Announcements

- Rough draft of research proposal due next week…
  - Just 1- to 3-page (single-spaced) sketch of your proposal is fine…
    - Should clearly state your question
    - Should give me idea of where you’re going with the identification strategy
    - *See grading template on Canvas*
  - **Upload it to Canvas** by noon next week
  - I will read and then send brief feedback
Background readings

- Roberts and Whited
  - Section 3

- Angrist and Pischke
  - Sections 4.1, 4.4, and 4.6

- Wooldridge
  - Chapter 5

- Greene
  - Sections 8.2-8.5
Outline for Today

- Quick review of panel regressions
- Discuss IV estimation
  - How does it help?
  - What assumptions are needed?
  - What are the weaknesses?
- Student presentations of “Panel Data”
Quick Review [*Part 1*]

- What type of omitted variable does panel data and FE help mitigate, and how?
  - **Answer #1** = It can help eliminate omitted variables that don’t vary within panel groups.
  - **Answer #2** = It does this by transforming the data to remove this group-level heterogeneity [or equivalently, directly controls for it using indicator variables as in LSDV].
Quick Review [Part 2]

- Why is random effects useless [at least in corporate finance settings]?
Quick Review *Part 3*

- What are three limitations of FE?
  
  #1 – Can’t estimate coefficient on variables that don’t vary within groups

  #2 – Could amplify any measurement error

  - For this reason, be cautious interpreting zero or small coefficients on possibly mismeasured variables

  #3 – Can’t be used in models with lagged values of the dependent variable
Outline for Instrumental Variables

- Motivation and intuition
- Required assumptions
- Implementation and 2SLS
  - Weak instruments problem
  - Multiple IVs and overidentification tests
- Miscellaneous IV issues
- Limitations of IV
Consider the following estimation

\[ y = \beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k + u \]

where \( \text{cov}(x_1,u) = \ldots = \text{cov}(x_{k-1},u) = 0 \)
\[ \text{cov}(x_k,u) \neq 0 \]

- If we estimate this model, will we get a consistent estimate of \( \beta_k \)?
- When would we get a consistent estimate of the other \( \beta \)'s, and is this likely?
**Motivation [Part 2]**

- **Answer #1:** No. We will not get a consistent estimate of $\beta_k$.

- **Answer #2:** Very unlikely. We will only get consistent estimate of other $\beta$ if $x_k$ is uncorrelated with all other $x$.

Instrumental variables provide a *potential* solution to this problem...
Instrumental variables – Intuition

- Think of $x_k$ as having ‘good’ and ‘bad’ variation
  - Good variation is not correlated with $u$
  - Bad variation is correlated with $u$

- An IV (let’s call it $z$) is a variable that explains variation in $x_k$, but doesn’t explain $y$
  - I.e., it only explains the “good” variation in $x_k$

- Can use the IV to extract the “good” variation and replace $x_k$ with only that component!
Outline for Instrumental Variables

- Motivation and intuition
- Required assumptions
- Implementation and 2SLS
  - Weak instruments problem
  - Multiple IVs and overidentification tests
- Miscellaneous IV issues
- Limitations of IV
Instrumental variables – Formally

- IVs must satisfy two conditions
  - Relevance condition
  - Exclusion condition

- What are these two conditions?
- Which is harder to satisfy?
- Can we test whether they are true?

To illustrate these conditions, let’s start with the simplest case, where we have one instrument, \( \zeta \), for the problematic regressor, \( x_k \).
Relevance condition [Part 1]

- The following must be true…
  - In the following model
    \[ x_k = \alpha_0 + \alpha_1 x_1 + \ldots + \alpha_{k-1} x_{k-1} + \gamma z + \nu \]
    \( z \) satisfies the relevance condition if \( \gamma \neq 0 \)
  - **What does this mean in words?**
    - **Answer:** \( z \) is relevant to explaining the problematic regressor, \( x_k \), after partialling out the effect of *all* the other regressors in the original model.
Relevance condition [Part 2]

