ECON3150/4150: Introductory Econometrics – Postponed Exam Spring 2023

1. (60%) You are interested in estimating the effect of income on maternal smoking during pregnancy. In your dataset `smoke` equals 1 if smoked per day while pregnant (0 otherwise), `faminc` is 1988 family income (1000 USD), `motheduc` is mother's years of education:

```
##             mean     SD min max    N
## faminc   29.0422 18.737 0.5  65 1387
## motheduc 12.9358  2.377 2.0  18 1387
## smoke     0.1528  0.360 0.0   1 1387
```

You estimate the following models:

```
##                              reg1           reg2           reg3         logit1
## Dependent Var.:             smoke          smoke          smoke          smoke
##
## Constant           0.256 (0.019)  0.357 (0.040)  0.643 (0.057) -0.882 (0.133)
## faminc           -0.004 (0.0005)                                -0.033 (0.005)
## log(faminc)                      -0.067 (0.011) -0.035 (0.012)
## motheduc                                        -0.030 (0.004)
## ---------------- --------------- -------------- -------------- --------------
## Family                      OLS            OLS            OLS          Logit
## S.E. type       Heteroske.-rob. Heterosk.-rob. Heterosk.-rob. Heterosk.-rob.
## SSR                     173.50         174.43         168.74             --
## Observations             1,387          1,387          1,387          1,387
```

   a. Interpret the estimates and their standard errors in the 1st column (`reg1`).

      ANSWER: The intercept estimates the fraction of people that smoke when faminc=0. The coefficient on faminc shows that a 100 USD increase in faminc is associated with a 0.4 percentage points decrease in the probability of smoking. 95% confidence intervals (estimate$\pm$1.96$\cdot$SE) show that both estimates are significant at the conventional level.

   b. Compute the predicted value for `faminc`=65 using the estimates in column 1 (`reg1`) and interpret the result.

      ANSWER: $0.256 - 0.004 \cdot 65 = -0.004$. This estimates the fraction of people that smoke when family income is 65,000 USD. This cannot logically be negative and illustrates the shortcoming of the linear probability model. It probably indicates that this probability is very small indeed.

   c. Interpret the coefficient on `log(faminc)` in the 2nd column (`reg2`).

      ANSWER: An increase om faminc with say 10% is associated with a decrease in the probability of smoking of 0.67 percentage points.

   d. What is the significance level of the confidence interval (-.07184, -.06216) for the coefficient on `log(faminc)` in the 2nd column (`reg2`)?

      ANSWER: The CI = $(-0.067 \pm c \cdot 0.011)$ this implies that c = 0.44. The attached table shows that $\Pr(Z \leq 0.44) = 0.67$, which means that the significance level is $2 \cdot (1 - 0.67) = 0.66$ (34% confidence).

e. Compute the R-squared of the regression in the 3rd column (`reg3`).

ANSWER: $R^2 = 1 - SSR/TSS$.

$TSS = (n-1) \cdot var(smoke) = (1387-1) \cdot (0.360^2) = 179.6$.

$R^2 = 1 - 168.74/179.6 = 0.06$.

f. The third column (`reg3`) adds mother's education to the specification. Compute the correlation between `log(faminc)` and `motheduc`.

ANSWER: From the omitted variable bias formula estimate in reg2 is:

$-0.067 = -0.035 - 0.030 \cdot cov(motheduc, log(faminc))/var(log(faminc))$

we also know that:

$var(0.357 - 0.067 \log(faminc)) = (-0.067)^2 \cdot var(\log(faminc)) = ESS/(n-1)$

since ESS = TSS - SSR = 179.6 - 174.43 = 5.17, we have:

$var(log(faminc)) = 5.17/(1386 \cdot (-0.067)^2) = 0.831$

This gives

$$cov(motheduc, log(faminc)) = ((-0.067 - -0.035) \cdot 0.831)/ - 0.030 = 0.886$$

and thus a correlation of $0.886/(sqrt(0.831) \cdot 2.377) = 0.409$.

g. Perform a joint test of the null-hypothesis that the coefficients on `log(faminc)` and `motheduc` are zero in the 3rd column (`reg3`).

