Econ 4545 Environmental Economics

Review Questions- Set 4

Revised November 22, 2014

Global Warming, Discounting, Present Value, Social Rate of Discount, etc.

1. What is the present value of $50,000/yr for 20 years if the discount rate is .10? As part of your answer, define present value and discount rate. Why is the present value of this stream less than $1,000,000? Show all of your calculations and explain them in words.

Answer: I am going to answer this and the next question assuming discrete discounting, what was presented in class. Simply put, present value is the value today of some stream of net benefits through time: what it is worth today. For example, the present value of $1 received today is $1, the present value of a $1 received a year from today is $1/(1+r) where r is the discount rate, and the present value of a $1 received a year ago is $1(1+r). The present value of $n received t years from today is $\$n/(1+r)^t$. In explanation, r and the discount formula identify the rate at which the economic agent in question (individual, society, etc.) trades off net benefits of the same magnitude received today and in the future. Consider the general formula for a net benefit of $n in period t, $\$n(1+r)^t$, where t=0 is the present, t<0 is t years in the future, and t>0 is t years in the past. In explanation, r and the discount formula identify the rate at which the economic agent in question (individual, society, etc.) trades off net benefits of the same magnitude received today and in the future.[1]

Put simply, discounting using the above formula assumes we discount such that present value is reduced by the same percent for each year the payment occurs in the future. Maybe this is not how preferences work.

If r = .10, the present value of $50,000/yr for 20 years, starting now, is

1 As an aside, one can also treat time as a continuous rather than a discrete flow. In which case $PV = \int_{t=0}^{\infty} NB(t)^{-rt}\,dt$ where $NB(t)$ is the net benefit at point in time t.

$50{,}000 + 50{,}000/(1.10) + 50{,}000/(1.10)^2 + ... + 50{,}000/(1.10)^{19} = \sum_{t=0}^{19} 50{,}000/(1.10)^t = \$468{,}250$
$= 50{,}000 + 45{,}454 + 41{,}322 + ... + 8175$. This

PV of this stream is less that $1 million because with a positive discount rate benefits received in the future are "discounted" (worth less) than if they were received today, and discounted more the farther in the future they occur. That is, the discounter cares less about a net benefit in the future than they do about a net benefit of the same magnitude today, and the farther in the future the less they care about it today.

Interestingly, many students answered the question assuming the 20 payments would start next year, rather than today. This obviously leads to a smaller PV, one losses 50,000 for the payment today) and gains 7,432 for the payment 20 years from now.

2. How much will you have in the bank after three years if you invest $1 in the bank today and the market rate of interest is 5%? Continuing to assume a market rate of interest of 5%, what is the present value of a $1 received four years from now? Show all of your calculations and explain them in words.

Answer: $((1(1+.05))(1+.05))(1+.05) = 1(1.05)^3 = \$1.1576$ The present value of a $1 received four years from now is $1/(1.05)^4 = \$.8227$

3. Assume there are three time periods left before the final, including now, next week, and the final. You are considering studying more for the final now, but need to determine whether it is in your interests to do so. Assume the benefits from studying more this period have no benefit to you this period or the next, but have benefits to you of $100 during the final. However the opportunity cost to you of studying more this period is $80. What range would your personal rate of interest have to be to make studying more this week a bad idea? Explain your answer and show your work.

Answer: PV=-80+0/(1+r)+100/(1+r)². Simplifying one gets, PV=-80+100/(1+r)². Let's see at

what r PV=0. 0=-80+100/(1+r)² implies 80=100/(1+r)² or .8=1/(1+r)² or 1/.8=(1+r)²= 1. 25 implies 1+r=(1.25)^{.5}= 1. 118=1+r so the r at which PV is zero is approximately 12%.If you discount rate is greater than 12% don't put in the extra time studying. If it's less than 12% do it, if your interest rate is 12% you're indifferent.