- Easy to test the relevance condition!
  - Just run the regression of $x_k$ on all the other $x$’s and the instrument $z$ to see if $z$ explains $x_k$
  - As we see later, this is what people call the ‘first stage’ of the IV estimation
Exclusion condition [Part 1]

- The following must be true...
  - In the original model, where
    \[ y = \beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k + u \]
    \( z \) satisfies the exclusion condition if \( \text{cov}(z, u) = 0 \)
  - What does this mean in words?
    - Answer: \( z \) is uncorrelated with the disturbance, \( u \)...
      i.e., \( z \) has no explanatory power with respect to \( y \)
      after conditioning on the other \( x \)'s;
Trick question! You **cannot** test the exclusion restriction **[Why?]**

- **Answer:** You can’t test it because \( u \) is **unobservable**
- You must find a convincing **economic** argument as to why the exclusion restriction is not violated
I’ve seen some try to use the below argument as support for the exclusion restriction… what’s wrong with it?

- Estimate the below regression…

\[
y = \beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k + \gamma z + u
\]

- If \( \gamma = 0 \), then exclusion restriction likely holds… i.e., they argue that \( z \) doesn’t explain \( y \) after conditioning on the other \( x \)’s
If the original regression doesn’t give consistent estimates, then neither will this one!

- $\text{cov}(x_k, u) \neq 0$, so the estimates are still biased
- Moreover, if we believe the relevance condition, then the coefficient on $z$ is certainly biased because $z$ is correlated with $x_k$
What makes a good instrument?

- Bottom line, an instrument must be justified largely on economic arguments
  - Relevance condition can be shown formally, but you should have an economic argument for why
  - Exclusion restriction cannot be tested... you need to provide a convincing economic argument as to why it explains $y$, but only through its effect on $x_k$
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  - Multiple IVs and overidentification tests
- Miscellaneous IV issues
- Limitations of IV
Implementing IV estimation

- You’ve found a good IV, now what?
- One can think of the IV estimation as being done in two steps
  - **First stage:** regress \( x_k \) on other \( x \)'s & \( z \)
  - **Second stage:** take predicted \( x_k \) from first stage and use it in original model instead of \( x_k \)

  This is why we also call IV estimations two stage least squares (2SLS)
First stage of 2SLS

- Estimate the following

\[ x_k = \alpha_0 + \alpha_1 x_1 + \ldots + \alpha_{k-1} x_{k-1} + \gamma z + \nu \]

Problematic regressor
[i.e., \( \text{cov}(x_k, u) \neq 0 \)]

All other non-problematic variables that explain \( y \)

Instrumental variable

- Get estimates for the \( \alpha \)'s and \( \gamma \)
- Calculate predicted values, \( \hat{x}_k \), where

\[ \hat{x}_k = \hat{\alpha}_0 + \hat{\alpha}_1 x_1 + \ldots + \hat{\alpha}_{k-1} x_{k-1} + \hat{\gamma} z \]
Second stage of 2SLS

- Use predicted values to estimate

\[ y = \beta_0 + \beta_1 x_1 + \ldots + \beta_k \hat{x}_k + u \]

Predicted values replace the problematic regressor

- Can be shown (see textbook for math) that this 2SLS estimation yields **consistent** estimates of all the \( \beta \) when both the relevance and exclusion conditions are satisfied
Intuition behind 2SLS

- Predicted values represent variation in $x_k$ that is ‘good’ in that it is driven only by factors that are uncorrelated with $u$
  - Specifically, predicted value is linear function of variables that are uncorrelated with $u$
- Why not just use other $x$’s? Why need $z$?
  - Answer: Can’t just use other $x$’s to generate predicted value because then predicted value would be collinear in the second stage
The “reduced form” estimation is when you regress $y$ directly onto the instrument, $z$, and other non-problematic $x$’s

$$y = \beta_0 + \beta_1 x_1 + ... + \beta_{k-1} x_{k-1} + \delta z + u$$

- It is an unbiased and consistent estimate of the effect of $z$ on $y$ (presumably through the channel of $z$’s effect on $x_k$)
Reduced Form Estimates [Part 2]