ANSWER: One should first recognize that this can only be done assuming homoskedasticity.

F = ((SSR_unrestricted - SSR_restricted) / #constraints) / (SSR_unrestr / dof).

Since the unrestricted model only has an intercept we have SSR_unrestricted = TSS (= 179.6).

F = ((179.6 - 168.74) / 2) / (168.74 / 1384) = 44.54

5% critical value F(2, 1384) = 2.9957 so we reject since $44.54 > 2.9957$.

h. Use the logit estimates in column 4 (`logit`) to predict the outcome at the average family income and interpret the result.

ANSWER:

$$p(x) = \frac{1}{1 + \exp(-(b0 + b1 \cdot x))} = \frac{1}{1 + \exp(-(-0.882 - 0.033 \cdot 29.0422))} = .137$$

The estimated smoking rate at the average income is 0.137. In other words, the estimated probability that someone with average income smokes is 0.137.

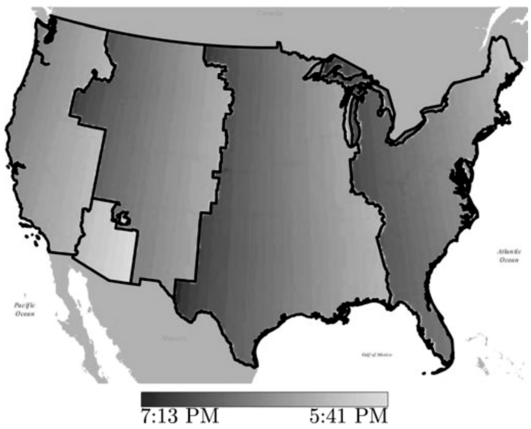
i. Compute the marginal effect of income at the sample average using the logit estimates in column 4 (`logit`), and compare them to the OLS results in column 1 (`reg1`).

ANSWER: Taking the derivative of p(x) to x we get $\partial p(x)/\partial x = b1(1-p)p$. Using the data we find $-0.033 \cdot 0.137 \cdot (1 - 0.137) = -0.0039$. This shows that the marginal "effect" of increasing family income by 1,000 USD is very close to the average slope estimated in column 1 which equals -0.004.

j. Someone tells you that if one is interested in estimating an average marginal effect of income on smoking that is causal, then the logit model is to be preferred over the linear probability model. What do you respond?

ANSWER: Linear probability models and logit models (and probit models for that matter) typically give estimates for average marginal effects that are very similar. They both rely on a proper specification of the conditional mean, and are both vulnerable to the same omitted variable bias. So while for estimating average causal effects these models typically won't make any meaningful difference, for prediction they might.

2. (40%) Gibson & Shrader (Review of Economics & Statistics, 2018) use American data to estimate the effect of sleep on productivity. Information on the average night-time sleep (hours per week) comes from a time use survey and productivity is measured by earnings and wages. To account for potential omitted variable bias Gibson & Shrader implement an instrumental variable approach. Their instrumental variable is annual average sunset time (hours), and is expected to affect the time when people go to bed and thereby the amount they sleep. The following figure shows the variation – within US time zones as well as sharp changes in sunset time around the boundaries of time zones – that is used in the estimation.



In their estimation Gibson & Shrader adjust for both geographic characteristics (coastal distance and latitude) and demographics (gender, age, race and occupation shares, plus population density). The following table summarizes some of their main estimation results for log(earnings):

	First-stage Sleep	Reduced-form log(earnings)
Sunset time	-0.93	-0.045
	(0.28)	(0.017)
Mean dep. var.	57.9	6.67

a. Compute the IV estimate of the effect of sleep on log(earnings) and interpret the result.

