# EC313-Fall 2013

Midterm

1:10-2:10pm, October 24, 2013

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*You will have 50 minutes to complete this exam. Anyone still working on their exam after this time expires is subject to an automatic penalty of not less than 5 points. No notes or books are allowed, but you may use a calculator. Cell phones and any device with a wireless connection must be off.*

*When you write up your answers, your goal should be to (1) be correct, and (2) convince your reader that your answer is correct. Answers which do not achieve these goals will not be awarded full credit. To accomplish the second objective, it is helpful if your work is legible and if all steps are presented, possibly with a line of explanation. Total points =100/Share of total grade =35% .*

1. (25) The Nanticoke coal fired power plant is the largest in Ontario and one of the largest on the continent. At its peak, it generated 24 billion kWh per year, although it is currently operating well below that level. The lifetime of these sorts of power plants is usually about 40 years.

   Suppose that the Nanticoke power plant runs for 40 years at 20 billion kWh/year. Calculate how much cooler the world would be in 2100 if this plant had been nuclear rather than coal fired.

   You may find the following constants useful for this calculation: Nordhaus rule of thumb, doubling $CO_2$ concentration from 280ppm to 560ppm causes 3 degrees Celsius of warming by 2100; 1ppm of atmospheric carbon weighs 2.12 Gt; one kWh causes about 0.95 kg of $CO_2$ emissions; 0.55 of each unit of $CO_2$ emissions remains in the atmosphere after one year; 44/12 tons of $CO_2$ contains one ton of carbon.

2. In their 1995 paper in American Economic Review, Mendelsohn et al estimate the relationship between US agricultural land rent, and temperature and rainfall in four seasons. Simplifying a little, they estimate that

   $$\text{rent/acre} = 1490 - 57 \times \text{January temp} + 75 \times \text{January rain} + \epsilon,$$

   where rainfall is inches and temperature is degrees Fahrenheit.

   To make things easy, suppose that initial January temperature and rainfall are zero. Suppose that there are two competing climate models. The first predicts 1 degree of warming and 2 inches of rain for January. The second predicts 2 degrees of warming an one inch of rain. Finally, suppose that $\epsilon$ is a random variable that takes the values 200 and minus 200 with equal probability.

   (a) (10) Calculate the expected change and standard deviation of land rent if the first climate model is correct. Repeat these calculations when the second climate model is correct.

   (b) (10) Suppose that you think both climate models are equally likely and that the draws of $\epsilon$ are independent of which model is true. Calculate the expected value and standard deviation of land rent for this case.

   (c) (5) In this example, does climate model uncertainty increase or decrease our uncertainty about the effect of climate change on land rent? Explain briefly.

3. (25) Consider the following data set:

| year | temp |
|---|---|
| 1980 | 10 |
| 1981 | 10.1 |
| 1982 | 10.2 |
| 1983 | 10.3 |
| 1984 | 10.4 |
| 1985 | 10.5 |
| 1986 | 10.6 |
| 1987 | 10.7 |
| 1988 | 10.8 |
| 1989 | 10.9 |

Consider a stata program which loads this data into memory and then executes the following commands:

```
 gen temp_avg = temp;
forvalues i = 1(1)9{;
   replace temp_avg=temp_avg[_n]+temp[_n-‘i’];
   };
replace temp_avg=temp_avg/10;
twoway scatter temp_avg year;
```

recalling that stata places the first argument of the twoway command on the y axis and the second on the x axis, draw the graph resulting from this program.

4. (25) Let $t = 0,1,2,...$ index years. Suppose that one ton of $CO_2$ emissions today causes 0\$ of damage for $t < 100$ and 50\$ of damage for $t \geq 100$ and $t \leq 1000$. Let $M$ denote the amount spent on mitigation at $t = 0$. If the interest rate is $r$ how much will a planner who maximizes the discount present value of consumption be willing to spend on abatement to reduce future damage to zero.

