demand curve intersects MC_{firm}.

   (b) Label the socially efficient quantity of gasoline on the graph and the deadweight loss resulting from being at the quantity in part (a) rather than this socially efficient quantity.

   The socially efficient level of gasoline will be at the point where social marginal cost intersects the demand curve. Any gallons of gasoline to the right of this point have a social marginal cost that exceeds the marginal benefit and would therefore be a net loss to society. The efficient level of gasoline is labeled g_b on the graph. The deadweight loss from being at the quantity in part (a) will be equal to the area between the demand curve and the social marginal cost curves between the quantities g_a and g_b.

   (c) On the graph, show the size of the quantity tax that would be necessary to achieve the socially efficient quantity of gasoline.

   The size of the tax that is needed to reach the socially efficient quantity is the distance between the social marginal cost curve and the firm's marginal cost curve at the efficient quantity. This distance is the same as the marginal costs of the pollution at the efficient quantity.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MC_{social}
DWL
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tax
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$D(p)$
gas
g_b
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