ANSWER: IV = RF / FS = -0.045 / -0.93 = 0.04839. One hour of additional sleep is estimated to increase earnings by about 5%.

b. If the IV estimate of sleep on log(wage) is 0.083, what is then the effect of sunset time on log(wage)?

ANSWER: That is the corresponding RF estimate and thus $0.083 \cdot -0.93 = -0.07719$: a one hour increase in the time the sun sets lowers earnings by about 7.7%.

c. What could violate the instrument's exclusion restriction? Do the controls (hint) help in this respect? Explain.

ANSWER: We are looking for things that may correlate with the variation is sunset time that is used here that may affect earnings directly or indirectly in other way than through sleep. For example, if people who dislike work tend to move to regions where the sun sets later then this would violate the exclusion restriction. This is why the regression adjusts for demographic characteristics.

d. Is the instrument relevant? Motivate your answer.

ANSWER: The first-stage coefficient has a $t = (-0.93/.28) = 3.3$ or an $F = 3.3^2 = 11$, and is therefore sufficiently strong.

e. Explain how you could use the variation highlighted in the figure above to estimate the effect of sleep on earnings using a regression discontinuity design. Make clear whether you would use a sharp or a fuzzy design.

ANSWER: The graph shows that there are sharp drops/increases around the bounderies of the time zones. A regression discontinuity design would only exploit these discontinous changes and estimate the effect at the boundary. It would be a fuzzy design where the the implementation would define the running variable as the distance from that boundary, the instrument would equal one when crossing the boundary, the endogenous variable (and corresponing first-stage) sleep, and the second stage earnings.

The Cumulative Standard Normal Distribution Function, $\Pr(Z \leq z)$

```
## Rows denote 1st decimal value of z, and columns 2nd decimal value of z

## So for example, P(Z <= 0.22) = 0.5871
```

	0	1	2	3	4	5	6	7	8	9
0.0 :	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1 :	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2 :	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3 :	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4 :	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5 :	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6 :	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7 :	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8 :	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9 :	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0 :	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1 :	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2 :	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3 :	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4 :	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5 :	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6 :	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7 :	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8 :	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9 :	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0 :	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1 :	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2 :	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3 :	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4 :	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5 :	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6 :	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7 :	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8 :	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9 :	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986

Critical Values for the $F_{m,\infty}$ Distribution

```
## Rows denote degrees of freedom (m), and columns significance level (%)

##          10%     5%     1%

##
##  1 :  2.7055 3.8415 6.6349
##  2 :  2.3026 2.9957 4.6052
##  3 :  2.0838 2.6049 3.7816
##  4 :  1.9449 2.3719 3.3192
##  5 :  1.8473 2.2141 3.0173
##  6 :  1.7741 2.0986 2.8020
##  7 :  1.7167 2.0096 2.6393
##  8 :  1.6702 1.9384 2.5113
##  9 :  1.6315 1.8799 2.4073
##  10 :  1.5987 1.8307 2.3209
##  11 :  1.5705 1.7886 2.2477
##  12 :  1.5458 1.7522 2.1847
##  13 :  1.5240 1.7202 2.1299
##  14 :  1.5046 1.6918 2.0815
##  15 :  1.4871 1.6664 2.0385
##  16 :  1.4714 1.6435 2.0000
##  17 :  1.4570 1.6228 1.9652
##  18 :  1.4439 1.6038 1.9336
##  19 :  1.4318 1.5865 1.9048
##  20 :  1.4206 1.5705 1.8783
##  21 :  1.4102 1.5557 1.8539
##  22 :  1.4006 1.5420 1.8313
##  23 :  1.3916 1.5292 1.8104
##  24 :  1.3832 1.5173 1.7908
##  25 :  1.3753 1.5061 1.7726
##  26 :  1.3678 1.4956 1.7554
##  27 :  1.3608 1.4857 1.7394
##  28 :  1.3541 1.4763 1.7242
##  29 :  1.3478 1.4675 1.7099
##  30 :  1.3419 1.4591 1.6964
```