- It can be shown that the IV estimate for $x_k$, $\hat{\beta}_k^{IV}$, is simply given by...

$$\hat{\beta}_k^{IV} = \frac{\hat{\delta}}{\hat{\gamma}}$$

- Reduced form coefficient estimate for $z$
- First stage coefficient estimate for $z$

- I.e., if you don’t find effect of $z$ on $y$ in reduced form, then IV is unlikely to work

- IV estimate is just scaled version of reduced form
Practical advice [Part 1]

- Don’t state in your paper’s intro that you use an IV to resolve an identification problem, unless...
  - You also state what the IV you use is
  - And provide a strong economic argument as to why it satisfies the necessary conditions

Don’t bury the explanation of your IV! Researchers that do this almost always have a bad IV. If you really have a good IV, you’ll be willing to defend it in the intro!
Practical advice \textit{[Part 2]}

- Don’t forget to justify why we should believe the exclusion restriction holds
  - Too many researchers only talk about the relevance condition
  - Exclusion restriction is \textit{equally} important
Do **not** do two stages on your own!

- Let the software do it; e.g., in Stata, use the IVREG or XTIVREG (for panel data) commands

Three ways people will mess up when trying to do 2SLS on their …

#1 – Standard errors will be wrong
#2 – They try using nonlinear models in first stage
#3 – They will use the fitted values incorrectly
Practical Advice [Part 3-1]

- Why will standard errors be wrong if you try to do 2SLS on your own?

  - **Answer:** Because the second stage uses ‘estimated’ values that have their own estimation error. This error needs to be considered when calculating standard errors!
Practical Advice [Part 3-2]

- People will try using predicted values from non-linear model, e.g., Probit or Logit, in a ‘second stage’ IV regression

  - But **only** linear OLS in first stage guarantees covariates and fitted values in second stage will be uncorrelated with the error

  - I.e., this approach is **NOT** consistent

  - This is what we call the “forbidden regression”
In models with quadratic terms, e.g.

\[ y = \beta_0 + \beta_1 x + \beta_2 x^2 + u \]

people often try to calculate one fitted value \( \hat{x} \) using one instrument, \( z \), and then plug in \( \hat{x} \) and \( \hat{x}^2 \) into second stage…

- Seems intuitive, but it is **NOT** consistent!
- Instead, you should just use \( z \) and \( z^2 \) as IVs!
Practical Advice [Part 3]

- Bottom line… if you find yourself plugging in fitted values when doing an IV, you are probably doing something wrong!
  - Let the software do it for you; it will prevent you from doing incorrect things
Practical Advice [Part 4]

- All $\times$’s that are not problematic, need to be included in the first stage!!!
  - You’re not doing 2SLS, and you’re not getting consistent estimates if this isn’t done
  - This includes things like firm and year FE!

- Yet another reason to let statistical software do the 2SLS estimation for you!
Practical Advice *[Part 5]*

- Always report your first stage results & $R^2$
- There are two good reasons for this…

*What are they?*

- **Answer #1:** It is direct test of relevance condition... i.e., we need to see $\gamma \neq 0$!
- **Answer #2:** It helps us determine whether there might be a weak IV problem…
Outline for Instrumental Variables

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- Limitations of IV
Consistent, but biased

- IV is a consistent, but biased, estimator
  - For any finite number of observations, $N$, the IV estimates are biased toward the biased OLS estimate
  - But, as $N$ approaches infinity, the IV estimates converge to the true coefficients

- This feature of IV leads to what we call the weak instrument problem...
Weak instruments problem

- A weak instrument is an IV that doesn’t explain very much of the variation in the problematic regressor

- Why is this an issue?
  - Small sample bias of estimator is greater when the instrument is weak; i.e., our estimates, which use a finite sample, might be misleading…
  - $t$-stats in finite sample can also be wrong
Weak IV bias can be severe [Part 1]

