EC 200

Exam 3 Review

Exam Review

- Coverage
  - Chapter 8: Non-linear regression
  - Chapter 9: Internal/External validity
  - Chapter 10: Panel Data
  - Chapter 12: Instrumental variables

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Big picture

- **What can go wrong with our regressions?**
  - Omitted variable bias (Always)
  - Erroneous functional form (Chapter 8)
  - Measurement error (Chapter 9)
  - Reverse causality (Chapter 9/12)
- **How can we solve these problems?**
  - Add more controls (always)
  - Add higher-order terms and/or interactions (Chapter 8)
  - Difference-in-differences model (Chapter 10)
  - First-differences model (Chapter 10)
  - Fixed effects model (Chapter 10)
  - Instrumental variables model (Chapter 12)

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What you need to know how to do

- What can go wrong with our regressions?
  - Omitted variable bias (Always)
  - Erroneous functional form (Chapter 8)
  - Measurement error (Chapter 9)
  - Reverse causality (Chapter 12)
- **Based on descriptions of regressions, questions, data sets**
  - Identify when these problems are likely to occur
  - Provide specific examples of what these problems look like
  - Discuss the impact this will have on your estimated regression coefficients
  - Discuss the impact this will have on your ability to determine causal relationships

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What you need to know how to do

- How can we solve these problems?
  - Difference-in-differences model (Chapter 10)
  - First-differences model (Chapter 10)
  - Fixed effects model (Chapter 10)
  - Instrumental variables model (Chapter 12)
- Write population models of these models
- Write step-by-step how to implement these models
- Review results of estimation of these models, interpret coefficients, and "big picture" interpretation.
- Compare results from these models with OLS and discuss which is more appropriate and why

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General skills you need

- Look at Stata output and/or formatted tables
  - Interpret coefficients (put numbers with them, and units!)
  - Interpret statistical significance (practice with those p-values)
  - Set up hypotheses and determine results
    - That a regression coefficient = 0
    - That multiple exclusion restrictions hold
    - Remember:
      - Set up a null
      - Set up an alternative
      - Compute a test statistic or p-value
      - Make a conclusion

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Non-linear functions

- Polynomials
  - Compute effects by derivative (approximate) or by calculating for each value and taking the difference (exact)
- Logs
- Interaction terms
  - Binary-binary
  - Continuous-binary
  - Continuous-continuous

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Using logs to compute percentage changes

- **We do not take logs of percents/etc.**
  - **If LFP is 75% → easy to think about 5pp increase (levels)**
    - **→ harder to think about about 5% increase → 0.05/0.75 = 6.7pp increase**
- Suppose we want to model hourly wages (wage) as a function of years of education (educ)

wage = 10.5 + 3educ

Level-level: A 1-year increase in years of education is associated with a $3 increase in wages (unit-unit)

log(wage) = 10.5 + 3log(educ)

Log-log (elasticity): A 1% increase in years of education is associated with a 3% increase in wages

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Using logs to compute percentage changes

$\log(wage) = 10.5 + 3educ$

Log-level (semi-elasticity): A 1-year increase in years of education is associated with a 300% increase in wages

(approximation)

$wage = 10.5 + 3\log(educ)$

Level-log: A 1% increase in years of education is associated with a 3/100 = $0.03 increase in wages

(approximation)

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Example

`assaults` = number of assaults in a particular weekend across a subset of US counties

`attend` = total weekend movie attendance (millions)

```
. sum assaults attend
```

Variable	Obs	Mean	Std. Dev.	Min	Max
assaults	516	4352.663	2120.995	683	8719
attend	516	18.86187	4.906061	9.8085	36.5028

Interpret the coefficient on `attend`

```
. regress assaults attend

      Source |       SS           df       MS      Number of obs   =       516
-------------+----------------------------------   F(1, 514)       =     28.40
       Model |   121306939         1   121306939   Prob > F        =    0.0000
    Residual |  2.1955e+09       514  4271367.88   R-squared       =    0.0524
-------------+----------------------------------   Adj R-squared   =    0.0505
       Total |  2.3168e+09       515  4498621.42   Root MSE        =    2066.7

------------------------------------------------------------------------------
    assaults |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      attend |   98.92505   18.56295     5.33   0.000     62.45647    135.3936
       _cons |   2486.752   361.7598     6.87   0.000     1776.042    3197.461
------------------------------------------------------------------------------
```

1 million more attendees associated w/ 98 more weekend assaults.

