Review of instrumental variables, and an introduction to the economics of institutions

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Institutional determinants of economic outcomes

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There is another view common in the social sciences that the political and economic fate of a country or a village is primarily determined by deep, historical forces.

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Principles of IV estimation

Assume that we have an equation that can be written as follows:

\[ Y_i = \beta_0 X_i + \epsilon_i \]

However, the equation suffers from omitted variable bias; accordingly, estimating this equation employing OLS will not yield an accurate estimate of the causal effect of interest.

Let us denote the true coefficient of interest \( \rho_0 \), while \( \beta_0 \) denotes the estimated coefficient in the OLS specification.
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Principles of IV estimation II

Now, let us assume that we have another measured variable, $Z_i$, that is correlated with $X_i$ but uncorrelated with $\epsilon_i$.

Formally, this lack of correlation between the instrument and the error term can be expressed as $\text{Cov}(Z_i, \epsilon_i) = 0$.

In this case, the coefficient of interest $\rho$ can be written as follows.

$$\rho_0 = \frac{\text{Cov}(Y_i, Z_i)}{\text{Cov}(X_i, Z_i)}$$

Note that this expression is only valid if the covariance of the instrument and the independent variable is different from zero; in practice, instrumental variables estimates are not particularly useful if $\text{Cov}(X_i, Z_i)$ is only marginally different from zero.
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Assumptions required for IV estimation

- First, there must be a significant relationship between the instrument $Z_i$ and the explanatory variable $X_i$. This relationship is deemed the first stage.
- Second, the instrument must satisfy an exclusion restriction: the only reason for the relationship between $Y_i$ and $Z_i$ is the first stage.
- This assumption has two parts.
  - The instrument is as good as randomly assigned (i.e., independent of potential outcomes, conditional on covariates.)
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Stylized example: education

- Parental education is strongly predictive of children’s education.
- We want to estimate the impact of education on income.
- Is parental education an appropriate instrument? Check the assumptions one by one.
  - Is there a first stage? Yes - we can verify this in the data.
  - Is the instrument as good as randomly assigned? No.
  - Even conditional on the children’s education, parental education could affect children’s outcomes in many other ways. Parents that have more education not only provide more education for their children, but more income, a more stimulating home environment, a different attitude toward learning, etc.
- This is an example of bad instrumentation.
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Stylized example: rainfall

- Rainfall is highly predictive of the number of car crashes in the United States.
- We want to estimate the impact of car crashes on mortality.
- Is this an appropriate instrument? Check the assumptions one by one.
  - Is there a first stage? Yes - we can verify this in the data.
  - Is the instrument as good as randomly assigned? Yes - rainfall is generally uncorrelated with other phenomena.
  - Does the instrument have an effect on mortality, other than via the number of car crashes? This may be not the case, as rainfall could also exacerbate illness and lead to more non-accidental deaths.
- This proposed instrumental variables strategy requires more investigation prior to implementation.
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We discussed last week the challenges in measuring the returns to education - how much higher your wages are as a result of education.

Two economists devised a clever approach to estimate the returns to years of education in high school by exploiting a quirk of educational policy in the U.S.: most districts require students to have turned five by September in the year in which they enter kindergarten, but you are legally allowed to leave school the day you turn 16.

If you are younger when you enter kindergarten (i.e., if you turned five on August 29, and your best friend turned five on January 1), and you both plan to leave school at the earliest possible date, you will attend school for a few more months than your best friend.
Example from the literature

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Proposed instrument

- Is there a first stage here? The authors showed that there was a first stage, a significant relationship between quarter of birth and years of schooling attained, though the relationship was small in magnitude. Why would the relationship be relatively weak?

- What about the exclusion restriction?
  - Is quarter of birth as good as randomly assigned? Maybe!
  - Does quarter of birth affect schooling through any other channel? Probably not.
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Evaluating a weak instrument problem

What is an F test?

An F test can often be used to test the significance of an entire regression; this is the F-test we’re interested in here.

A low F test generally suggests that the regression is not significant, while a higher F test suggests more significance; the exact critical value will vary depending on the number of coefficients estimated.

Econometric research has shown that we want the first stage in two-stage least squares estimation to have an F statistic of ideally around 10, or at minimum, 5.
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- Econometric research has shown that we want the first stage in two-stage least squares estimation to have an F statistic of ideally around 10, or at minimum, 5.
Why?

