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

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February 17, 2016

Institutional determinants of economic outcomes

- Last week's papers that presented evidence that short-term changes in the characteristics of political leaders, either at the national or local level, can immediately impact economic and political outcomes.
- 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.
- Today, we will analyze the most famous paper that presents evidence of this theory, and also represents a particularly innovative use of instrumental variables analysis, in addition to another more recent paper that focuses on the long-term impact of the slave trade.

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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.
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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 ϵ_i.
- Formally, this lack of correlation between the instrument and the error term can be expressed as $Cov(Z_i, \epsilon_i) = 0$.
- In this case, the coefficient of interest ρ can be written as follows.

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

- 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 $Cov(X_i, Z_i)$ 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.
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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 – the rain 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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Example from the literature

- 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.

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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!
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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.

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

- 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 σ^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 β can be written as follows.

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

- In this case, given the measurement error, β can be written as follows.

$$\begin{aligned}\hat{\beta} &= \frac{\widehat{Cov}(X_i^* + u_i, Y)}{\widehat{Var}(X_i^* + u_i)} \\ &= \frac{\widehat{Cov}(X_i^* + u_i, \beta(X_i^* + u_i) + \epsilon_i)}{\widehat{Var}(X_i^* + u_i)} \\ &= \frac{\beta\sigma_x^2}{\sigma_x^2 + \sigma_u^2}\end{aligned}$$

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Conclusion

- We can observe that β 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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AJR: Colonial Origins of Comparative Development

- 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.
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- 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.
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Plotting the reduced form

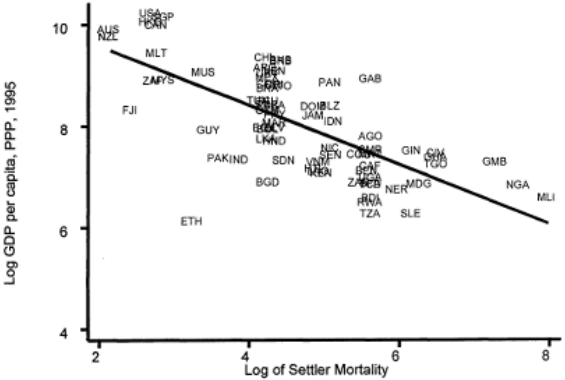

Figure 1. Reduced-Form Relationship Between Income and Settler Mortality

Estimating equation

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

  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.

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- 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.
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- Do you find the identification strategy plausible? What are potential sources of bias?
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- Is this result useful? Are there policy implications?
- 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
ESTIMATED TOTAL SLAVE EXPORTS BETWEEN 1400 AND 1900 BY COUNTRY

Isocode	Country name	Trans-Atlantic	Indian Ocean	Trans-Saharan	Red Sea	All slave trades
AGO	Angola	3,607,020	0	0	0	3,607,020
NGA	Nigeria	1,406,728	0	555,796	59,337	2,021,859
GHA	Ghana	1,614,793	0	0	0	1,614,793
ETH	Ethiopia	0	200	813,899	633,357	1,447,455
SDN	Sudan	615	174	408,261	454,913	863,962
MLI	Mali	331,748	0	509,950	0	841,697
ZAR	Democratic Republic of Congo	759,468	7,047	0	0	766,515
MOZ	Mozambique	382,378	243,484	0	0	625,862
TZA	Tanzania	10,834	523,992	0	0	534,826
TCD	Chad	823	0	409,368	118,673	528,862
BEN	Benin	456,583	0	0	0	456,583
SEN	Senegal	278,195	0	98,731	0	376,926
GIN	Guinea	350,149	0	0	0	350,149
TGO	Togo	289,634	0	0	0	289,634
GNB	Guinea-Bissau	180,752	0	0	0	180,752
BFA	Burkina Faso	167,201	0	0	0	167,201
MRT	Mauritania	417	0	164,017	0	164,434
MWI	Malawi	88,061	37,370	0	0	125,431
MDG	Madagascar	36,349	88,927	0	0	125,275
COG	Congo	94,663	0	0	0	94,663
KEN	Kenya	303	12,306	60,351	13,490	86,448
SLE	Sierra Leone	69,607	0	0	0	69,607
CMR	Cameroon	66,719	0	0	0	66,719
DZA	Algeria	0	0	61,835	0	61,835
CIV	Ivory Coast	52,646	0	0	0	52,646
SOM	Somalia	0	229	26,194	5,855	32,277
ZMB	Zambia	6,552	21,406	0	0	27,958
GAB	Gabon	27,403	0	0	0	27,403
GMB	Gambia	16,039	0	5,693	0	21,731
NER	Niger	133	0	0	19,779	19,912
LBY	Libya	0	0	8,848	0	8,848
LBR	Liberia	6,790	0	0	0	6,790
UGA	Uganda	900	3,654	0	0	4,554
ZAF	South Africa	1,944	87	0	0	2,031
CAF	Central African Republic	2,010	0	0	0	2,010
EGY	Egypt	0	0	1,492	0	1,492
ZWE	Zimbabwe	554	536	0	0	1,089
NAM	Namibia	191	0	0	0	191
BDI	Burundi	0	87	0	0	87
GNQ	Equatorial Guinea	11	0	0	0	11
DJI	Djibouti	0	5	0	0	5
BWA	Botswana	0	0	0	0	0

Identification strategy

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FIGURE V
Example Showing the Distance Instruments for Burkina Faso

Basic empirical specification

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

$$\ln y_i = \beta_0 + \beta_1 \ln(exports_i / area_i) + C_i' \delta + X_i' \delta + \epsilon_i$$

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- 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).
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- 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.
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