4. What does a negative rate of discount imply? A rate of zero?

5. How would you determine the present value of a stream of benefits and costs?

6. Why are market rates of interest positive?

7. Define the term *social rate of discount*, and discuss its significance for environmental policy making.

8. Provide at least four reasons why the social rate of discount should be positive.

9. Personally, at what rate do you think society should discount the future? Provide some economic or non-economic justifications for your conclusion.

10. Some have argued that rather than allocating resources to reducing the rate of GW we should allocate those resources to increasing the standard-of-living in the poor countries that will be most adversely affected by GW.

In a page or less (typed and sent to me electronically) cover the following.

Describe the basic rationale for this recommendation

Is the argument for doing this an efficiency argument, an equity argument, or both?

What is the role of the social rate of discount in this argument?

Are there assumptions under which this recommendation is more or less sound?

How does the soundness of the recommendation depend on the rate and effects of GW?

(Before answering make sure you have done the relevant readings, and feel free to cite relevant articles or facts. You can insert links)

Write as if you are explaining and critiquing the recommendation for a senior undergraduate in Economics, onewho has great grades, but, unfortunately, never took environmental economics.

I will grade your answer as if, he were that person.

Write out the recommendation and your critique of it as if it will become lecture notes for the course.

A 10 grade would be something I can put directly on the web page, with no edits. What I would like to do.

A 9 would require a few small edits, correctly getting the major points across, unflawed

An 8 would be a good answer with a few flaws.

Repeating:

Some have argued that rather than allocating resources to reducing the rate of GW, we should allocate those resources to increasing the standard-of-living in the poor countries that will be most adversely affected by GW.

Answer: While not always explicit, the recommender seems to be assuming a number of things:

1. That GW will mostly affect the poor in poor countries that border seas or oceans and that are, relatively speaking, near the Equator. This is not explicit, but the presumption is that GW will affect some countries more than others, and affect some richer counties little on net, if at all.

2. In step with the first assumption, is the implicit assumption that GW will not be catastrophic for the planet. He is not addressing a scenario where life on earth, as we know it, hits the fan. Whether GW will, or won't, cause the shit to hit the fan is an empirical question.

3. There is likely the implicit assumption that resources allocated now to retarding GW will not immediately have influence.

4. The future should be discounted, but not necessarily a lot.

5. The goal is to help the poor that will be impacted. He takes this as a given. His justification for this is probably that most of the rest of us will not be drastically affected. And that the suffering poor deserve our attention. This is an equity/fairness goal.2

6. It is possible to increase the standard-of-living of the poor impacted population(s).

An economist would say that if the intent is to allocate a given amount of resources to helping a population (in this case the poor that will be affected by GW) those resources should be allocated so as to maximize the net benefits to that population. Since we are talking about now into the

2 The goal might, in fact, be inefficient if society is defined as all people now and in the future. The WTP on the part of the poor in the impacted countries to increase their SOL might be less than what it costs people in the developed countries to increase the SOL in those poor countries. Recollect that that, ceteris paribus, the lower one's income the lower one's WTP.

future, the economic goal would be to maximize the present value of the net-benefit stream from the investment.

It that is the intent, then it would, in general, be incorrect, to say the resources should be allocated to a addressing a particular problem. For example, if the intent is to spend $10,000 making Edward better off, it would be counter-productive to say that all it must be spent to replenish his quickly depleting wine cellar, even though he dearly loves wine. There are likely better ways to spend the money, even if the sole intent is to increase Edward's welfare.

The recommender is being a contrarian in that, like all good economists, he questions whether what "everyone" wants to do—retard the rate of GW—is the best thing to do.

Putting a restriction on how the resources must be used cannot be efficiency increasing, and is likely efficiency decreasing. This does not imply that none of the allocated resources be used to fight GB, only that there should not be a requirement that they are used exclusively to fight GW.

Given assumption 3 (that resources allocated to retarding GW will only have longish-run influence), the higher the SRD, the sounder his proposal.

