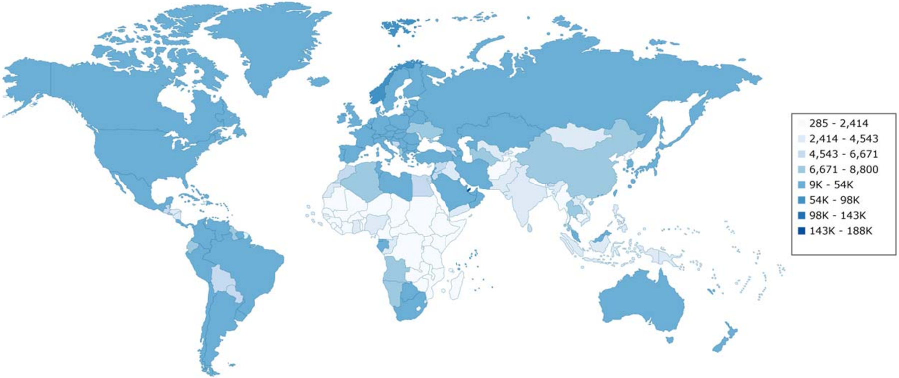
14.750x: The Deep Determinants of Economic Development: Macro Evidence

Ben Olken

Several explanations for poverty at the macro level

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

Distribution of poor countries



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?

The Settler Mortality Hypothesis

Acemoglu, Johnson, and Robinson (2001): "The Colonial Origins of Comparative Development: An Empirical Investigation"

- Discuss: what is the idea of the AJR paper?
- Why do they use settler mortality?
- What do they find?
- 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.

The Settler Mortality Hypothesis

Acemoglu, Johnson, and Robinson (2001): "The Colonial Origins of Comparative Development: An Empirical Investigation"

- 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.

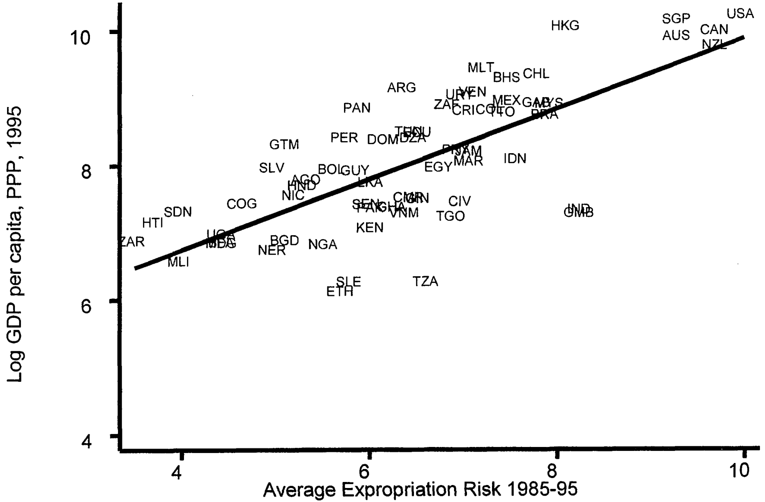


FIGURE 2. OLS RELATIONSHIP BETWEEN EXPROPRIATION RISK AND INCOME

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

Instrumental Variables

- Suppose that we are interested in

$$Y_c = \alpha + \beta X_c + \varepsilon_c$$

  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 ε_c 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

$$E\left[X_c \mid Z_c = 1\right] - E\left[X_c \mid Z_c = 0\right]$$

  This is called the **first stage**.

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

$$E\left[Y_c \mid Z_c = 1\right] - E\left[Y_c \mid Z_c = 0\right]$$

  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 $Y_c = \alpha + \beta X_c + \varepsilon_c$, we have that

$$\begin{aligned} E\left[Y_c \mid Z_c = 1\right] &= \alpha + \beta E\left[X_c \mid Z_c = 1\right] + E\left[\varepsilon_c \mid Z_c = 1\right] \\ E\left[Y_c \mid Z_c = 0\right] &= \alpha + \beta E\left[X_c \mid Z_c = 0\right] + E\left[\varepsilon_c \mid Z_c = 0\right] \end{aligned}$$

- Therefore

$$\begin{aligned} & E\left[Y_c \mid Z_c = 1\right] - E\left[Y_c \mid Z_c = 0\right] \\ & \qquad = \beta E\left[X_c \mid Z_c = 1\right] - \beta E\left[X_c \mid Z_c = 0\right] \\ & \qquad\qquad + E\left[\varepsilon_c \mid Z_c = 1\right] - E\left[\varepsilon_c \mid Z_c = 0\right] \end{aligned}$$

- What can we assume about

$$E\left[\varepsilon_c \mid Z_c = 1\right] - E\left[\varepsilon_c \mid Z_c = 0\right]?$$

- What underlies this assumption?

