Exam ECON4136, ECON5100, ECON9100 – Fall 2014

IMPORTANT: Always explain answers. Answers should show knowledge and understanding of the concepts taught in the course. Each subquestion is weighted equally in the final grade.

Buser, T. (2014), The effect of income on religiousness (*American Economic Journal: Applied Economics*) investigates whether income affects religiousness using *survey* data from Ecuador. The sample consists of relatively poor households. Assume that they spend all their (monthly) income, i.e. $income = expenditures$. Religiousness is measured both by self-assessment on a scale from 0 to 10 (-*religiousness*-), and by the number of religious services that are attended in a month (-*attendance*-). Below you see some sample statistics, and the results from a regression of attendance on log of expenditures (-*logexp*-), log of household size (-*loghhs*-), and the age (-*age*-) and schooling (-*edu*-) of the respondent (both in years):

```
. sum attendance logexp edu age loghhs
    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
  attendance |      2645    4.586579    6.406292          0         30
      logexp |      2638    5.578003    .5088621   2.079442   7.438384
         edu |      2630    7.446388    3.686763          0         18
         age |      2645    42.71871     11.0413          0         90
      loghhs |      2645    1.403439    .4428044          0   3.091042

. reg attendance logexp edu age loghh, robust
Linear regression                               Number of obs =    2623
                                                F(  4,  2618) =    7.67
                                                Prob > F      =  0.0000
                                                R-squared     =  0.0119
                                                Root MSE      =  6.3378
------------------------------------------------------------------------------
             |               Robust
  attendance |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      logexp |   .1589818   .2896088     0.55   0.583    -.4089035     .726867
         edu |   .0492528   .0390654     1.26   0.208    -.0273494    .1258551
         age |   .0694903   .0126477     5.49   0.000     .0446899    .0942908
      loghhs |   .1777673   .3421433     0.52   0.603    -.4931314     .848666
       _cons |   .0901014   1.652156     0.05   0.957    -3.149562    3.329765
------------------------------------------------------------------------------

. mat l e(V)
            logexp         edu         age      loghhs       _cons
logexp   .08387323
   edu  -.00004765   .00152611
   age   .00022973   .00016474   .00015996
loghhs  -.04446538  -.00180977   .00058075   .11706204
 _cons   -.4139303  -.01526259  -.00986856   .07526461   2.7296187
```

1. Answer the following questions in detail

   (a) Explain when the coefficient on -*logexp*- in the regression above can be given a causal interpretation.

ANSWER: if logexp is independent of the error term, conditional on edu, age, loghhs.

   (b) Give examples that lead to the coefficient on -*logexp*- being biased upwards. Give examples that can cause the coefficient on -*logexp*- to be biased downwards.

ANSWER: some examples upward bias: unobserved factor that correlates positively with income and with attendance: more churches in more affluent neighborhoods? religion? downward bias: measurement error, unobserved factor that correlates positively with income and negatively with attendance: intelligence?

   Assume that the regression above can be given a causal interpretation.

   (c) What is the estimated average effect of a 12 percent increase in monthly income on the number of religious services attended? What is the standard error of this estimate?

ANSWER: 0.12*.1589818 = 0.019. se: 0.12*.2896088 = .03475306

   (d) Consider a policy that increases the income of households by 12 percent. You are interested in the effect of this policy on religious attendance. Suppose that in a sample of size 2,600, half randomly receive the treatment, while the other half is the control group. You will estimate the treatment effect by the difference in mean attendance between the treated and controls. What is the statistical power of this design?