The logic of his proposal is based on the six assumptions listed above. For example, if it is impossible to increase the standards-of-living in poor Equatorial countries, there is no justification for his proposal.

His proposal also makes no sense if the one rejects the equity presumption that rich developed countries have an obligation to helping the poor that will be affected by GW. Many would reject his equity presumption.

A relevant reading is

The Cost of Combating Global Warming, Thomas Schelling, Foreign Affairs, Nov-Dec 1997

Thomas Schelling won the 2005 Nobel Prize in economics for his work in game theory and conflicts. In this article, which you have read, he feels that society should consider spending resources to increase the SOL in the impacted countries instead of retarding the rate of GW.

Some comments on some of your essays

It is correct to say that the more wealth a country has the better it will be able to mitigate the negative effects of GW. But the recommendation for increasing the SOL for the impacted poor is not based on the premise that the best way to fight the effects of GW is to make people better off. The recommendation is based on the presumption that the goal is to make people better off. While better preparing people to live with GW will make them better off, this is not the motivator for the recommendation; it is an important aside.

One could start their answer to the quiz with the assumption that the goal is either to (1) retard the rate of GW, or (2) build infrastructure to reduce the impacts of GW, or (3) some combination of these two.

If an economist were given one of these goals (economists do not very often get to decide where resources should be spent), she would argue that that efficiency requires that given the goal, it should be achieved at minimum cost.

However, an economist would say the primary goal is to make people better off, not to reduce the rate of GW or to build dikes. So, if you start with the assumption that the goal is to reduce or fight GW, you are missing the main economic point.

So, the above might sound a bit crazy. Keep in mind that the goal of environmental policy is not necessarily to make the world a cleaner and more pristine place, the goal is to use society's scarce resources to maximize the benefits to society's members. Sometimes having more pollution is

worth it. That is why environmentalists often conclude that environmental economists are traitors to the cause.

Now it is the case that policy makers often set goals with little consideration of efficiency. For example the law might say that the level of a pollutant in the air (ambient air quality) needs to be at a level where no one's health is negatively impacted (an economist would say this is not likely efficient). But given the goal/law is in place, an economist would advise that the goal should be achieved at minimum cost.
Make sure you have read

Achieving Environmental goals at minimum cost

You might reasonably reject this economic way of looking at the world (many do, maybe me) but then you are not being a good economist. That said, there is no rule that says you have to be a good economist. Remember economists might envision a scenario where the best thing to do is to drive people to extinction; even most people would conclude that envisioning such a scenario is nuts.

Why might you, and other reasonable people, reject the goal of maximizing the PV of net benefits to people? There are lots of good reasons. (1) You think *sustainability* is the primary goal, not efficiency or equity (2) You do **not** equate "good" with more pleasure and less pain. For example, you might think that what is good and what is bad is determined by the "Word of God." (3) You might believe that the primary goal should be to protect the planet in its "natural" state, etc.

However, do not reject the goal of maximizing the PV of net benefits to people because you are unclear about what that implies.

Alexander's main concern (a past grader) was that some of you have flaws in your understanding of efficiency. He also felt that you might not realize the significance of discounting for this

question. Put simply, if you are poor you would probably prefer a higher SOL now than in the future (poor people typically have a high discount rate). But if "society" has a discount rate of zero, then giving immediate help to the poor of the impacted countries might not be the way to go.

11. So, the U.S. Government has decided to impose a tax **on oil** to reduce CO_2 emission. Note that this tax on oil will raise the price of gasoline and all other products made from oil such as heating oil and jet fuel. Convince me that increase in the oil tax **might** increase, rather than decrease, CO2 emissions. How might one change the policy to make it more likely that the policy will decrease CO2 emissions?

Write you answer for a student of intermediate microeconomics. You might want to utilize isoquants to make your points. There will be a bonus for the best answer. I would like an answer I could post directly into the set of review questions.