Instrumental Variables

- If we assume that $E\left[\varepsilon_c \mid Z_c = 0\right] - E\left[\varepsilon_c \mid Z_c = 0\right] = 0$, then

$$\begin{aligned} E\left[Y_c \mid Z_c = 1\right] - E\left[Y_c \mid Z_c = 0\right] \\ = \beta E\left[X_c \mid Z_c = 1\right] - \beta E\left[X_c \mid Z_c = 0\right] \\ + E\left[\varepsilon_c \mid Z_c = 1\right] - E\left[\varepsilon_c \mid Z_c = 0\right] \end{aligned}$$

  simplifies to

$$\begin{aligned} E\left[Y_c \mid Z_c = 1\right] - E\left[Y_c \mid Z_c = 0\right] \\ = \beta E\left[X_c \mid Z_c = 1\right] - \beta E\left[X_c \mid Z_c = 0\right] \end{aligned}$$

- Thus

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

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

The Wald Estimator

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

- What is the interpretation of β?
- 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 $E\left[\varepsilon_c \mid Z_c = 1\right] - E\left[\varepsilon_c \mid Z_c = 0\right] = 0$. 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

$$\hat{\beta} = \frac{E\left[Y_c \mid Z_c = 1\right] - E\left[Y_c \mid Z_c = 0\right]}{E\left[X_c \mid Z_c = 1\right] - E\left[X_c \mid Z_c = 0\right]}$$

Substituting

$$\begin{aligned} E\left[Y_c \mid Z_c = 1\right] - E\left[Y_c \mid Z_c = 0\right] = \\ \beta E\left[X_c \mid Z_c = 1\right] - \beta E\left[X_c \mid Z_c = 0\right] \\ + E\left[\varepsilon_c \mid Z_c = 1\right] - E\left[\varepsilon_c \mid Z_c = 0\right] \end{aligned}$$

yields

$$\hat{\beta} = \beta + \frac{E\left[\varepsilon_c \mid Z_c = 1\right] - E\left[\varepsilon_c \mid Z_c = 0\right]}{E\left[X_c \mid Z_c = 1\right] - E\left[X_c \mid Z_c = 0\right]}$$

- So small amounts of bias can actually be magnified substantially.
- The exclusion restriction must therefore be true exactly.

Back to Settler Mortality and Institutions

- 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.

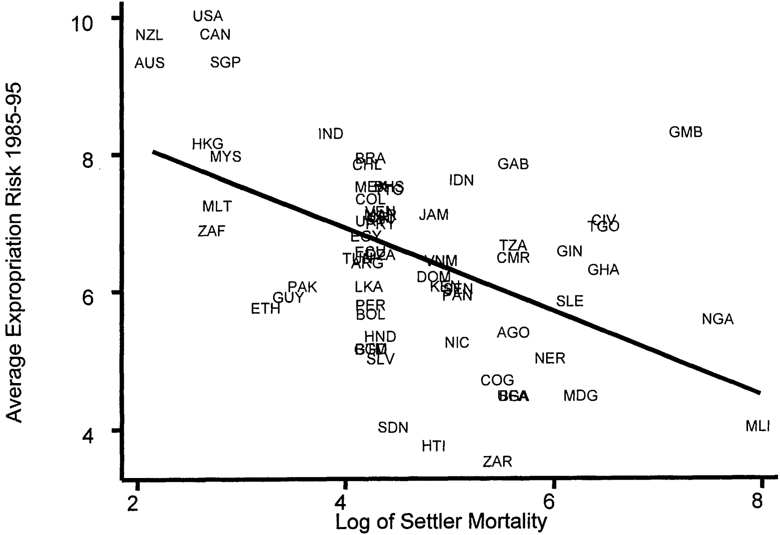


FIGURE 3. FIRST-STAGE RELATIONSHIP BETWEEN SETTLER MORTALITY AND EXPROPRIATION RISK

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.

What do they find?