- Recall the formula for the estimated coefficient in a two-stage least squares specification.
  \[
  \rho_0 = \frac{\text{Cov}(Y_i, Z_i)}{\text{Cov}(X_i, Z_i)}
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- If the relationship between \( X_i \), the explanatory variable, and \( Z_i \), the instrument, is weak, what does this imply for this formula?

- Research has shown the bias can be worse in 2SLS with weak instruments, compared to simple OLS.
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Measurement error . . .

- is a related, but different problem; it is a challenge researchers often seek to solve using instrumental variables.
- Note measurement error is also not the same as omitted variable bias.
- Assume that we have a standard linear regression, but what we observe, $X_i$, is not the true value of the explanatory variable; rather, $X_i = X_i^* + u_i$, where $X_i^*$ is the true value.

$$Y_i = \beta(X_i^* + u_i) + \epsilon_i$$
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Why relevant?

- All data contains some errors, even the best-quality data; in many cases, the errors are minor, and don’t require much attention from economists.
- But, in some cases we expect much more significant measurement error, and in that case we may want to understand and correct for the bias introduced.
- This is, typically, a particularly acute problem for political economy papers given that many institutional features are hard to measure - and if we are considering historical institutional data, all the more so.
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Classical measurement error

- This may remind you of OVB, where we postulated a hypothetical additional variable $W_i$ that was correlated with $X_i$.
- In this case, however, the measurement error term $u_i$ is uncorrelated with $X_i$, and assumed to have mean zero and some standard deviation $\sigma^2$ - this is the classical measurement error case.
- This may seem innocuous, but what is the result?
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Signing the bias

Recall the regression coefficient $\beta$ can be written as follows.

$$\hat{\beta} = \frac{\widehat{\text{Cov}}(X, Y)}{\widehat{\text{Var}}(X)}$$

In this case, given the measurement error, $\beta$ can be written as follows.

$$\hat{\beta} = \frac{\widehat{\text{Cov}}(X_i^* + u_i, Y)}{\widehat{\text{Var}}(X_i^* + u_i)}$$

$$= \frac{\widehat{\text{Cov}}(X_i^* + u_i, \beta(X_i^* + u_i) + \epsilon_i)}{\widehat{\text{Var}}(X_i^* + u_i)}$$

$$= \frac{\beta \sigma_x^2}{\sigma_x^2 + \sigma_u^2}$$
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Conclusion

- We can observe that $\beta$ will be smaller in absolute value (i.e., closer to zero), than the true coefficient due to measurement error.
- Does anyone remember what this type of bias is called?
- Attenuation bias: because the coefficient is attenuated toward zero.
- This is discussed in AJR, but may also be relevant for many other papers this semester.
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The authors begin with the question: what is the fundamental cause of large differences in income per capita across countries?

Given that one plausible hypothesis is that differences in institutions and property rights lead to differences in income, how can this hypothesis be tested?

The objective of the authors is to identify the impact of institutions on economic performance, and accordingly, they need a source of exogenous variation in institutions.

In other words, they need an instrument: a variable correlated with institutions, but otherwise uncorrelated with economic performance.
The authors begin with the question: what is the fundamental cause of large differences in income per capita across countries?

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AJR: Colonial Origins of Comparative Development

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Overview of the identification strategy

- European powers set up different types of institutions under colonialism: some highly extractive, some with greater emphasis on protections against expropriation and misuse of power.
- The type of institution chosen was influenced by the feasibility of settlement: if settler mortality was lower, there was a higher probability of better-quality institutions.
- Better-quality institutions persist, and lead to higher economic performance in the present day.
- Key insight: use settler mortality as an instrument for institutions.
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Reduced-form relationship

- The reduced-form relationship refers to the correlation between the instrument $Z_i$ and the outcome variable of interest $Y_i$.
- In this case, the core relationship of the paper can be captured graphically.
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Plotting the reduced form

**Figure 1. Reduced-Form Relationship Between Income and Settler Mortality**
The primary equation of interest is the following.

$$\log y_i + \mu + \alpha R_i + X_i' \gamma + \epsilon_i$$

where $y$ denotes per-capita income, $R$ is a measure of current institutions (protection against expropriation between 1985 and 1995), and $X$ is other covariates.

