14.75: The Deep Determinants of Economic Development: Macro Evidence

Ben Olken
Several explanations for poverty at the macro level

- There are lots of current policy reasons why countries may fail to grow.
- But astriking fact about the world is that poor countries are not randomly distributed throughout the world.
Distribution of poor countries

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Several explanations for poverty at the macro level

- There are lots of current policy reasons why countries may fail to grow
- But a striking fact about the world is that poor countries are not randomly distributed throughout the world
- Instead poor countries tend to be:
  - Hot (e.g. near the equator)
  - Have been colonized by the Europeans
- Of course this is not always true. Counterexamples?
  - Singapore is hot and rich; Afghanistan is cold and poor
  - Thailand is poor and was not colonized; the US is rich and was colonized
- These are deep determinants – in the sense that they were determined hundreds of years ago. Do they matter now?
- The goal of this lecture is to see how we can tease this out in the data
The colonial legacy

- Many people have argued that colonization was bad for development. Why might this be?
- Now former colonies are independent. Why might colonialism still be bad today?
- But clearly colonization wasn’t always bad. Counterexamples? E.g. US, Canada, Australia
- So was colonization itself bad for economic development? And if so, what about it?
- Suppose the data says that former colonies are poorer than non-former colonies.
- This is surely true: Africa is poorer than Europe, for example. What can we conclude about colonialism?
AJR propose the following hypothesis to make sense of all this:

- There are different types of colonial institutions:
  - In places where they wanted to live themselves (e.g., Boston), colonizers set up good institutions to replicate Europe. Checks and balances, good protections for property rights, and so on.
  - In places where they wanted to extract resources (e.g., Congo), colonizers set up institutions to allow themselves to extract resources. Strong government, lack of protection for private property.

- These institutions persist even after independence.
- Thus the kind of colonialism you had 300-500 years ago can affect current economic performance.
To test this empirically, they suggest that:

- Which type of institutions they chose was affected by the feasibility of establishing settlements. If settlers were likely to die, they were more likely to set up the extractive institutions.
- So the idea is that those places where settlers were more likely to die 500 years ago should have worse institutions, and worse economic performance, today.

They propose this hypothesis and then test this in the data.

This is one of the most cited economics papers of the last decade – over 4,000 citations. How does it work? And does it make sense?
Instrumental Variables

- The empirical idea used in this paper is called *instrumental variables*. Also known as two-stage least squares.
- It’s going to come up a lot this semester, so we’re going to take a bit of a detour to explain how it works.
The identification challenge

- The empirical challenge is like the one we saw with leaders
  - Sometimes leader changes didn’t happen randomly. They were correlated with other things.

- Suppose you just looked at the cross-section. You had a measure of "extractive institutions" and a measure of "per-capita GDP" and looked at the cross-section.
The identification challenge

- The empirical challenge is like the one we saw with leaders
  - Sometimes leader changes didn’t happen randomly. They were correlated with other things.

- Suppose you just looked at the cross-section. You had a measure of "extractive institutions" and a measure of "per-capita GDP" and looked at the cross-section.

- What can you conclude? Does this tell you about the impact of extractive institutions on GDP per capita? Why or why not?

- Suppose you had a randomized experiment, and you could randomly assign some countries to have better or worse institutions. Would that help?
Instrumental Variables

- When you don’t have a real randomized experiment, one idea is to have an "instrument." This is a variable that affects the independent variable of interest, but does not directly affect the outcome.
- Let’s see how this works
Suppose that we are interested in

\[ Y_c = \alpha + \beta X_c + \varepsilon_i \]

where \( Y_c \) is country \( c \)'s per-capita income, \( X_c \) is the quality of a country’s institutions.

The problem is that \( X_c \) and \( \varepsilon_i \) are correlated. For example, countries with worse institutions may also have lower levels of education, be located in worse places, etc.

So suppose we have a variable \( Z \) that affects \( Y \) only through its effect on \( X \).

- E.g. suppose that if the Europeans arrived in the country on an odd-numbered day, they set up bad institutions and if they arrived on an even-numbered day, they set up good institutions.
- So let’s set \( Z_c = 1 \) to be arrived on an even-numbered day, and set up good institutions, and \( Z_c = 0 \) to be arrived on an odd-numbered day and set up bad institutions.
Instrumental Variables

- In this case, the impact of arriving an even numbered day on institutions is

\[ E [X_c \mid Z_c = 1] - E [X_c \mid Z_c = 0] \]

This is called the **first stage**.

