14.03/14.003 Exam 3
Fall 2014
SOLUTIONS

Professor David Autor

Monday, 12/15/2014

Instructions

- Please do not open this exam until directed
- There are 80 points on this exam and you have 120 minutes to complete it.
- You may not use a calculator (there is no need for it).
- No other reference material is allowed.
- There are 3 parts to the exam: please use a separate exam book for each part.
- Correct answers without explanation do not receive credit.
- Part I is SHORT ANSWER. Answer 4 problems of 6. (5 points each, 20 points total.) You must explain your answers with one or two sentences or graphs. Correct answers without explanation do not receive credit. *If you answer more than 4 questions, we will only grade the first 4.*
- Part II has 1 long question that you must answer. (30 points)
- Part III has 1 long question that you must answer. (30 points)

Part I

Short Questions: Answer 4 of 6 questions [5 points each, 20 points total]

1. True/False/Uncertain and why?: If people are worried about adverse selection in the health insurance market, then a plan of introducing more competition among many insurance providers (by, for example, forcing them to have similar plans and letting the buyers choose the cheapest) would likely solve the problem.

   Solution: *More competition will reduce the price but will not solve the problem of adverse selection. For the same plan, competition will make the price of the plan actuarily fair (so that none of the insurance companies make any profit). But whether individuals will choose a particular plan still depends upon their risk types. At any given price, individuals will buy an insurance plan if their expected benefit exceeds the price of the plan. Since individuals still know about their risks better than insurance companies, only higher risk individuals will buy a given plan. This increases cost of providing a plan as the average individual who purchase the plan has higher risk than average individual in the population. Since insurance companies need to break even in expectation, this will raise the actuarily fair price of the plan to the point where the average payoffs to those who enroll is same as the the price of the plan. Hence, perfect competition will not solve the problem of adverse selection.*

2. A set of risk averse consumers, each with identical preferences and identical wealth $w > 0$, faces identical independent risks of experiencing loss $w > L > 0$. True, false, or uncertain and why: There are no potential gains from trade in risk among these consumers.

   Solution: *False. They can pool risk to mutually insure*

3. True, false, uncertain and why: A central requirement for a valid regression discontinuity design is that the treatment and control groups are identical in every way but they are treated differently due to randomization of the 'running' variable (e.g., credit score, age, etc.).

   Solution: *False. The treatment and control groups are not identical: they have very slightly different values of the running variable, and the running variable is not randomly assigned.*

4. The film studio Twentieth Century Fox once insured actress Betty Grables' legs for $1 million each (~$17 million in current USD). Is this insurance arrangement likely an example of risk pooling, risk spreading, or risk transfer? Explain.

   Solution: *The insurance policy is very unlikely to be an example of risk pooling; there were not a large number of other actresses whose legs would be insured (such that the insurer could pool the risk). This policy is very unlikely to be an example of risk spreading. The policy was sold on the private market; it was not a form of social insurance, involving transfers among citizens.*

The most plausible explanation for this policy is risk transfer. Twentieth Century Fox faced a small chance of experiencing a large financial loss if their prime asset (Grables' million dollar legs) became unsuitable for movie-making. Twentieth Century Fox was able to buy insurance because there were gains from trade between the studio and the insurer. The studio's maximum willingness to pay to avert the risk exceeded the insurer's minimum willingness to accept payment to bear the risk. Thus, the insurer acted like a relatively risk-tolerant agent buying risk from a less risk-tolerant agent.

5. When hiring young lawyers, law firms attempt to screen out applicants who plan to have children during the first ten years of their career (call these applicants "family types"). This is because lawyers tend to reduce their billable hours and thus generate less profit for their law firms once they have children. True, false, uncertain or why: The *full disclosure* principle says that job applicants will explicitly or implicitly reveal their type (family type, non family type) during the interview process, and hence screening for this characteristic is not necessary.