Table 4—IV Regressions of Log GDP per Capita

	Base sample (1)	Base sample (2)	Base sample without Neo-Europes (3)	Base sample without Neo-Europes (4)	Base sample without Africa (5)	Base sample without Africa (6)	Base sample with continent dummies (7)	Base sample with continent dummies (8)	Base sample, dependent variable is log output per worker (9)
Panel A: Two-Stage Least Squares									
Average protection against expropriation risk 1985–1995	0.94	1.00	1.28	1.21	0.58	0.58	0.98	1.10	0.98
	(0.16)	(0.22)	(0.36)	(0.35)	(0.10)	(0.12)	(0.30)	(0.46)	(0.17)
Latitude		−0.65		0.94		0.04		−1.20	
		(1.34)		(1.46)		(0.84)		(1.8)	
Asia dummy							−0.92	−1.10	
							(0.40)	(0.52)	
Africa dummy							−0.46	−0.44	
							(0.36)	(0.42)	
"Other" continent dummy							−0.94	−0.99	
							(0.85)	(1.0)	
Panel B: First Stage for Average Protection Against Expropriation Risk in 1985–1995									
Log European settler mortality	−0.61	−0.51	−0.39	−0.39	−1.20	−1.10	−0.43	−0.34	−0.63
	(0.13)	(0.14)	(0.13)	(0.14)	(0.22)	(0.24)	(0.17)	(0.18)	(0.13)
Latitude		2.00		−0.11		0.99		2.00	
		(1.34)		(1.50)		(1.43)		(1.40)	
Asia dummy							0.33	0.47	
							(0.49)	(0.50)	
Africa dummy							−0.27	−0.26	
							(0.41)	(0.41)	
"Other" continent dummy							1.24	1.1	
							(0.84)	(0.84)	
R^2	0.27	0.30	0.13	0.13	0.47	0.47	0.30	0.33	0.28
Panel C: Ordinary Least Squares									
Average protection against expropriation risk 1985–1995	0.52	0.47	0.49	0.47	0.48	0.47	0.42	0.40	0.46
	(0.06)	(0.06)	(0.08)	(0.07)	(0.07)	(0.07)	(0.06)	(0.06)	(0.06)
Number of observations	64	64	60	60	37	37	64	64	61

They then check that it's robust to various controls

TABLE 5—IV REGRESSIONS OF LOG GDP PER CAPITA WITH ADDITIONAL CONTROLS

	Base sample (1)	Base sample (2)	British colonies only (3)	British colonies only (4)	Base sample (5)	Base sample (6)	Base sample (7)	Base sample (8)	Base sample (9)
Panel A: Two-Stage Least Squares									
Average protection against expropriation risk, 1985–1995	1.10	1.16	1.07	1.00	1.10	1.20	0.92	1.00	1.10
	(0.22)	(0.34)	(0.24)	(0.22)	(0.19)	(0.29)	(0.15)	(0.25)	(0.29)
Latitude		−0.75				−1.10		−0.94	−1.70
		(1.70)				(1.56)		(1.50)	(1.6)
British colonial dummy	−0.78	−0.80							
	(0.35)	(0.39)							
French colonial dummy	−0.12	−0.06							0.02
	(0.35)	(0.42)							(0.69)
French legal origin dummy					0.89	0.96			0.51
					(0.32)	(0.39)			(0.69)
p-value for religion variables							[0.001]	[0.004]	[0.42]
Panel B: First Stage for Average Protection Against Expropriation Risk in 1985–1995									
Log European settler mortality	−0.53	−0.43	−0.59	−0.51	−0.54	−0.44	−0.58	−0.44	−0.48
	(0.14)	(0.16)	(0.19)	(0.14)	(0.13)	(0.14)	(0.13)	(0.15)	(0.18)
Latitude		1.97				2.10		2.50	2.30
		(1.40)				(1.30)		(1.50)	(1.60)
British colonial dummy	0.63	0.55							
	(0.37)	(0.37)							
French colonial dummy	0.05	−0.12							−0.25
	(0.43)	(0.44)							(0.89)
French legal origin					−0.67	−0.7			−0.05
					(0.33)	(0.32)			(0.91)
R^2	0.31	0.33	0.30	0.30	0.32	0.35	0.32	0.35	0.45
Panel C: Ordinary Least Squares									
Average protection against expropriation risk, 1985–1995	0.53	0.47	0.61	0.47	0.56	0.56	0.53	0.47	0.47
	(0.19)	(0.07)	(0.09)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Number of observations	64	64	25	25	64	64	64	64	64