You might want to include in you answer some data on how much CO2 is emitted when oil is burned vs. other energy sources. Thanks.

Answer: CO2 is produced whenever a carbon-based fuel is burned, and oil is not the only carbon-based fuel; coal is a carbon-based fuel. If the government taxes one carbon-based fuel and not another, the tax will cause some users to switch fuels from the taxed to an untaxed carbon-based fuel, or from the taxed fuel to a non-carbon-based fuel. For example, users will be more likely to heat their house with coal and propel their car with coal, or natural gas.

Let's break the analysis down into two parts: substitution in production and substitution by consumers. So, initially, artificially assume that the amount of useable energy produced is not affected the oil tax and address the issue of how the tax will affect how useable energy is produced.

One can directly heat one's house with coal (when I was little my house was heated with coal) or indirectly heat one's house with coal (electric heat where the electricity is produced by a coal-burning power plant). Coal-fired cars are not common, but one can switch to an electric car where the electricity comes, most likely, from a coal-burning power plant. If the tax on oil were high enough, everyone, in the longrun, would switch out of oil towards other sources of energy.

The substitutes for oil include, coal, natural gas, nuclear energy, solar energy, hydropower, and a few more. Only the first two are carbon based. Consider a world where usable energy can be produced with any of these inputs. The cost-minimizing energy-source combination for an energy producer will depend on the state of technology for producing useable energy (a production function)

Picture, for example, an isoquant for producing 1 million watts of energy; it will be a dish in six-dimensions. (First think more simply with oil on one axis and all other energy sources on the other axis.) How easily one can switch out of oil will depend on marginal rates of technical substitution, MRTS, for example the MRTS between oil and natural gas and the MRTS between oil and coal.

Before the tax increase, given the relative prices of the different energy sources, producers will choose the combination of energy sources that minimize its cost of producing useable energy. The cost-minimizing input combination will vary as a function of what is being produced (e.g. steel as compared to miles driven), even though every producer faces the same energy-source prices. Given the current state of technical knowledge for producing useable energy and give the prices of the different energy sources, a lot of oil is burned—it is cost effective.

Consider what happens when the tax is imposed on only oil. Producers will substitute away from oil. How much and to what extent will depend on the MRTS and on how much the tax has changed relative prices.

So, after the tax more of our power **might** come from coal, so this switch could, in theory, cause an increase in CO2 emissions. To make sure this does not happen, an easy fix is to have a carbon-based tax rather than an oil tax: a tax on fuels based on their carbon content. In this case oil, coal, natural gas, and wood would all be taxed. If the intent is to tax the use of carbon, tax it directly; an oil tax is not a direct tax on all types of carbon. A carbon tax would cause substitution from CO2 intensive sources to less-intensive CO2 sources, and substitution from CO2 sources to non-CO2 sources.

Note that the oil tax might reduce CO2 emission if it leads, for example, to a greater use of natural gas. If one produces a given amount of energy with gas it will emit less CO2 than if one produced that amount of energy with oil.[3] Whether we would switch more to coal or more to natural gas depends on the MRTS between oil and natural gas, the MRTS between oil and coal, and the relative prices of natural gas and coal.

The oil tax could also reduce CO2 emissions if it leads to a greater use of non-carbon based energy sources: solar, nuclear, etc. It all depends on how easily the different sources substitute for one another and relative prices.

Basically you answer to here should be an explanation of how firms choose **how** to produce their products—applied to energy production.

Now consider the effects of the oil tax on the prices of products:

The relative prices of oil-intensive goods will rise. This will cause the demands for these goods to decrease. If this is all that happened this effect by itself would, ceteris paribus, push CO2 emissions downwards. But everything else is not constant. If, for example, the effect is to increase the demand for coal-intensive goods things could go the other way.

In summary:

The oil tax will cause producers to substitute away from oil and cause consumers to substitute

away from oil-intensive goods, but whether this increases or decreases aggregate CO2 emission depends on MRTR, MRS, and prices.