   Solution: *This would only be true if lawyers had a credible and costless way to reveal their types. If there is no credible way to reveal this information, or if credibly revealing it has a positive cost, the full disclosure principle is not guaranteed to hold.*

6. State Lotteries sold \$53 billion of lottery tickets in 2010. Suppose the cost of playing is \$1 and the expected value of playing is 50 cents (i.e. $\Sigma_i p_i W_i = \$0.50$ where W_i is payout i, and p_i is probability of that payout). Mr. Jo, a VNM expected utility maximizer, is indifferent between playing the lottery or not. Is Mr. Jo risk-averse, risk-loving, neither, or is there not enough information to say? Explain.

   Solution: *Mr. Jo's certainty equivalent of playing the lottery is \$1 (since he is indifferent between playing or not), so $CE\,[Lottery] > EV\,[Lottery]$ and the risk premium is -50 cents. This makes Mr. Jo a risk-lover (even though he may not actually play the lottery).*

Part II

Body Cameras [30 points]

Suppose that Congress approves funds for 50,000 body cameras to be used by police officers across the U.S. There are 3,000 counties in the U.S. but only enough cameras initially for 1,000 counties. To maximize effectiveness, body cameras will only be used initially in the counties with the highest crime rates as measured by homicides per 10,000 persons. Specifically, the assignment rule is:

$$C_i = \begin{cases} 1 & \text{if } H_i \geq 0.65 \\ 0 & \text{if } H_i < 0.65 \end{cases}$$

where C_i denotes whether county i is allocated body cameras and H_i is the homicide rate per 10,000 persons in county i. There are exactly 1,000 counties with $H_i \geq 0.65$. You are a grad student at MIT (sorry) and you work for David Autor (sorry). President Obama has personally asked you to evaluate the program, finding its effects on incidents of police brutality.

1. Suppose that you have data on reports of police brutality (B_i) in each county i one year after the policy was introduced. Explain carefully how you would construct a regression discontinuity estimator of the effect of the cameras on incidents of police brutality. Call this estimator T_{RD}. **(5 points)**

   *[**Solution:** intuitively, the estimator comes from comparing incidents of brutality in counties just above the homicide threshold to those just below it. Formally our estimate is*

   $$T_{RD} = \lim_{\epsilon \downarrow 0} E\left[B_i \mid H_i = 0.65 + \epsilon\right] - \lim_{\epsilon \uparrow 0} E\left[B_i \mid H_i = 0.65 + \epsilon\right]$$

   which in the limit is equal to

   $$T = E\left[B_{i1} - B_{i0} \mid H_i = 0.65\right]$$

   with potential outcomes notation such that B_{i1} is police brutality in county i if this county received police cameras.]

2. Does T_{RD} provide an unbiased estimate of the causal effect of receiving police cameras on police brutality? Explain why or why not, along with any assumptions you need to make. **(6 points)**

   *[**Solution:** yes, we have an unbiased estimate provided that potential outcomes are continuous around the homicide rate threshold, i.e. that*

   $$\lim_{\epsilon \downarrow 0} E\left[B_{i1} \mid H_i = 0.65 + \epsilon\right] = \lim_{\epsilon \uparrow 0} E\left[B_{i1} \mid H_i = 0.65 + \epsilon\right]$$

   $$\lim_{\epsilon \downarrow 0} E\left[B_{i0} \mid H_i = 0.65 + \epsilon\right] = \lim_{\epsilon \uparrow 0} E\left[B_{i0} \mid H_i = 0.65 + \epsilon\right]$$

For this, we would like that no other policies that may affect incidents of police brutality vary discontinuously around the 0.65 *threshold (so we should check this).]*

3. Suppose that you find $T_{RD} = -5$. President Obama thinks that this is strong enough evidence to support the expansion of the policy to the remaining counties in the U.S. Do you think that T_{RD} is an unbiased estimate of the causal effect for these remaining counties with $H_i < 0.65$? Why or why not? **(6 points)**