- Hahn and Hausman (2005) show that finite sample bias of 2SLS is $\approx$ 

$$\frac{j\rho(1-r^2)}{Nr^2}$$

- $j =$ number of IVs [we’ll talk about multiple IVs in a second]
- $\rho =$ correlation between $x_k$ and $u$
- $r^2 =$ $R^2$ from first-stage regression
- $N =$ sample size
Weak IV bias can be severe \([Part 2]\)

More instruments, which we’ll talk about later, need not help; they help increase \(r^2\), but if they are weak (i.e., don’t increase \(r^2\) much), they can still increase finite sample bias

A low explanatory power in first stage can result in large bias even if \(N\) is large

\[
\frac{j\rho(1-r^2)}{Nr^2}
\]
Detecting weak instruments

- **Number of warning flags to watch for…**
  - Large standard errors in IV estimates
    - You’ll get large SEs when covariance between instrument and problematic regressor is low
  - Low F statistic from first stage
    - The higher F statistic for excluded IVs, the better
    - Stock, Wright, and Yogo (2002) find that an F statistic above 10 likely means you’re okay…
Excluded IVs – *Tangent*

- Just some terminology…
  - In some ways, can think of all non-problematic \(x\)’s as IVs; they all appear in first stage and are used to get predicted values.
  - But, when people refer to excluded IVs, they refer to the IVs (i.e., \(z\)’s) that are excluded from the second stage.
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More than one problematic regressor

Now, consider the following...

\[ y = \beta_0 + \beta_1 x_1 + ... + \beta_k x_k + u \]

where \( \text{cov}(x_1,u) = ... = \text{cov}(x_{k-2},u) = 0 \)

\( \text{cov}(x_{k-1},u) \neq 0 \)

\( \text{cov}(x_k,u) \neq 0 \)

- There are two problematic regressors, \( x_{k-1} \) and \( x_k \)
- Easy to show that IVs can solve this as well
Multiple IVs [Part 1]

- Just need one IV for each problematic regressor, e.g., $z_1$ and $z_2$

- Then, estimate 2SLS in similar way...
  - Regress $x_k$ on all other $x$’s (except $x_{k-1}$) and both instruments, $z_1$ and $z_2$
  - Regress $x_{k-1}$ on all other $x$’s (except $x_k$) and both instruments, $z_1$ and $z_2$
  - Get predicted values, do second stage
Multiple IVs [Part 2]

- Need at least as many IVs as problematic regressors to ensure predicted values are not collinear with the non-problematic $x$’s

  - If # of IVs match # of problematic $x$’s, model is said to be “Just Identified”
“Overidentified” Models

- Can also have models with more IVs than # of problematic regressors
  - E.g., $m$ instruments for $b$ problematic regressors, where $m > b$
  - This is what we call an overidentified model

- Can implement 2SLS just as before…
Overidentified model conditions

- **Necessary conditions very similar**
  - **Exclusion restriction** = none of the instruments are correlated with $u$
  - **Relevance condition**
    - Each first stage (there will be $h$ of them) must have at least one IV with non-zero coefficient
    - Of the $m$ instruments, there must be at least $h$ of them that are partially correlated with problematic regressors [otherwise, model isn’t identified]

E.g., you can’t just have one IV that is correlated with all the problematic regressors, and all the other IVs are not
Benefit of Overidentified Model

- Assuming you satisfy the relevance and exclusion conditions, you will get more asymptotic efficiency with more IVs

  - **Intuition:** you can extract more ‘good’ variation from the first stage of the estimation
However, Overidentification Dilemma

- Suppose you are a very clever researcher...
  - You find not just $h$ instruments for $h$ problematic regressors, you find $m > h$
    - First, you should consider yourself very clever [a good instrument is hard to come by]!
    - But why might you not want to use the $m-h$ extra instruments?
Answer – Weak instruments

- Again, as we saw earlier, a weak instrument will increase likelihood of finite sample bias and misleading inferences!
  - If have one good IV, not clear you want to add some extra (less good) IVs...
Helpful to always show results using “just identified” model with your best IVs