ANSWER: basically as in seminar 1:
power = 1 - Pr(reject H0 | H1 is true) = 1 - Pr(Type 2 error)
we test $H_0 : \beta = 0$ vs $H_1 : \beta \neq 0$ (we typically do two-sided hypothesis testing)
in (a) we estimated the effect of a 12 percent increase in hh income on attendance, so assume this is our true effect: $\beta_0 = 0.019$
our test statistic is the difference in mean attendance between the treated and controls

$$\hat{b} = \overline{y}_{T=1} - \overline{y}_{T=0}$$

our test statistic is $\hat{t} = \hat{b}/\hat{se}$ and from seminar 1 we know that

$$= \Pr(\text{type 2 error}) = \Pr(t_{\alpha/2} < \hat{t} < t_{1-\alpha/2}) \approx \Phi(t_{1-\alpha/2} - \frac{\beta_0}{\hat{se}}) - \Phi(t_{\alpha/2} - \frac{\beta_0}{\hat{se}})$$

we will use $2\sigma/\sqrt{N}$ for $\hat{se}$. we know from the stata output that $\sigma(attendance) = 6.4$ so use $\hat{se} \approx 2 * 6.4/\sqrt{2600} \approx 0.251$
set $\alpha = 0.05$ and assume normality then $t_{0.975} = 1.96$, $t_{0.025} = -1.96$ and the power is

$1-\Phi(1.96-0.02/0.251))+\Phi(-1.96-0.02/0.251)) = 1-\Phi(1.88)+\Phi(-2.04) \approx 0.009$

(e) What sample size is necessary to achieve a power of 0.8 in (d)?

ANSWER: to achieve power of 0.8 we need to solve

$$0.8 = 1 - \Phi(1.96 - 0.02/(2 * 6.4/\sqrt{N})) + \Phi(-1.96 - 0.02/(2 * 6.4/\sqrt{N}))$$

we can only do this numerically, but since $\Phi(-1.96 - 0.02/(2 * 6.4/\sqrt{N}))$ is typically small, assume it equals zero as in seminar 1, then we can solve

$$0.8 = 1 - \Phi(1.96 - 0.02/(2 * 6.4/\sqrt{N}))$$

which gives

$$N = ((1.96 - \Phi^{-1}(0.2))2 * 6.4/0.02)^2$$

from the std normal table in the seminar 1 exercise we have that $\Phi^{-1}(0.2) \approx -0.84$.
using this we then get N=3211264

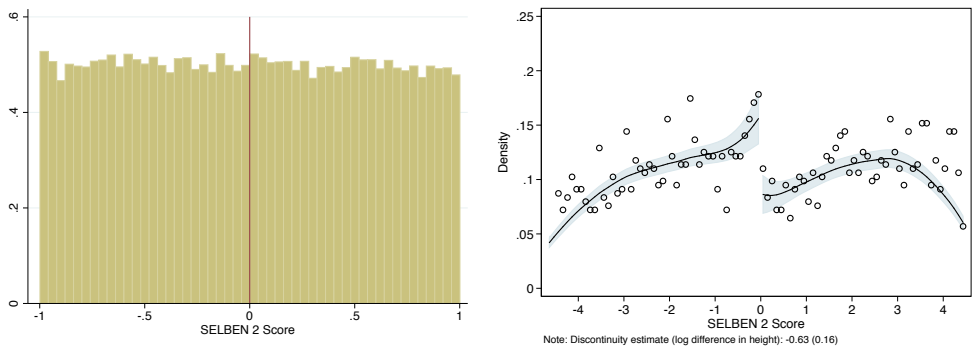
2. To estimate the effect of income on religious attendance, Buser (2014) exploits a feature of a cash transfer program: Families who are below a threshold on a poverty index are eligible for a cash transfer. The index variable is called -*selben2*- and the threshold is at 0. The variable

-eligible- equals one if a family's index is below the threshold, and is zero otherwise. On average the size of the transfer is about 12 percent of family income.

(a) The estimation approach consists of comparing people around the threshold. Explain what conditions need to hold for this approach to give causal estimates of the cash transfer.

ANSWER: potential outcomes y^1, y^0 should be continuous in the running variable (selben2) at the discontinuity. (for average effects we need that $E[y^j|selben2 = s]$ is continuous in s at s_0). in the fuzzy design we also need that $\lim_{s\uparrow s_0} E[treat|selben2 = s] \neq \lim_{s\downarrow s_0} E[treat|selben2 = s]$

(b) The graph to the left shows the distribution of people around the threshold in Ecuador reported in Buser (2014). The graph to the right shows the same distribution, but in the sample used for estimation. Discuss possible explanations for the observed differences, and the potential implications of these differences for the analysis.