   *[**Solution:** T_{RD} gives us an unbiased local causal effect – that is to say, it is unbiased for counties with $H_i = 0.65$. Extrapolating away from the cutoff requires more assumptions, so we cannot say much about what the policy's effects will be for counties that start off with lower homicide rates. For one thing, we might think that the number of police brutality incidents tends to be lower in counties with the lowest homicide rates. It follows that the treatment effect may be smaller in these places. In particular, if the initial number of incidents in some set of counties is less than 5, clearly the treatment effect of cameras cannot be* -5 *here since the number of incidents is bounded below by zero.]*

4. You discover another policy that varies at the threshold: counties with $H_i \geq 0.65$ are allowed to use armored police cars, whereas counties with $H_i < 0.65$ are not allowed. This policy was introduced two years before the body cameras. When will this be a problem for your estimates? Can you suggest a test to check for this problem? [Hint: you can assume that you have data on police brutality both for the years before and the years after the cameras were introduced.] **(6 points)**

   *[**Solution:** this will be a problem if it leads to a violation of potential outcomes being equal on either side of the threshold. This will be the case if armored police cars also have an effect on the number of incidents of police brutality (e.g. an increase because the use of 'unnecessary' armored police cars reduces the respect people have for the police). Since the policy was introduced two years before the body cameras were, we can calculate a regression discontinuity estimate for one of these two 'pre-years'. Specifically we would estimate*

   $$T_{RD} = \lim_{\epsilon \downarrow 0} E\left[B_{iy} \mid H_i = 0.65 + \epsilon\right] - \lim_{\epsilon \uparrow 0} E\left[B_{iy} \mid H_i = 0.65 + \epsilon\right]$$

   where y is one of the two years prior to the introduction of body cameras, but after introduction of armored cars.]

5. Suppose that you find that cameras reduce the number of police arrest incidents that result in death. Some years later, many (but not all) other counties decide independently to spend the money to buy cameras. How might you use this information to estimate the value of statistical life? Would your estimate be a lower or upper bound, or neither? Explain carefully the assumptions that would need to hold for your estimate to be valid. **(7 points)**

   *[**Solution:** this is similar in flavor to Ashenfelter and Greenstone (2004) – in their case, some states show willingness to raise speed limits, accepting greater risk of death in exchange*

for a certain amount of time savings. In this case we have the opposite – some counties show willingness to spend money in exchange for a lower risk of death. Suppose the cost per year of police cameras is C and the RD estimate for the reduction in annual arrest incidents that result in death is R. In this case we have a ***lower*** *bound for the VSL as $\frac{C}{R}$. For this to be valid, we need the following assumptions:*

- *Counties make voluntary decisions (not under pressure from Federal government for example)*
- *Our RD estimate for R is unbiased not only for the local effect, but also for the average effect for the untreated counties that decide to buy police cameras*
- *Counties make informed decisions – knowing R and C (the effect of cameras on incidents that result in death) in advance*
- *Counties consider the only benefits of the policy to be the reduction in deaths (there are no additional political benefits for example)*

  Alternatively, we could discard the RD estimate of R and instead calculate a diff-in-diff estimate of R (as in Ashenfelter-Greenstone) using the fact that not all of the 'control' counties buy the body cameras. We may think that this is a more credible estimate of the effect on deaths for these counties, given that the RD estimate is really a local estimate (as discussed above).]

Part III

The Market For Windmills [30 points]

To improve their homes' resale values, many Massachusetts homeowners install windmills in their backyards. High quality houses are initially worth H and Low quality houses are worth L, with $H > L > 1$. Once a windmill is installed, the home's value increases from H to H^2 or from L to L^2.

It costs $I > 0$ to install a windmill and homeowners must get I from the First Windmill Bank. In exchange, they give the bank a fraction $s \in (0, 1)$ of the value of their homes. If an owner of a house of type $X \in \{H, L\}$ installs a windmill, the bank receives a payment of sX^2 while the homeowner keeps $(1 - s) X^2$.