- The impact of arriving an even numbered day on economic growth is

\[ E [Y_c \mid Z_c = 1] - E [Y_c \mid Z_c = 0] \]

This is called the **reduced form**. It is the net effect of the instrument on the outcome of interest.
Instrumental Variables

- How do we interpret the reduced form? Using our equation that
  \[ Y_c = \alpha + \beta X_c + \varepsilon_i, \]
  we have that
  \[ E [Y_c \mid Z_c = 1] = \alpha + \beta E [X_c \mid Z_c = 1] + E [\varepsilon \mid Z_c = 1] \]
  \[ E [Y_c \mid Z_c = 0] = \alpha + \beta E [X_c \mid Z_c = 0] + E [\varepsilon \mid Z_c = 0] \]

- Therefore
  \[ E [Y_c \mid Z_c = 1] - E [Y_c \mid Z_c = 0] \]
  \[ = \beta E [X_c \mid Z_c = 1] - \beta E [X_c \mid Z_c = 0] \]
  \[ + E [\varepsilon \mid Z_c = 1] - E [\varepsilon \mid Z_c = 0] \]

- What can we assume about
  \[ E [\varepsilon \mid Z_c = 1] - E [\varepsilon \mid Z_c = 0] ? \]

- What underlies this assumption?
If we assume that $E[\varepsilon | Z_c = 0] - E[\varepsilon | Z_c = 0] = 0$, then

$$E[Y_c | Z_c = 1] - E[Y_c | Z_c = 0]$$

$$= \beta E[X_c | Z_c = 1] - \beta E[X_c | Z_c = 0]$$

$$+ E[\varepsilon | Z_c = 1] - E[\varepsilon | Z_c = 0]$$

simplifies to

$$E[Y_c | Z_c = 1] - E[Y_c | Z_c = 0]$$

$$= \beta E[X_c | Z_c = 1] - \beta E[X_c | Z_c = 0]$$

Thus

$$\beta = \frac{E[Y_c | Z_c = 1] - E[Y_c | Z_c = 0]}{E[X_c | Z_c = 1] - E[X_c | Z_c = 0]}$$

This is called the **Wald Estimator**. Also known as *instrumental variables* or *two-stage least squares*. 
The Wald Estimator

$$\beta = \frac{E [Y_c | Z_c = 1] - E [Y_c | Z_c = 0]}{E [X_c | Z_c = 1] - E [X_c | Z_c = 0]}$$

- What is the interpretation of $\beta$?
- For this to be valid, we need two things to be true. What are they?
  1. There must be a **first stage**. That is, the instrument $Z$ must affect $X$. What was this in our hypothetical example?
  2. $Z$ can affect the outcome only through its effect on $X$. Formally, this is the assumption that $E [\varepsilon | Z_c = 1] - E [\varepsilon | Z_c = 0] = 0$. This is called the **exclusion restriction**.
Bias in the Wald Estimator

- What happens if the exclusion restriction is wrong? We can get big bias problems. Why?
- Suppose the exclusion restriction is wrong, but we try to calculate

\[
\hat{\beta} = \frac{E [Y_c | Z_c = 1] - E [Y_c | Z_c = 0]}{E [X_c | Z_c = 1] - E [X_c | Z_c = 0]}
\]

Substituting

\[
E [Y_c | Z_c = 1] - E [Y_c | Z_c = 0] = \\
\beta E [X_c | Z_c = 1] - \beta E [X_c | Z_c = 0] \\
+ E [\varepsilon | Z_c = 1] - E [\varepsilon | Z_c = 0]
\]

yields

\[
\hat{\beta} = \beta + \frac{E [\varepsilon | Z_c = 1] - E [\varepsilon | Z_c = 0]}{E [X_c | Z_c = 1] - E [X_c | Z_c = 0]}
\]

- So small amounts of bias can actually be magnified substantially.
- The exclusion restriction must therefore be true exactly.
How do they use IV in this context?

