14.41 Midterm Solutions
Fall 2005

True/False/Uncertain [10 or 15 points]:

For those of you who took the test with Chris and did the 2nd problem, this question was worth 15 points and your exam was scaled out of 85 points. Everyone else's exam was out of 80 points, with 10 points assigned to this question.

1) [5 points] FALSE. Computing the PDV of costs and benefits:

$$PDV_{Costs} = \$50,000 + \sum_{t=1}^{\infty} \frac{\$5000}{(1+0.1)^t} = \$50,000 + \frac{\$5000}{0.1} = \$100,000$$

$$PDV_{Benefits} = \$7*(5000 + \sum_{t=1}^{\infty} \frac{1000}{(1+0.1)^t}) = \$7*(5000 + \frac{1000}{0.1}) = \$105,000$$

Since the PDV of benefits exceeds the PDV of costs, the project should be undertaken.

2) [5 points] FALSE. The cost that Peter pays for his stereo is for a high-quality system, not to compensate the people that suffer from the loud noise. The externalities aren't internalized, and the outcome is inefficient.

3) [5 points] FALSE (or UNCERTAIN). Under the Tiebout mechanism, localities can achieve optimal public goods provision if the residents are able to move to communities where the other residents have similar preferences. There are numerous reasons where Tiebout might not hold:

   a. It is costly to move between towns.
   b. There aren't always enough towns to choose from so that people can't find one with their preferred level of spending.
   c. Lump-sum taxation is politically undesirable, and towns use other taxing mechanisms (mainly property taxes). With property taxes, not everyone is taxed equally for public goods. This creates problems of free-riding by people who pay lower taxes.
   d. Education is not the only public good provided by a town. If towns offer a basket of public goods, it will be a lot harder for someone to find a town which matches her exact preferences.
   e. There are numerous spillovers from education across towns. These include reduced crime, more informed voters, and possible production externalities. This last point is especially important with education, and was required for you to receive full credit.

Problem 1 [15 points]:

1) [5 points]

	After	Before	Difference
Lexington	$28,500	$25,000	$3,500
Concord	$23,750	$22,500	$1,250
		Difference in Difference:	**$2,250**

The difference in difference causal estimate of the effects of Lexington's educational spending is $2,250. Some people thought of this in percentage terms instead of in levels (i.e. by how many more percentage points do Lexington's wages increase over Concord's?) – this is also an acceptable approach, provided the percentages were properly calculated.

2) [5 points] The D-in-D estimator assumes that the difference in earnings growth rate between the two towns is due entirely to the change in educational spending – that is, except for educational spending, nothing else occurs that impacts one town's earnings differently than the other's. This assumption is *likely* to be untrue if one finds significant differences between the towns in other variables, such as college education rates, crime rates, test scores, etc. - but even if the towns are different across some of these dimensions, it may still be true that average graduate earnings would've changed by the same amount (or the same percentage) in absence of the spending increase. So the crucial assumption is: in the absence of the educational spending increase, the earnings of graduates in Lexington and Concord would have increased by the same amount.

Given the experiment that we're considering (the comparison of Lexington and Concord), the best evidence for this assumption is to "test the pre-trends" – that is, to look at the trends in average earnings prior to the spending increase, and see if the trend in earnings was similar across the two towns. If earnings were increasing by the same amount for each town prior to the policy change, and then we witness a greater increase in Lexington once educational spending rises, then this is suggestive evidence that the earnings increase was due to the policy shift. Of course it also must be true that there was no additional policy change (or economic shock) in one town and not the other that occurs simultaneously with the spending increase and actually caused the earnings increase. This would be violated, for instance, if a big, high paying corporation moved in to one town and not the other, such that earnings increased more in one town in response.

Many people suggested comparing various variables from Lexington and other Massachusetts towns. This would provide evidence regarding whether Concord is a proper control (perhaps Lexington is in fact similar to most towns in the state, but Concord isn't – then it would be better to compare Lexington to those towns that are most similar). However, this technique still isn't strong enough to test the assumption that earnings in Lexington would have increased by the same amount as other towns in the absence of the spending increase. Why? Suppose you find that your D-in-D estimate for Lexington and Concord is quite similar to the estimates for Lexington and other similar towns in the state. If Lexington naturally has a higher growth rate (perhaps due to the industrial composition of the town), then you'll find a positive D-in-D estimate, but not

because of the spending increase – rather, just because the annual earnings increase is greater in Lexington. For this reason, the most important evidence for justifying a D-in-D estimate is examining the trends in the variable of interest (earnings) prior to the policy change.