ANSWER: the data used in the analysis come from a survey. differences should therefore come from (non-representative) sampling, or from selective survey response. for the estimates in the paper we ultimately care about balance/bunching in the estimation sample. even if things are balanced in the population, the observed bunching in the sample is potentially problematic if this leads to a violation of $y^1, y^0|d$ at the the discontinuity (exact condition in the slides).

(c) Explain for each of the variables below whether they are good candidates for a test of covariate balance around the cutoff.

```
. reg selben2 rel edu loghhs age, noheader
------------------------------------------------------------------------------
     selben2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
religiousness |  -.0317039   .0210593    -1.51   0.132    -.0729984    .0095907
         edu |   .0481182   .0152145     3.16   0.002     .0182845    .0779518
      loghhs |  -.2263135   .1144582    -1.98   0.048     -.450751   -.0018761
         age |   .0080028   .0051462     1.56   0.120    -.0020883    .0180939
```

```
       _cons |  -.0591586    .367655    -0.16   0.872    -.7800816    .6617644
------------------------------------------------------------------------------


. reg attendance rel edu loghhs age, noheader
------------------------------------------------------------------------------
  attendance |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
religiousness |   .6664174    .050627    13.16   0.000     .5671446    .7656902
         edu |   .0443575    .036576     1.21   0.225    -.0273632    .1160781
      loghhs |   .3528093   .2751594     1.28   0.200    -.1867419    .8923605
         age |   .0560195   .0123716     4.53   0.000     .0317603    .0802786
       _cons |  -3.191777   .8838487    -3.61   0.000    -4.924888   -1.458666
------------------------------------------------------------------------------
```

ANSWER:
first one should make the distinction between predetermined (age, edu, loghhs) and endogenous (religiousness) variables
-> we don't want to do balancing check on endogenous variables
then for the predetermined variables we can distinguish between variables that are potential confounders and those that are not
potential confounding variables should i) correlate with potential outcomes, AND ii) be different across the threshold
the regression of the observed outcome is therefore suggestive of i)
while the regression on the running variable (selben2) is suggestive of ii)
the regression tables therefore suggest that *it is not likely that* age, edu and loghss are potential confounders
finally note that finding imbalance wrt to variables that are not probable confounders may still point to imbalance in unobserved confounders

(d) Consider the regression

$$collect = \delta_0 + \delta_1 eligible + \delta_2 selben2$$

where -*collect*- equals one if families collect the cash transfer and is zero otherwise. What are the implications of a so-called sharp design for the coefficients in this regression?

ANSWER: in a perfect sharp design $\delta_0 = 1, \delta_1 = 1, \delta_2 = 0$

(e) Consider the OLS regression

$$attendance = \beta_0 + \beta_1 eligible + \beta_2 selben2 + \beta_3 selben2 * eligible$$

on the subsample where $selben2 \in [-1, 1]$. Is the estimate $\hat{\beta}_1$ from this regression

equivalent to the local linear regression estimate of eligibility using a uniform kernel and bandwidth of 1? Explain your answer.

ANSWER: Yes. the uniform bandwidth basically restricts the samples around the threshold. and since we interact the intercept and running variable this is equivalent to running a separate linear regression to the left and right of the threshold. the final piece that makes that $\hat{\beta}_1$ is the jump at the threshold comes from the fact that the threshold is at 0.

3. Most people, about 83 percent, attend at most one service a week. Define a dummy variable *-dattend-* which equals one if people attend a religious service more than once a week, and which is zero otherwise. You are interested in estimating

$$\Pr(dattend = 1|eligible) \tag{1}$$

(a) What Stata code would you use to estimate (1) using a linear probability model?

ANSWER: reg dattend eligible, robust (half the points for reg, half for robust)

You decide to estimate (1) using the non-linear Logit model.