# EC313-Fall 2012

Midterm solutions
October 23, 2012
Matt Turner

1. 20b kWh for 40 years is 800b kWh over the lifetime of the plant. Each kWh generates about 0.95kg Co2, so the plant generates 76b kg or 0.76 Gt of CO2 emissions over its lifetime. Converting this to C by multiplying by 12/44 gives 0.2 Gt of C emissions. About 0.55 of each unit of emissions stays in the atmosphere so we have 0.11 Gt of atmospheric carbon over the lifetime of the plant. Converting to concentration by dividing by 2.12 GtC/ppm this is 0.052ppm increase in concentration.

   From the Nordhaus rule, a 280ppm increase in concentration causes 3 degrees Celsius of warming by 2100, so each unit of concentration causes about 3/280 degrees of warming. It follows that over the course of its lifetime, the Nanticoke plant will generate enough emissions to cause about 0.052 *times* 3/280 = 0.0006 degrees of warming by 2100.

   There are well over 1000 coal fired power plants in North America, however, the Nanticoke plant is quite large and accounts for between one half and one percent of all coal fired power in North America. Scaling our calculation above, suggests that replacing all coal fired plants with nuclear plants would reduce warming by 0.05 to 0.1 degrees in 100 years.

2. (a) Under the first climate model land rent is a lottery, $R_1 = (1383, 1783, \frac{1}{2}, \frac{1}{2})$. Under the second climate model, we have $R_2 = (1251, 1651, \frac{1}{2}, \frac{1}{2})$.
   The expected values of these lotteries are:

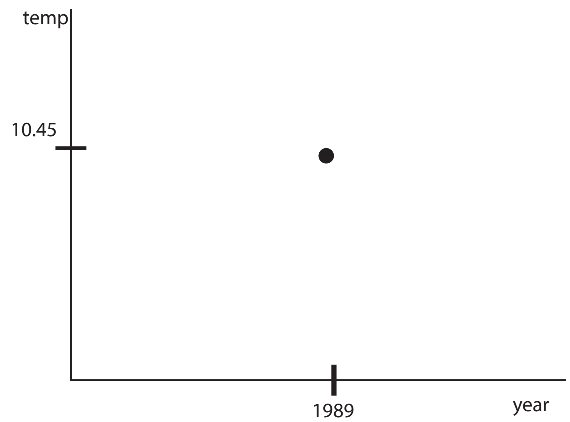
$$\begin{aligned} E(R_1) &= \frac{1}{2}(1383) + \frac{1}{2}(1783) \\ &= 1583 \\ E(R_2) &= \frac{1}{2}(1251) + \frac{1}{2}(1651) \\ &= 1451 \end{aligned}$$

   The standard deviations of these lotteries are:

$$\begin{aligned} sd(R_1) &= [\frac{1}{2}(1383 - 1583)^2 + \frac{1}{2}(1783 - 1583)^2]^{\frac{1}{2}} \\ &= 200 \\ sd(R_2) &= [\frac{1}{2}(1251 - 1451)^2 + \frac{1}{2}(1651 - 1451)^2]^{\frac{1}{2}} \\ &= 200 \end{aligned}$$

   (b) If we think each climate model is equally likely then land rent is described by the compound lottery $R_3 = (R_1, R_2, \frac{1}{2}, \frac{1}{2}) = (1383, 1783, 1251, 1651, \frac{1}{4}, \frac{1}{4}, \frac{1}{4}, \frac{1}{4})$. Calculating mean and standard deviation in the usual way, we have $E(R_3) = 1517$ and $SD(R_3) = 210.6$.
   Since model uncertainty increases the standard deviation of our prediction, it increases our uncertainty.

3. The code calculates a moving average based on the current value and the preceeding 9 values. Since only 1989 has 9 trailing values, this is the only year where this moivng average can be evaluated. The resulting graph will look like this:




4. The discounted present value of damage is:

$$
\begin{aligned}
&\sum_{t=100}^{1000} \delta^t 50 \\
&= \delta^{100} \sum_{t=0}^{900} \delta^t 50 \\
&= 50 \frac{\delta^{100}(1-\delta^{901})}{1-\delta}
\end{aligned}
$$

But $\delta = 1/(1+r)$, so this equals

$$
50 \frac{(\frac{1}{1+r})^{100}(1-(\frac{1}{1+r})^{901})}{1-(\frac{1}{1+r})}
$$

The planner should be willing to spend any amount less than this, or with smaller discounted present value, to avoid this damage.