(To receive full credit, you needed to mention using pre-trends in earnings to test the assumption).

3) [5 points] The human capital model of returns to education is that education actually improves the skill set of people (their human capital) – and hence their productivity. The screening model implies that employers view the amount of education that people receive as a signal of their inherent productivity: more productive people will achieve higher levels of education, because education is less costly to them.

An increase in educational spending should theoretically result in an increase in the quality of education provided. If the screening model of education is correct, and assuming the spending increase doesn't affect graduation rates, then the spending increase should have no effect on wages – because everyone still has the same level of education as before. If the human capital model is correct, then the spending increase should raise wages, because the quality of education received is greater than before. Since the D-in-D estimate is positive, this is evidence in favor of the human capital explanation for returns to education.

Problem 2 [25 points]:

1) [6 points] The *socially optimal* level of public goods provision is always determined by summing the marginal rates of substitution across individuals, and setting it equal to the marginal rate of transformation (many people tried to solve for an individual's choice of L and multiply this by 4 – this is *not* the socially optimal level, although disappointingly enough it will get you the right answer in this case). In this case, since we're just talking about the level of spending on each good, the "price" of C and L is 1, so the MRT is 1.

$$MRS_i = \frac{MU_L}{MU_{C_i}} = \frac{1/L}{9/C_i} = \frac{C_i}{9L}$$

$$C_i = 200 - L_i \Rightarrow MRS_i = \frac{200 - L_i}{9L}$$

$$\sum MRS_i = \frac{800 - L_1 - L_2 - L_3 - L_4}{9L} = \frac{800 - L}{9L} = MRT = 1 \Rightarrow L = 80$$

2) [6 points] It's best to think of this intuitively: since the *societal* marginal benefit from cigarettes has fallen, the social optimum should now have less cigarettes and more libraries. Remember, we don't care that individuals wouldn't internalize their externality when making private decisions – when we're looking for a social optimum, we want to find the level of C_i and L that maximizes social surplus. An alternative way to think about this is that the marginal utility that each person gets from library spending is higher than (1), since additional libraries imply fewer cigarettes for the rest of the people (this has to be true because each person is taxed equally for library provision – so an increase in libraries increases everyone's taxes and reduces their cigarette consumption).

Some people tried to write out the new MRS and thought that it actually equals the old MRS, and reasoned that therefore there shouldn't be a change in libraries from (1). This is not correct, because the marginal utility of libraries is in fact different in (2) than in (1); the new marginal utility of libraries includes not only the benefit from libraries, but also the benefit each individual receives due to the reduction in cigarette consumption from the other three.

3) [7 points] Now, each person tries to decide how much of a lump tax should be used to finance library construction. Just by examining the utility functions, it should be clear that person 1 is the median voter (because person 5 likes libraries more than 1, and person 6 likes cigarettes relative to libraries more than 1). You also needed to state that the median voter theorem applies because each person has single-peaked preferences (which should be obvious from inspection of their utility functions). Person 1's problem is:

$$\left.\begin{array}{l}\max\ 9\ln C_i + \ln L \\ st\ 200 = C_i + \frac{1}{3}L\end{array}\right\} \Rightarrow L = 60 \Rightarrow T = 20$$

Here, the "price" of libraries is 1/3 because person 1 only has to pay for 1/3 of library spending.

You could also think about person 1's problem as:

$$\begin{array}{l}\max\ 9\ln C_i + \ln 3L_i \\ \quad st\ 200 = C_i + L_i\end{array}$$

(i.e. choosing an individual level of spending, given that everyone else has to pay the same amount). This gives the same answer. It is *not* correct to say that the outcome will be person 1's choice from question (1) – *because question 1 was about a social optimum, and not a private decision! Person 1 has no choice in question 1!!!* Also, it is not correct to simply solve:

$$\begin{array}{l}\max\ 9\ln C_i + \ln L_i \\ \quad st\ 200 = C_i + L_i\end{array}$$

Even though solving this gives L_i=20, and multiplying by 3 would coincidentally enough give the right answer, this technique demonstrates a lack of intuition behind the problem, because you'd be treating libraries as a *private* good in this case.