- It is least likely to suffer small sample bias
- In fact, the just identified model is median-unbiased making weak instruments critique less of a concern
When model is overidentified, you can supposedly “test” the quality of your IVs

The logic of the tests is as follows…

- If all IVs are valid, then we can get consistent estimates using any subset of the IVs
- So, compare IV estimates from different subsets; if find they are similar, this suggests the IVs okay
But I see the following all the time…

- Researcher has overidentified IV model
- All the IVs are highly questionable in that they lack convincing economic arguments
- But authors argue that because their model passes some “overidentification test” that the IVs must be okay

What is wrong with this logic?
Answer = All the IVs could be junk!

- The “test” implicitly assumes that some subset of instruments is valid
- This may not be the case!

To reiterate my earlier point...

- There is no test to prove an IV is valid! Can only motivate that the IV satisfies exclusion restriction using economic theory
“Informal” checks – *Tangent*

- It is useful, however, to try some “informal” checks on validity of IV
  - E.g., One could show the IV is uncorrelated with other non-problematic regressors or with $y$ that pre-dates the instrument
    - Could help bolster economic argument that IV isn’t related to outcome $y$ for other reasons
    - But don’t do this for your actual outcome, $y$, why?
      **Answer** = It would suggest a weak IV (at best)
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- Miscellaneous IV issues
- Limitations of IV
Miscellaneous IV issues

- IVs with interactions
- Constructing additional IVs
- Using lagged $y$ or lagged $x$ as IVs
- Using group average of $x$ as IV for $x$
- Using IV with FE
- Using IV with measurement error
IVs with interactions

- Suppose you want to estimate

\[ y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_1 x_2 + u \]

where \( \text{cov}(x_1, u) = 0 \)

\( \text{cov}(x_2, u) \neq 0 \)

- Now, both \( x_2 \) and \( x_1 x_2 \) are problematic
- Suppose you can only find one IV, \( z \).

Is there a way to get consistent estimates?
IVs with interactions \textit{[Part 2]}

- **Answer** = Yes! In this case, one can construct other instruments from the one IV
  
  - Use $\zeta$ as IV for $x_2$
  - Use $x_1\zeta$ as IV for $x_1 x_2$

- Same **economic argument** used to support $\zeta$ as IV for $x_2$ will carry through to using $x_1\zeta$ as IV for $x_1 x_2$
Now, suppose you want to estimate \( y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + u \)

where

\[
\begin{align*}
\text{cov}(x_1, u) &= 0 \\
\text{cov}(x_2, u) &\neq 0 \\
\text{cov}(x_3, u) &\neq 0
\end{align*}
\]

Now, both \( x_2 \) and \( x_3 \) are problematic.

- Suppose you can only find one IV, \( z \), and you think \( z \) is correlated with both \( x_2 \) and \( x_3 \)...

Can you use \( z \) and \( z^2 \) as IVs?
Constructing additional IV [Part 2]

- **Answer** = Technically, yes. But probably not advisable…

  - Absent an economic reason for why \( z^2 \) is correlated with either \( x_2 \) or \( x_3 \) after partialling out \( z \), it’s probably not a good IV.

- Even if it satisfies the relevance condition, it might be a ‘weak’ instrument, which can be problematic [as seen earlier].
Lagged instruments

- It has become common in CF to use lagged variables as instruments.
- This usually takes two forms:
  - Instrumenting for a lagged $y$ in dynamic panel model with FE using a lagged lagged $y$.
  - Instrumenting for problematic $x$ or lagged $y$ using lagged version of the same $x$. 
Example where lagged IVs are used

- As noted last week, we cannot estimate models with both a lagged dep. var. and unobserved FE

\[ y_{i,t} = \alpha + \rho y_{i,t-1} + \beta x_{i,t} + f_i + u_{i,t}, \quad |\rho| < 1 \]

- The lagged \( y \) independent variable will be correlated with the error, \( u \)

- One proposed solution is to use lagged values of \( y \) as IV for problematic \( y_{i,t-1} \)
Using lagged $y$ as IV in panel models