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Interpret the coefficient on `ln_attend`

```
. regress ln_assaults ln_attend
```

Source	SS	df	MS
Model	15.652297	1	15.652297
Residual	189.04063	514	.367783327
Total	204.692927	515	.397461994

Number of obs	=	516
F(1, 514)	=	42.56
Prob > F	=	0.0000
R-squared	=	0.0765
Adj R-squared	=	0.0747
Root MSE	=	.60645

ln_assaults	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ln_attend	.6788489	.1040591	6.52	0.000	.4744154	.8832824
_cons	6.244118	.3033823	20.58	0.000	5.648096	6.84014

1% increase in attendance associated with 0.67% increase in assaults

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Interpret the coefficient on `attend`

```
. regress ln_assaults attend ,robust

Linear regression                               Number of obs     =        516
                                                F(1, 514)         =      29.21
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0633
                                                Root MSE          =     .61077
```

ln_assaults	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
attend	.0323187	.0059794	5.40	0.000	.0205716	.0440659
_cons	7.606019	.1207744	62.98	0.000	7.368746	7.843291

0.032 → When attendance increases by 1 million, assaults increase by 3.2%

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Interpret the coefficient on `ln_attend`

```
. regress assaults ln_attend

      Source |       SS           df       MS      Number of obs   =       516
-------------+----------------------------------   F(1, 514)       =     33.54
       Model |   141908410         1   141908410   Prob > F        =    0.0000
    Residual |  2.1749e+09       514   4231287.2   R-squared       =    0.0613
-------------+----------------------------------   Adj R-squared   =    0.0594
       Total |  2.3168e+09       515  4498621.42   Root MSE        =      2057

------------------------------------------------------------------------------
    assaults |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   ln_attend |   2044.034   352.9558     5.79   0.000     1350.621    2737.448
       _cons |   -1583.56   1029.036    -1.54   0.124    -3605.194    438.0734
------------------------------------------------------------------------------
```

When 1% increase in attendance leads to 20.44 assautls

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Interaction terms

```
. reg sleepdef male hrstotwrk yngkid marr maleXmarr maleXyngkid maleXhrs
```

Source	SS	df	MS
Model	8.81324949	7	1.25903564
Residual	105.222161	698	.150748082
Total	114.035411	705	.161752356

Number of obs =	706
F(7, 698) =	8.35
Prob > F =	0.0000
R-squared =	0.0773
Adj R-squared =	0.0680
Root MSE =	.38826

sleepdef	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
male	-.1301368	.1032824	-1.26	0.208	-.3329181	.0726445
hrstotwrk	.0053348	.0014888	3.58	0.000	.0024119	.0082578
yngkid	.1116302	.0787625	1.42	0.157	-.0430096	.2662699
marr	-.1240539	.0521929	-2.38	0.018	-.2265278	-.02158
maleXmarr	.004336	.0795358	0.05	0.957	-.1518221	.1604941
maleXyngkid	-.0827995	.0953117	-0.87	0.385	-.2699315	.1043325
maleXhrstotwrk	.0023426	.0020265	1.16	0.248	-.0016361	.0063213
_cons	.126543	.0671915	1.88	0.060	-.0053787	.2584647

What is the predicted probability of being sleep deficient for a married woman with young kids who works 40 hours/week? For an equivalent man?

Chapter 9

- Internal Validity
  - OBV → correlation between x and u non-zero → endogeneity
  - Errors in measurements!
  - Simultaneous causality bias
  - Functional form error
  - Selection bias
- External validity → we know what we set out to find out, but is it valid/applicable to tother populations/setting

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Internal/External Validity

Internal Validity (5 threats)

Do we measure what we meant to measure?