4) [6 points] Majority voting, in general, is not efficient because the *intensity* of preferences is not taken into account – that is, the median outcome, rather than the mean preferred level of outcome, is what results from majority voting. In this case, person 5 really likes libraries, so his preferred level of spending on libraries is much different from person 1's. Person 6's preferences are very close to person 1's, so his preferred level of spending on libraries will be very close to person 1's. The median outcome will be person 1's choice – but the mean of their preferred outcomes will be much closer to person 6's. The social optimum would account equally for everyone's benefits, and so 6's high level of preferred spending would result in a social optimum much higher than that under majority voting. Note that the inefficiency of majority voting does not result from "free riding" – since there is no individual contribution to the public good, there is no way for one person to free-ride on the contributions of another.

Problem 3.

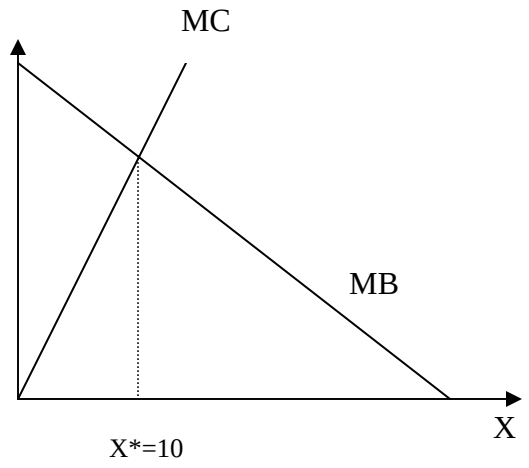
1) [6 points] As was discussed in class, unhealthy behavior (in this case, working near asbestos) can impose externalities if the additional costs of health care are borne by others. This occurs with public health programs, such as Medicare, because premiums are equal regardless of exposure, but payments most likely increase with exposure (although they could decrease due to premature death). In addition, there could be externalities in the private insurance market if the extra risk is not accounted for by additional premiums. Other externalities could be imposed on people working or living in asbestos-containing buildings if those people were not compensated. However, because the question mentioned that asbestos mainly harmed construction workers, this second explanation was not sufficient for full credit.

2) [6 points] If the workers faced a 2% increase in the chance of death and made an additional $100,000 in their lifetimes, the implicit value of life is $100,000/0.02 = $5 million.

   This might not be the true valuation of life because, as stated in the question, exposure can cause non-fatal disease. To the extent that the workers have to bear these health costs, part of the $100,000 would compensate for these costs in addition to the risk of death. Thus, you would expect the value of life to be *less* than $5 million.

   Many of you mentioned that these valuation exercises extrapolate the risks linearly, and that the first small amount of risk may not take on the same value as the 100th percent. Additionally, asbestos workers may have different valuations of life than the population at large, so that the valuation may not represent a good valuation of life for non-asbestos workers. These are also correct, although a perfect answer would have included something about the risk of non-fatal disease.

3) [6 points] MC=8X, MB=100-2X. The optimal level of abatement is the level when the curves cross, or 100-X=10X, X=10.



The private market will reach the socially optimal level of abatement if the conditions of the Coase Theorem hold, i.e., if there are well-defined property rights (either the right to use asbestos on the part of the firm or the right to not be exposed on the part of the workers) and costless bargaining between workers and firms.

4) [6 points] Tradable permits only work when the social value of abatement at one site is the same as at other sites (as is the case with many forms of air pollution). In the case of asbestos, the benefits are highly localized: workers in the asbestos-containing building are affected. The social benefit of abatement may be very different across different buildings. And given a fixed number of permits, the market won't account for these different benefits; it will merely equalize costs across sites. Workers in firms that purchase permits may suffer disproportionally, and the social optimum may not be achieved. This was probably the hardest question on the exam, and very few got it right.

5) [6 points] The underlying assumption is that in the absence of asbestos exposure, the cancer rates of workers who worked in these industries would be the same as the rates of workers in the non-asbestos industries. In the terminology from class, the workers in other industries are an unbiased approximation of the counterfactual case where the asbestos industry workers were not exposed.

This assumption may not hold if the underlying tendency of asbestos industry workers to get cancer is higher than that of workers in other industries. This could be caused by unhealthy behavior in general, the specific case of lung cancer was intended to point you towards another risky behavior, smoking. Smokers may be more likely to work in industries with asbestos exposure. Thus, the additional lung cancer could be caused by smoking and not asbestos.

Small aside: As the dangers of asbestos exposure have become well known, asbestos firms have been ordered by the courts to pay damages to former employees who currently are suffering from lung diseases. Over the last several

years, these firms have filed a number of lawsuits against the large tobacco companies, claming that many cases of lung disease were actually being caused by smoking and not asbestos. For the most part, these lawsuits have not been definitively resolved. It is indeed hard to determine the true causal effects!