The key empirical idea in this paper is that settler mortality is an instrument for institutions in a regression of per-capita income on institutions.

What does this require?

1. *First stage.* What is this? Settler mortality ($Z$) is correlated with extractive institutions ($X$). This we can check in the data.
The first stage


Figure 3. First Stage Relationship Between Settler Mortality and Expropriation Risk

Table 4. Regressions of Log GDP per Capita

Table 5. Regressions of Log GPD per Capita with Additional Controls

Table 6. Robustness Checks for IV Regressions of Log GHP per Capita
How do they use IV in this context?

- How do they use IV in this context?
- The key empirical idea in this paper is that settler mortality is an instrument for institutions in a regression of per-capita income on institutions
- What does this require?
  1. **First stage.** Settler mortality is correlated with institutions. This we can check in the data.
  2. **Exclusion restriction.** What is this? Settler mortality affects per-capita income only through its effect on institutions.
- The exclusion restriction is an assumption. We can’t check it directly, we just need to decide whether we think it’s believable or not.
- What do you think? What would it mean for it not to be believable?
- What are some examples of factors that might be correlated with settler mortality that might also affect per-capita incomes?
- Health, temperature, latitude, particular colonizers
- They try to argue that the relationship is there even controlling for these variables.
Back to the macro relationships...

- What’s the point of this paper? What have they shown? Is it convincing?
- Other people have argued that countries are poor because they are hot:

> “There are countries where the excess of heat enervates the body, and renders men so slothful and dispirited that nothing but the fear of chastisement can oblige them to perform any laborious duty.”

— Montesquieu (1750)

- Suppose you believe that extractive colonial institutions persist and have negative effects on incomes. Settlers were more likely to die—and colonizers more likely to set up extractive institutions—in hot places. Does this mean that temperature doesn’t affect economic growth?
Temperature and economic growth
Dell, Jones, and Olken (2011): Temperature Shocks and Economic Growth: Evidence from the Last Half Century

- The empirical challenge with climate is that it is a fixed country characteristic.
- So it is hard to tease it out from the many other fixed country characteristics (longitude, precipitation, rockiness, etc).
- But, temperatures vary from year to year.
- The idea of this paper is to ask whether in hotter years, economic performance is lower.
  - Suppose this were true. What would we learn about the role of temperature?
  - Suppose this were not true. What would we learn?
How does this work empirically?

- The idea of this paper is to use only the variation across years within a given country.
- We do not want to use the fact some countries are warmer or colder than others on average.
  - Why not? Why might using the annual variation be better?
- To do this, we estimate the following equation:

\[ g_{ct} = \alpha_c + \beta TEMP_{ct} + \varepsilon \]

where \( \alpha_c \) are country dummy variables (also called fixed effects).
Example

\[ g_{ct} = \alpha_c + \beta TEMP_{ct} + \epsilon \]

- Suppose there were 3 countries and 2 years. What are \( \alpha_c \) ?
- Example

\[
g_{ct} \quad TEMP_{ct} \quad \alpha_{USA} \quad \alpha_{INDO} \quad \alpha_{NIGER}
\]

USA\(_{2010}\)
USA\(_{2011}\)
Indonesia\(_{2010}\)
Indonesia\(_{2011}\)
Niger\(_{2010}\)
Niger\(_{2011}\)
Example

\[ g_{ct} = \alpha_c + \beta TEMP_{ct} + \varepsilon \]

- Suppose there were 3 countries and 2 years. What are \( \alpha_c \)?
- Example

<table>
<thead>
<tr>
<th></th>
<th>( g_{ct} )</th>
<th>( TEMP_{ct} )</th>
<th>( \alpha_{USA} )</th>
<th>( \alpha_{INDO} )</th>
<th>( \alpha_{NIGER} )</th>
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<td>27</td>
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<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

- In this example is the overall relationship between temperature and growth positive or negative?
- What about if we use only the within-country variation between temperature and growth?
What do fixed effects do?