- Specifically, papers propose using first differences combined with lagged values, like $y_{i,t-2}$, as instrument for $y_{i,t-1}$
  - *Could* work in theory, …
    - Lagged $y$ will likely satisfy relevance criteria
    - But exclusion restriction requires lagged values of $y$ to be uncorrelated with differenced residual, $u_{i,t} - u_{i,t-1}$

**Is this plausible in corporate finance?**
Lagged $y$ values as instruments?

- Probably not…
  - Lagged values of $y$ will be correlated with changes in errors if errors are serially correlated
  - This is common in corporate finance, suggesting this approach is not helpful

[See Holtz-Eakin, Newey, and Rosen (1988), Arellano and Bond (1991), Blundell and Bond (1998) for more details on these type of IV strategies]
Lagged $x$ values as instruments? [Part 1]

- Another approach is to make assumptions about how $x_{i,t}$ is correlated with $u_{i,t}$
  - Idea behind relevance condition is $x$ is persistent and predictive of future $x$ or future $y$ [depends on what you’re trying to instrument]
  - And exclusion restriction is satisfied if we assume $x_{i,t}$ is uncorrelated with future shocks, $u$
Lagged $x$ values as instruments? [Part 2]

- Just not clear how plausible this is...
  - Again, serial correlation in $u$ *(which is very common in CF)* all but guarantees the IV is invalid
  - An **economic argument** is generally lacking, *[and for this reason, I’m very sceptical of these strategies]*

[See Arellano and Bond (1991), Arellano and Bover (1995) for more details on these type of IV strategies]
Using group averages as IVs [Part 1]

- Will often see the following...

\[ y_{i,j} = \alpha + \beta x_{i,j} + u_{i,j} \]

- \( y_{i,j} \) is outcome for observation \( i \) (e.g., firm) in group \( j \) (e.g., industry)
- Researcher worries that \( \text{cov}(x,u) \neq 0 \)
- So, they use group average, \( \bar{x}_{-i,j} \), as IV

\[
\bar{x}_{-i,j} = \frac{1}{J-1} \sum_{\substack{i \in j \\ k \neq i}} x_{k,j} \\
J \text{ is } \# \text{ of observations in the group}
\]
Using group averages as IVs [Part 2]

- They say...
  - “group average of $x$ is likely correlated with own $x$” – i.e., relevance condition holds
  - “but group average doesn’t directly affect $y$” – i.e., exclusion restriction holds

- Anyone see a problem?
Using group averages as IVs [Part 3]

- **Answer =**
  - Relevance condition implicitly assumes some common group-level heterogeneity, \( f_j \), that is correlated with \( x_{ij} \)
  - But if model has \( f_j \) (i.e., group fixed effect), then \( \bar{x}_{-i,j} \) must violate exclusion restriction!

- **This is a bad IV** [see Gormley and Matsa (2014) for more details]
Other Miscellaneous IVs

- As noted last class, IVs can also be useful in panel estimations
  
  #1 – Can help identify effect of variables that don’t vary within groups [which we can’t estimate directly in FE model]

  #2 – Can help with measurement error
Use the following three steps to identify variables that don’t vary within groups...

#1 – Estimate the FE model

#2 – Take group-averaged residuals, regress them onto variable(s), \( x' \), that don’t vary in groups (i.e., the variables you couldn’t estimate in FE model)

Why is this second step (on its own) problematic?

Answer: because unobserved heterogeneity (which is still collinear with \( x' \)) will still be in error (because it partly explains group-average residuals)
#1 – IV and FE models [Part 2]

- Solution in second step is to use IV!
  
  #3 – Use covariates that do vary in group (from first step) as instruments in second step

- Which x’s from first step are valid IVs?

- **Answer** = those that don’t co-vary with unobserved heterogeneity but do co-vary with variables that don’t vary within groups [again, economic argument needed here]

- See Hausman and Taylor (1981) for details
- Done in Stata using `XTHTTAYLOR`
#2 – IV and measurement error [Part 1]

- As discussed last week, measurement error can be a problem in FE models
- IVs provide a potential solution
  - Pretty simple idea…
  - Find $\xi$ correlated to mismeasured variable, but not correlated with $\nu$; use IV
But easier said then done!