Additional variables of interest: $C$ is a measure of early (circa 1900) institutions, $S$ is a measure of European settlements (fraction of population with European descent in 1900), and $M$ is mortality rates.
Estimating equation

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Comparing OLS and 2SLS results

What direction of bias would we expect in the OLS results?

First, there may be measurement error in how we measure institutional quality; what direction of bias will this generate?

Second, institutions are endogenously determined. What direction of bias will this generate?
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Ongoing debate

- This paper has been the center of an ongoing scholarly debate initiated by David Alouay at the University of Michigan, who published a critique of the paper.

- He argued that there were significant challenges with the mortality data, particularly given that in a number of cases mortality rates for countries were not based on data collected within their borders, but rather imputed from countries with similar disease environments.

- When adjustments to the mortality rate are made, the first stage has very limited predictive power (low F-statistic).

- The debate about the validity of AJR’s empirical results continued! You can find Alouay's critique and AJR’s response in the AER.
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- Reminder: what direction of bias would measurement error and endogeneity, respectively, generate? Which appears to dominate?
- Do you find the identification strategy plausible? What are potential sources of bias?
- What can we observe about the strength of the first stage?
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▶ This was a “rock star” paper, providing seemingly rigorous evidence of a relationship that previously had been assumed.
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▶ How do we interpret “protection from expropriation”? Do you think this is the primary, or only, dimension of institutions that matters?
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## Descriptive statistics

### Table II

<table>
<thead>
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<th>Code</th>
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<th>Trans-Saharan</th>
<th>Red Sea</th>
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</tbody>
</table>
Identification strategy

Figure V
Example Showing the Distance Instruments for Burkina Faso
Nunn begins by examining the relationship between past slave exports and common economic performance.

\[ \ln y_i = \beta_0 + \beta_1 \ln(\frac{exports_i}{area_i}) + C'_i\delta + X'_i\delta + \epsilon_i \]

Do the OLS estimates (negative) capture a causal estimate?
Basic empirical specification

- Nunn begins by examining the relationship between past slave exports and common economic performance.

\[ \ln y_i = \beta_0 + \beta_1 \ln \left( \frac{\text{exports}_i}{\text{area}_i} \right) + C_i\delta + X_i\delta + \epsilon_i \]

- Do the OLS estimates (negative) capture a causal estimate?
Causality and measurement challenges

- Alternative explanation: societies that were initially underdeveloped select into the slave trade, and also show persistently lower levels of per-capita income.

- In order to address this challenge, Nunn employs a set of instruments that capture the distance between each country and the major destinations of the slave trade (ports in the Atlantic, ports in the Indian Ocean, slave depots in north Africa, and ports of export for the Red Sea trade).

- We will return, at length, to discussing the magnitude and sign of these estimates, as well as potential problems.
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Channels of the causal effect

- In the final section, Nunn explores potential channels through which the slave trade affects current economic performance.
- The results here are more speculative, in that he primarily documents correlations between the intensity of the slave trade and ethnic fractionalization, as well as precolonial state formation.
- Correlations suggest the slave trade may have impeded the formation of broader ethnic identities, as well as the formation of precolonial states.
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Discussion questions - econometrics

- How does the magnitude of the 2SLS estimates compare to the OLS estimates?
- What econometric phenomena could explain the difference? Measurement error? Endogeneity?
- Can you tell me the endogeneity story that would result in this bias?
- Let’s consider again weak instruments: is this a potential risk in this analysis?
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- Evaluating this paper raises some of the same questions asked about AJR: it presents rigorous empirical evidence of an intuitive result. (How could the slave trade NOT be bad?)
- What, if anything, have we learned that might be policy-relevant?
- What about the evidence about channels? Ethnic fractionalization and weak states are still very prevalent phenomena. Are there negative economic consequences? Do they have their roots in the slave trade? What about in other regions of the world?
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Discussion questions - interpretation

- Evaluating this paper raises some of the same questions asked about AJR: it presents rigorous empirical evidence of an intuitive result. (How could the slave trade NOT be bad?)
- What, if anything, have we learned that might be policy-relevant?
- What about the evidence about channels? Ethnic fractionalization and weak states are still very prevalent phenomena. Are there negative economic consequences? Do they have their roots in the slave trade? What about in other regions of the world?