- Dummy variable (fixed effects) are equivalent to subtracting the average of the X and Y variables.
- To see this, consider the equation
  \[ g_{ct} = \alpha_c + \beta TEMP_{ct} + \epsilon_{ct} \]
  Take the means by country on each side
  \[ \bar{g}_c = \bar{\alpha}_c + \beta \bar{TEMP}_c + \bar{\epsilon}_c \]
- Since \( \alpha_c \) is constant within country, \( \alpha_c = \bar{\alpha}_c \)
- So subtracting
  \[ g_{ct} - \bar{g}_c = \alpha_c - \bar{\alpha}_c + \beta TEMP_{ct} - \beta \bar{TEMP}_c + \epsilon - \bar{\epsilon}_c \]
  \[ g_{ct} - \bar{g}_c = \beta (TEMP_{ct} - \bar{TEMP}_c) + \epsilon'_{ct} \]
- Thus including country fixed effects is equivalent to taking out country averages from all variables
- This is why including fixed effects uses variation only from within countries
Back to our example

$$g_{ct} = \alpha_c + \beta TEMP_{ct} + \epsilon$$

Example

<table>
<thead>
<tr>
<th></th>
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- This is equivalent to

\[ g_{ct} \quad TEMP_{ct} \quad \alpha_{USA} \quad \alpha_{INDO} \quad \alpha_{NIGER} \]

USA_{2010}  
USA_{2011}  
Indonesia_{2010}  
Indonesia_{2011}  
Niger_{2010}  
Niger_{2011}
Back to our example

\[ g_{ct} = \alpha_c + \beta \text{TEMP}_{ct} + \epsilon \]

- This is equivalent to

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<th>( \alpha_{INDO} )</th>
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<td>(-0.5)</td>
<td>(-0.5)</td>
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</tr>
</tbody>
</table>
In practice...

- In practice, DJO run a slightly more complicated version that includes two dimensions of fixed effects

\[ g_{crt} = \alpha_c + \gamma_{rt} + \beta T_{rt} + \varepsilon_{crt} \]

where \( c \) is a country, \( r \) is a region (continent), and \( t \) is a year

- So \( \alpha_c \) are country dummies as before, but now they also add \( \gamma_{rt} \), which are continent-year dummies (e.g. Africa in 1996, Africa in 1997, North America in 1996, North America in 1997, etc).

- Why might you also want to do this?
Heterogeneity and interactions

- The second thing DJO do is to look at heterogeneous effects.
  - In particular, DJO hypothesize that temperature may have different effects in rich vs. poor countries. People in poor countries spend more time working outdoors, can’t afford air conditioning, etc.
- To do this in a regression format, we consider interactions. Define a variable $POOR_c$ to capture the country’s income level at the beginning of the sample. Then we can regress

$$g_{crt} = \alpha_c + \gamma_{rt} + \beta T_{rt} + \tau T_{rt} \times POOR_c + \epsilon_{crt}$$

- The interpretation of $\tau$ is that it is like a second derivative. Differentiating the equation above:

$$\frac{\partial^2 g}{\partial T \partial POOR} = \tau$$

- So $\tau$ tells us how $\frac{\partial g}{\partial T}$ changes with a given change in $POOR$
Heterogeneity and interactions

\[ g_{crt} = \alpha_c + \gamma_{rt} + \beta T_{rt} + \tau T_{rt} \times POOR_c + \varepsilon_{crt} \]

- Suppose we are interested in the effect of 1 extra degree on growth for a country with \( POOR = 0.1 \). How do we compute this?
- How about for \( POOR = 0.7 \)?
- In practice, DJO just divide countries in half, so \( POOR = 1 \) if a country is in the bottom half and 0 otherwise.
Note: in general, in a regression like this you also want to include all first-order terms:

\[ g_{crt} = \alpha_c + \gamma_{rt} + \beta T_{rt} + \gamma POOR + \tau T_{rt} \times POOR_c + \varepsilon_{crt} \]

But since in this case, \( POOR_c \) only varies by country, and you have \( \alpha_c \), which soaks up everything that only varies by country, it's not necessary.

Table 2: Main Panel Results
Interpretation

- On average, no effect of temperature
- But temperature seems to negatively affect economic growth in poor countries
  - 1 degree Centigrade warmer \(\rightarrow\) 1.4 percentage points lower growth
- Is this large or small?
- Also show that temperature affects industrial output, agriculture, and likelihood of political change
- What does this mean for the institutions results?
Nunn argues that slave trade had negative impacts on slave exporting countries.