- Identifying a valid instrument requires researcher to understand exact source of measurement error

- This is because the disturbance, \( u \), will include the measurement error; hence, how can you make an economic argument that \( \gamma \) is uncorrelated with it if you don’t understand the measurement error?

[See Biorn (2000) and Almeida, Campello, and Galvao (RFS 2010) for examples of this strategy]
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Limitations of IV

- There are two main limitations to discuss
  - Finding a good instrument is hard; even the seemingly best IVs can have problems
  - External validity can be a concern
Subtle violations of exclusion restriction

- Even the seemingly best IVs can violate the exclusion restriction
  - Roberts and Whited (pg. 31, 2011) provide a good example of this in description of Bennedsen et al. (2007) paper
  - Whatever group is discussing this paper next week should look… 😊
Paper studies effect of family CEO succession on firm performance

- IVs for family CEO succession using gender of first-born child
  - Families where the first child was a boy are more likely to have a family CEO succession
  - Obviously, gender of first-born is totally random; seems like a great IV…

Any guesses as to what might be wrong?
Problem is that first-born gender may be correlated with disturbance $u$

- Girl-first families may only turnover firm to a daughter when she is very talented
- Therefore, effect of family CEO turnover might depend on gender of first born
- I.e., gender of first born is correlated with $u$ because it includes interaction between problematic $\times$ and the instrument, $\varepsilon$!
External vs. Internal validity

- **External validity** is another concern of IV [and other identification strategies]

  - **Internal validity** is when the estimation strategy successfully uncovers a causal effect

  - **External validity** is when those estimates are predictive of outcomes in other scenarios

  - IV (done correctly) gives us internal validity
  - But it doesn’t necessarily give us external validity
External validity [Part 1]

- Issue is that IV estimates only tell us about subsample where the instrument is predictive
  - Remember, you’re only making use of variation in $x$ driven by $z$
  - So, we aren’t learning effect of $x$ for observations where $z$ doesn’t explain $x$!

- It’s a version of LATE (local average treatment effect) and affects interpretation
External validity [Part 2]

- Again, consider Bennedsen et al (2007)
  
  - Gender of first born may only predict likelihood of family turnover in certain firms…
    - I.e., family firms where CEO thinks females (including daughters) are less suitable for leadership positions
  
  - Thus, we only learn about effect of family succession for these firms
  
  - Why might this matter?
Answer: These firms might be different in other dimensions, which limits the external validity of our findings.

- E.g., Could be that these are poorly run firms…
  - If so, then we only identify effect for such poorly run firms using the IV
  - And effect of family succession in well-run firms might be quite different…
External validity \([Part 4]\)

- Possible test for external validity problems
  - Size of residual from first stage tells us something about importance of IV for certain observations
    - Large residual means IV didn’t explain much
    - Small residual means it did
  - Compare characteristics (i.e., other \(x\)’s) of observations of groups with small and large residuals to make sure they don’t differ much
IV estimation is one possible way to overcome identification challenges.

A good IV needs to satisfy two conditions:
- Relevance condition
- Exclusion condition

Exclusion condition cannot be tested; must use economic argument to support it.
Summary of Today [Part 2]

- IV estimations have their limits
  - Really hard to find good IV
  - Weak instruments can be a problem, particularly when you have more IVs than problematic regressors
  - External validity can be a concern
In First Half of Next Class

- Natural experiments \([Part 1]\)
  - How do they help with identification?
  - What assumptions are necessary to make causal inferences?
  - What are their limitations?

- Related readings… see syllabus
Assign papers for next week...

- Gormley (JFI 2010)
  - Foreign bank entry and credit access

- Bennedsen, et al. (QJE 2007)
  - CEO family succession and performance

  - Debt overhang and performance
Break Time

- Let’s take our 10-minute break
- We’ll do presentations when we get back