Each homeowner knows whether her house is High or Low quality. First Windmill Bank cannot distinguish H from L houses but it knows that half of all houses are High quality and half are Low quality ($\Pr(H) = \Pr(L) = 0.5$).

Your problem is to determine under what conditions a pooling or separating equilibrium will exist in which First Windmill gives I to homeowners who ask for it in exchange for an ownership stake s. First consider a *separating* equilibrium:

1. What is the threshold value of s above which type H will *not* wish to build a windmill (call this s_H)? What is the threshold value of s above which type L will *not* wish to build a windmill (call this s_L)? Compare s_H and s_L. Explain *why* one of the following is true: $s_H = s_L$, or $s_H > s_L$, or $s_H < s_L$. **(5 points)**

   Solution: $s_H = 1 - \frac{1}{H}$, $s_L = 1 - \frac{1}{L}$. *Each type X will build a windmill iff $s \leq s_X$. Since $H > L$, we know that $s_H > s_L$. The increase in house value is larger for H than L owners.*

2. At a separating equilibrium, only one type of homeowner, $X \in \{H, L\}$ will choose to build a windmill. Based on your answer above, is X equal to H or L? Assume that First Windmill Bank *know*s that only type X wishes to install a windmill. For what values of s will First Windmill Bank be willing to pay I to type X to build a windmill in exchange for payment sX^2? **(5 points)**

   Solution: *From part 1, for every value of s that type L is willing to invest, type H is also willing to invest (follows from $s_H > s_L$). Therefore, if a separating equilibrium exists, it must be the case that type H invests and type L doesn't.*

   FWB invests if $sH^2 \geq I$, so $s \geq I/H^2$.

3. Write the conditions under which this separating equilibrium will exist. Specifically, what must be true so that: (1) Type X wishes to borrow at cost s to build a windmill; (2) Type X' does *not* wish to borrow at cost s to build a windmill; and (3) First Windmill Bank is willing to pay I to any homeowner who requests it in exchange for ownership stake s. **(8 points)**

Solution: *We need that the high type be willing to invest.* $(1-s)(H^2) > H$, *or* $1 - \frac{1}{H} > s$ *And the low type not want to invest* $(1-s)L^2 < L$ *or* $1 - \frac{1}{L} < s$. *This implies* $s_H > s > s_L$ *The investor needs* $sH^2 \geq I$ *or* $s \geq \frac{I}{H^2}$. *So, in one condition* $s_H > s \geq \max\left(\frac{I}{H^2}, s_L\right)$.

4. What value of s^* would First Windmill Bank choose to maximize its profits at the separating equilibrium? What are First Windmill Bank's profits (per homeowner) at rate s^*? **(5 points)**
   Solution: $s = 1 - 1/H$, $w = \left(\frac{H-1}{H}\right) H^2 - I = H(H-1) - I$

5. Now consider a potential *pooling* equilibrium. What is the maximum value of s at which both H and L homeowners will wish to build a windmill (call this s_p)? Write the expression for First Windmill's expected profit (per homeowner) if it pays I to any homeowner who requests it in exchange for ownership stake s_p. When would it be willing to offer this contract (s_p) to homeowners, as opposed to offering no contract at all [Note that it would not be in its interest to offer any $s < s_p$]? **(6 points)**
   Solution: $s_p = \min[s_H, s_L] = s_L$. *Expected profits are* $s_p(\frac{1}{2}H^2 + \frac{1}{2}L^2) - I$. *First Windmill would be willing to offer this contract if it does not incur a loss or, if* $s_p(\frac{1}{2}H^2 + \frac{1}{2}L^2) - I \geq 0$. *So, this pooling equilibrium exists iff* $s_L \geq \frac{2I}{H^2+L^2}$.