(b) Will this give the same estimate of (1) as the linear probability model?

ANSWER: yes. in a saturated model the logit model is equivalent to a lp model:

$$\begin{aligned} \Pr(dattend = 1|eligible) &= \frac{\exp(\gamma_0 + \gamma_1 eligible)}{1 + \exp(\gamma_0 + \gamma_1 eligible)} \\ &= \alpha + \beta \cdot eligible \end{aligned}$$

where $\alpha = \frac{\exp(\gamma_0)}{1+\exp(\gamma_0)}$ and $\beta = \frac{\exp(\gamma_0+\gamma_1)}{1+\exp(\gamma_0+\gamma_1)} - \frac{\exp(\gamma_0)}{1+\exp(\gamma_0)}$.

Suppose the results of the Logit estimation are:

```
. logit dattend eligible, noheader

------------------------------------------------------------------------------
     dattend |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    eligible |   .2256065   .1053454     2.14   0.032     .0191333    .4320797
       _cons |  -1.741551    .077833   -22.38   0.000    -1.894101   -1.589001
------------------------------------------------------------------------------

. mat l e(V)

                   dattend:    dattend:
                   eligible       _cons
dattend:eligible   .01109765
   dattend:_cons  -.00605798   .00605798
```

(c) What is the estimated sample average effect of eligibility on the probability to attend at least one religious service per week?

ANSWER: note that the question should have read "What is the estimated sample average effect of eligibility on the probability to attend ~~at least~~ more than one religious service per week?"
let $P' = \hat{E}[dattend = 1|elig = 1]$ and $P = \hat{E}[dattend = 1|elig = 0]$
then

$$\hat{\beta} = P' - P = \frac{\exp(\hat{\gamma}_0 + \hat{\gamma}_1)}{1 + \exp(\hat{\gamma}_0 + \hat{\gamma}_1)} - \frac{\exp(\hat{\gamma}_0)}{1 + \exp(\hat{\gamma}_0)}$$

exp(-1.74 + 0.226)/ (1 + exp(-1.74 + 0.226)) - exp(-1.74)/ (1 + exp(-1.74)) = .18 -.15 = .03

(d) What is the standard error of the sample average effect of eligibility in (c)?

ANSWER:
use delta method to get s.e.'s:

$$V(\hat{\beta}) = \begin{pmatrix} \partial\hat{\beta}/\partial\hat{\gamma}_1 \\ \partial\hat{\beta}/\partial\hat{\gamma}_0 \end{pmatrix}' V_\gamma \begin{pmatrix} \partial\hat{\beta}/\partial\hat{\gamma}_1 \\ \partial\hat{\beta}/\partial\hat{\gamma}_0 \end{pmatrix}$$

note that if $f(x) = exp(x)/(1 - exp(x))$ then $\partial f/\partial x = f(1 - f)$ so that

$$\begin{pmatrix} \partial\hat{\beta}/\partial\hat{\gamma}_1 \\ \partial\hat{\beta}/\partial\hat{\gamma}_0 \end{pmatrix} = \begin{pmatrix} P'(1 - P') \\ (P'(1 - P') - P(1 - P)) \end{pmatrix} \approx \begin{pmatrix} .15 \\ .02 \end{pmatrix}$$

and

$$V(\hat{\beta}) \approx \begin{pmatrix} .15 \\ .02 \end{pmatrix}' \begin{pmatrix} .01109765 & \\ -.00605798 & .00605798 \end{pmatrix} \begin{pmatrix} .15 \\ .02 \end{pmatrix} \approx .000216$$

after taking the sqrt we get a se of approximately 0.015.

4. Not everybody who is eligible for the cash transfer in Buser (2014), actually collected the money. Let -*collect*- be a dummy variable that equals 1 if a family collected the cash transfer, and is zero otherwise.