12. Argue that it is not worth it to allocate current resources to reducing global warming. Now argue that significant resources should be allocated to reducing global warming.

13. What, if anything, do you personally think should be done about global warming? Provide economic argument to justify what you think should be done.

14. Assume significant resources should be allocated to reduce CO2 emissions. Where should these resources be allocated on efficiency grounds and why? Assume your audience is students in a principles micro course. Convince them of your answer.
Is your conclusion "as to where" fair. Discuss

Answer: Put simply, the resources should be allocated so that they maximize the resulting reduction in CO2 emissions. That is, where the marginal cost of reducing CO2 emissions are the smallest. Efficiency dictates that one minimizes the cost of whatever CO2 reduction occurs, or said another way, for a given expenditure on CO2 reduction, efficiency dictates that the amount of the reduction be maximized.

This implies that a lot of the reduction in emissions should occur where emissions are the result of primitive technologies (technologies that are carbon intensive rather than capital intensive). This will likely be in developing/poor countries where production tends to be more carbon intensive. Capital is relatively more expensive in poor countries. A technology is more "carbon efficient" if it uses less carbon fuels to produce the same amount of stuff, be it products, warm homes or cooked meals.

33 Note that natural gas wells often emit methane, which is a GW gas. But the question is only about CO2.

Is this fair? It depends on who is paying for the resources. If it is the poor country, yes it would be unfair by the standards of many. If the cost is being paid by rich countries, no.

Christina (a former grader) noted, "Many students answered the question in terms of permits and not resources. Also, many students understood that it would be efficient to reduce CO2 in developing countries because the technology is more carbon-intensive there, but didn't necessarily understand that meant the MC of reducing carbon emissions was lower there, which was in fact the reason why reducing CO2 was more efficient there. Also, many students neglected to answer the fairness issue altogether (which also followed from the fact that many students based their arguments on developing a permit system), and out of those students who did answer the fairness question, very few actually noted that fairness could be achieved depending on who pays for the emission reductions. Most of them just said it wasn't fair, or that fairness was a normative issue and was unimportant.

15. What is global warming, what causes it, and why?

16. List some possible benefits of global warming.

17. Assume that the U.S. must reduce the emissions of greenhouse gases to pre-1990 levels. Suggest a method of accomplishing this task at minimum cost (efficiently) and explain why it accomplishes the task at minimum cost.

18. Assume that the U.S. must reduce the emissions of greenhouse gases to pre-1990 levels. Discuss the efficiency and equity implications of achieving this goal using a global permit system for greenhouse gas emissions (CO_2, N_2O and CH_4). How might such a system work? Would such a system require different permits for different gases? As part of your discussion, consider the efficiency, equity, and political implications of different rules for distributing the permits.

19. Is global warming the result of a market failure? If so, what kind and why?

20. Are automobiles a significant contributor to the production of greenhouse gases? If so, how and why? What would need to be done to reduce their contribution? Suggest a feasible method of reducing the amount of CO_2 emissions produced by cars. Why are car makers concerned about policies to reduce the rate of global warming?

21. Is the cost of global warming a function of the rate of warming? Yes or no, and explain why?

22. Briefly outline how the costs and benefits of global warming are likely to be distributed by location, income level, and generation.

23. Are greenhouse gases stock or flow pollutants? What are the policy implications of your answer?

24. Is there anything good about that fact that greenhouse gases are global pollutants? Explain. As part of your answer define global pollutants.

25. Could some pollutants partially offset the impact of increasing concentrations of greenhouse gases on global warming?

26. Is the marginal cost of decreasing the emissions of greenhouse gases likely greater or smaller in developing versus developed countries? Why? What are the implications for reducing these emissions in the minimum cost way?

Some General Question

1. Are uniform emissions standards cost-effective for achieving a given amount of emissions reduction? Discuss.

2. Write a short essay that discusses, from a regulatory perspective, the distinction between fund and stock pollutants.