- Most common way that slaves were taken was through cross-village, or cross-state, raids. This impeded formation of large states / communities.
- Individuals of the same / similar ethnicity enslaved one another – this further undermined trust, led to a weakening of states, and corruption.
- Led to increase in corruption of state institutions.
- Large in magnitude – estimates are that by 1850, Africa's population was half what it would have been had the slave trade not taken place.

All of these factors could undermine institutional fabric of a country, which could still matter today.
The slave trade’s impact today

- Did the slave trade matter today?
- To test this, Nunn obtains data from ship records on how many slaves were exported from each country.
The slave trade’s impact today

Images removed due to copyright restrictions.
Figure III Relationship Between Log Slave Exports Normalized by Land Area, In(exports/area), and Log Real Per Capita GDP in 2000
Figure VIII Paths of Economic Development Since 1950
Table III Relationships Between Slave Exports and Income
Figure V Example Showing the Distance Instruments for Burkina Faso
Table IV Estimation of the Relationship Between Slave Export and Income
Other controls

- Nunn also controls for many of the other factors that might be correlated with the slave trade, e.g.
  - Distance from equator
  - Temperature and precipitation
  - Legal origins
  - Which colonizer
  - Natural resources
IV approach

- You still might be concerned about other things you haven’t properly controlled for in this regression.
- So Nunn proposes using instrumental variables.
- His instruments are the distances from your country to the main 4 slave trading locations.
IV approach

- You still might be concerned about other things you haven’t properly controlled for in this regression
- So Nunn proposes using instrumental variables to instrument for volume of slave trade
- His instruments are the distances from your country to the main 4 slave trading locations
- What do we need to think about in terms of whether this is a valid instrument?
  1. First stage. Does distance to slave trading locations affect volume of slave trade?
You still might be concerned about other things you haven’t properly controlled for in this regression

So Nunn proposes using instrumental variables to instrument for volume of slave trade

His instruments are the distances from your country to the main 4 slave trading locations

What do we need to think about in terms of whether this is a valid instrument?

1. *First stage.* Does distance to slave trading locations affect volume of slave trade?

2. *Exclusion restriction.* Is slave trade the only way that distance to slave locations could affect income today?
TABLE IV
ESTIMATES OF THE RELATIONSHIP BETWEEN SLAVE EXPORTS AND INCOME

<table>
<thead>
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<th>(2)</th>
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<td>Second Stage.</td>
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<td>Dependent variable is log income in 2000, ( \ln y )</td>
<td></td>
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</tr>
<tr>
<td>( \ln(\text{exports/area}) )</td>
<td>(-0.208^{***})</td>
<td>(-0.201^{***})</td>
<td>(-0.286^{*})</td>
<td>(-0.248^{***})</td>
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<td>52</td>
<td>52</td>
<td>42</td>
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Notes. IV estimates of (1) are reported. Slave exports \( \ln(\text{exports/area}) \) is the natural log of the total number of slaves exported from each country between 1400 and 1900 in the four slave trades normalized by land area. The colonizer fixed effects are indicator variables for the identity of the colonizer at the time of independence. Coefficients are reported, with standard errors in brackets. For the endogenous variable \( \ln(\text{exports/area}) \), I also report 95% confidence regions based on Moreira’s (2003) conditional likelihood ratio (CLR) approach. These are reported in square brackets. The \( p\)-value of the Hausman test is for the Wu–Hausman chi-squared test. \( ^{*}\), \( ^{**}\), and \( ^{***}\) indicate significance at the 1%, 5%, and 10% levels. The “restricted sample” excludes island and North African countries. The “geography controls” are distance from equator, longitude, lowest monthly rainfall, avg max humidity, avg min temperature, and \( \ln(\text{coastline/area}) \). The first-stage estimates are reported in the bottom panel of the table. The coefficients for the instruments are generally negative, suggesting that the further a country was from slave markets, the fewer slaves it exported. The specifications assume a linear first-stage relationship. The estimates are similar if one also allows for a nonlinear relationship between slave exports and income.
Conclusions

- What’s the conclusion about the deep determinants of economic performance?
- What does this imply for the role of current institutions?
14.75 Political Economy and Economic Development
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