   Consider the following regression:

```
. gen selben2_1 = selben2 * eligible
. gen selben2_0 = selben2 * (1 - eligible)
. reg collect eligible  selben2_1 selben2_0, robust noheader
------------------------------------------------------------------------------
             |               Robust
     collect |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    eligible |   .8045451    .022037    36.51   0.000     .7613336    .8477566
   selben2_0 |  -.0015438   .0041907    -0.37   0.713    -.0097612    .0066736
   selben2_1 |  -.0091181   .0075935    -1.20   0.230    -.0240079    .0057717
       _cons |   .0328388   .0111414     2.95   0.003     .0109921    .0546855
------------------------------------------------------------------------------
```

(a) How do you interpret the coefficient on -*eligible*-?

ANSWER: being eligible increases the probability of collecting benefits by about 0.8. This means that at the threshold 80 percent complies with the policy.

(b) Explain how you would estimate the causal effect of receiving the cash-benefit on -*attendance*-.

ANSWER: do IV where we instrument collect with eligible while controlling for the running variable

(c) Suppose the point estimate you obtain in (b) is 1.8. Interpret this estimate, also in light of 1(c) above.

ANSWER: collecting cash benefits increasing the nr of attendances by 1.8 days per month. this is the average effect for people how collect the benefit because they are eligible (the compliers). it is about two orders of magnitude (100 times) larger than the estimate in 1c. if we were to believe this RD/IV estimate, the OLS in 1c needs to be seriously downward biased.

(d) Explain how you would estimate the causal effect of the cash-benefit policy on -*attendance*-, and discuss its interpretation.

ANSWER: this is the so-called intention-to-treat, which we estimate using the reduced form:
regress attendance on eligible while controlling for the running variable

(e) Consider the following expression

$$\delta = E[attendance \times collect|eligible = 1] - E[attendance \times collect|eligible = 0]$$

Derive δ in terms of potential outcomes and potential treatments, assuming eligibility is random, and has no independent effect on -attendance-. Also assume that eligibility can only affect people's tendency to collect money in one direction.

ANSWER: First note that

$$att = colt \cdot att^1 + (1 - col) \cdot att^0$$

where the superscript on potential attendance refers to treatment. thanks to the exclusion restriction potential attendance does not depend on eligibility.
and

$$col = col^1 \cdot elig + col^0 \cdot (1 - elig)$$

so

$$\begin{aligned}
E[att \cdot col|elig = 1] &= E[att|col = 1, elig = 1]P(col = 1|elig = 1) \\
&= E[att^1|col^1 = 1, elig = 1]P(col^1 = 1|elig = 1) \\
&= E[att^1|col^1 = 1]P(col^1 = 1) \text{ [use indep of elig]} \\
&= E[att^1|\underbrace{col^1 = 1, col^0 = 1}_{\text{always taker}}]P(col^0 = 1, col^1 = 1) \\
&+ E[att^1|\underbrace{col^1 = 1, col^0 = 0}_{\text{complier}}]P(col^0 = 1, col^1 = 0)
\end{aligned}$$

and similarly

$$\begin{aligned}
E[att \cdot col|elig = 0] &= E[att|col = 1, elig = 0]P(col = 1|elig = 0) \\
&= E[att^1|col^0 = 1, elig = 0]P(col^0 = 1|elig = 0) \\
&= E[att^1|col^0 = 1]P(col^0 = 1) \text{ [use indep of elig]} \\
&= E[att^1|\underbrace{col^1 = 1, col^0 = 1}_{\text{always taker}}]P(col^0 = 1, col^1 = 1) \\
&+ E[att^1|\underbrace{col^1 = 0, col^0 = 1}_{\text{defier}}]P(col^0 = 0, col^1 = 1) \\
&= E[att^1|col^1 = 1, col^0 = 1]P(col^0 = 1, col^1 = 1)
\end{aligned}$$

where in the last step we used that eligibility can only affect people's tendency to collect money in one direction implies that $col^1 - col^0 \geq 1$ and therefore $P(col^0 = 0, col^1 = 1) = 0$
taking the difference shows that

$$E[att \cdot col|elig = 1] - E[att \cdot col|elig = 0] = E[att^1|\text{complier}]P(\text{complier})$$