- Omitted variable bias
- Bad functional form
- Missing data/sample selection
- Measurement error
- Simultaneity

External validity

Do the results generalize?

- What if we change the setting?
- What if we change the population?

Measurement error

- Dependent variable (if uncorrelated with x)
  - Reduces precision
  - Does not affect coefficients

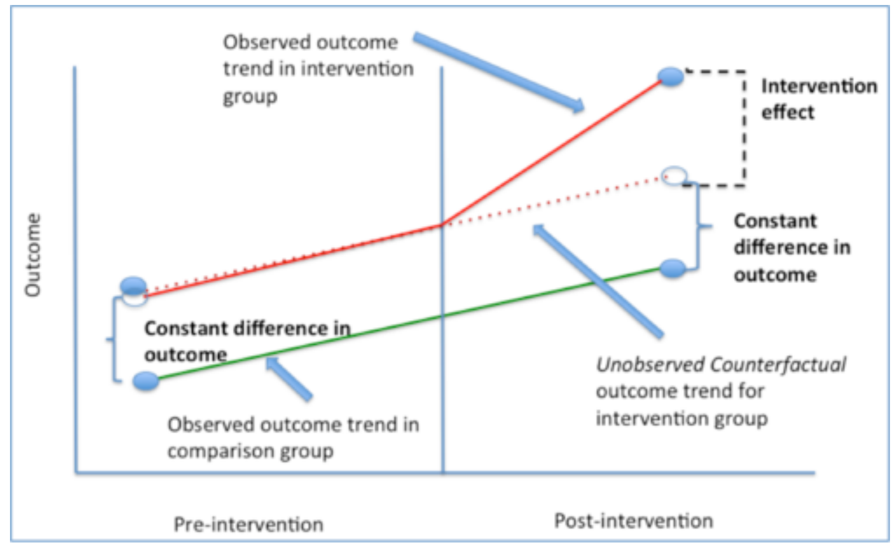
- Independent variable
  - Classical (at random)
    - Attenuation bias

$$\widehat{\beta_1} \xrightarrow{p} \frac{\sigma_X^2}{\sigma_X^2 + \sigma_w^2}\beta_1$$

  - Non-classical (not at random)
    - Bias!

Panel data methods

- Difference-in-differences
  - Requires ”natural experiment”
  - For our purposes, before and after, “treatment” and “control”
  - Assumption of parallel trends



$$y_{it} = \beta_0 + \beta_1 Post_t + \beta_2 Treat_i + \beta_3 Post_t X Treat_i + u_{it}$$

Panel data methods

- First differences:
  - Measure impact of change in x on change in y!
  - Subtract out any time-invariant characteristics

$$\Delta y_i = \beta_0 + \beta_1 \Delta x_i + u_i$$

- Fixed effects
  - Control specifically for individual/unit-specific effects!
  - Control specifically for time-invariant effects
  - Still assume no omitted variables

$$y_{it} = \beta_0 + \beta_1 x_{it} + a_i + b_t + u_{it}$$

Instrumental variables

- Find an instrument: something that manipulates Y *only through* manipulating X
  - That is, corr(z,x)> 0 but corr(z,u) = 0!

Good instruments are…

- **Powerful:** (First stage F-stat > 10)
- **Excludable:** Not correlated with y directly
- **Exogenous:** Not correlated with other unobserved factors

Instrumental variables

- First stage

$$x_1 = \alpha_0 + \alpha_1 z + \alpha_2 x_2 + v$$

$$\rightarrow \widehat{x_1} = \widehat{\alpha_0} + \widehat{\alpha_1} z + \widehat{\alpha_2} x_2$$

- Second stage

$$y = \beta_0 + \beta_1 \widehat{x_1} + \beta_2 x_2 + u$$

- β_1 is causal impact of x on y among those who responded to z
  - Local average treatment effect
- Covariates (like x_2) can help meet our identification assumptions