They then check that it's robust to various controls

TABLE 6—ROBUSTNESS CHECKS FOR IV REGRESSIONS OF LOG GDP PER CAPITA

	Base sample (1)	Base sample (2)	Base sample (3)	Base sample (4)	Base sample (5)	Base sample (6)	Base sample (7)	Base sample (8)	Base sample (9)
Panel A: Two-Stage Least Squares									
Average protection against expropriation risk, 1985–1995	0.84	0.83	0.96	0.99	1.10	1.30	0.74	0.79	0.71
	(0.19)	(0.21)	(0.28)	(0.30)	(0.33)	(0.51)	(0.13)	(0.17)	(0.20)
Latitude		0.07		−0.67		−1.30		−0.89	−2.5
		(1.60)		(1.30)		(2.30)		(1.00)	(1.60)
p-value for temperature variables	[0.96]	[0.97]							[0.77]
p-value for humidity variables	[0.54]	[0.54]							[0.62]
Percent of European descent in 1975			−0.08	0.03					0.3
			(0.82)	(0.84)					(0.7)
p-value for soil quality					[0.79]	[0.85]			[0.46]
p-value for natural resources					[0.82]	[0.87]			[0.82]
Dummy for being landlocked					0.64	0.79			0.75
					(0.63)	(0.83)			(0.47)
Ethnolinguistic fragmentation							−1.00	−1.10	−1.60
							(0.32)	(0.34)	(0.47)
Panel B: First Stage for Average Protection Against Expropriation Risk in 1985–1995									
Log European settler mortality	−0.64	−0.59	−0.41	−0.4	−0.44	−0.34	−0.64	−0.56	−0.59
	(0.17)	(0.17)	(0.14)	(0.15)	(0.16)	(0.17)	(0.15)	(0.15)	(0.21)
Latitude		2.70		0.48		2.20		2.30	4.20
		(2.00)		(1.50)		(1.50)		(1.40)	(2.60)
R^2	0.39	0.41	0.34	0.34	0.41	0.43	0.27	0.30	0.59
Panel C: Ordinary Least Squares									
Average protection against expropriation risk, 1985–1995	0.41	0.38	0.39	0.38	0.46	0.42	0.46	0.45	0.38
	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)	(0.05)	(0.06)	(0.06)

Back to the macro relationships...

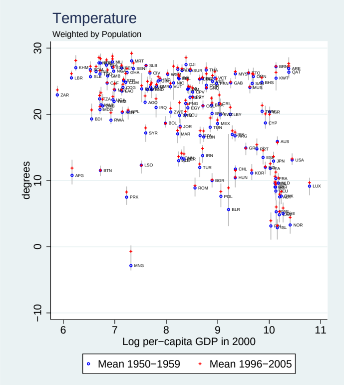
- What's the point of this paper? What have they shown? Is it convincing?
- Other people have argued that countries are poor because they are hot:

> *"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

- Recall the cross-sectional correlation between temperature and incomes.



- What can we conclude?

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 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:

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

where α_c are country dummy variables (also called fixed effects).

Example

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

- Suppose there were 3 countries and 2 years. What are α_c ?
- Example

	g_{ct}	$TEMP_{ct}$	α_{USA}	α_{INDO}	a_{NIGER}
USA_{2010}					
USA_{2011}					
Indonesia_{2010}					
Indonesia_{2011}					
Niger_{2010}					
Niger_{2011}					

Example

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

- Suppose there were 3 countries and 2 years. What are α_c ?
- Example

	g_{ct}	$TEMP_{ct}$	α_{USA}	α_{INDO}	a_{NIGER}
USA_{2010}	3	12	1	0	0
USA_{2011}	3.2	14	1	0	0
$Indonesia_{2010}$	1	22	0	1	0
$Indonesia_{2011}$	1.3	23	0	1	0
$Niger_{2010}$	0.1	28	0	0	1
$Niger_{2011}$	0.1	27	0	0	1

- 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

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

- Take the means by country on each side

$$\overline{g_c} = \overline{\alpha_c} + \beta \overline{TEMP_c} + \bar{\varepsilon}_c$$

- Since α_c is constant within country, $\alpha_c = \overline{\alpha_c}$
- So subtracting

$$\begin{aligned} g_{ct} - \overline{g_c} &= \alpha_c - \overline{\alpha_c} + \beta TEMP_{ct} - \beta \overline{TEMP_c} + \varepsilon_{ct} - \bar{\varepsilon}_c \\ g_{ct} - \overline{g_c} &= \beta \left(TEMP_{ct} - \overline{TEMP_c} \right) + \varepsilon'_{ct} \end{aligned}$$

- 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

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

- Example

	g_{ct}	$TEMP_{ct}$	α_{USA}	α_{INDO}	a_{NIGER}
USA_{2010}	3	12	1	0	0
USA_{2011}	3.2	14	1	0	0
Indonesia_{2010}	1	22	0	1	0
Indonesia_{2011}	1.3	23	0	1	0
Niger_{2010}	0.1	28	0	0	1
Niger_{2011}	0.1	27	0	0	1

Back to our example

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

- This is equivalent to

	g_{ct}	$TEMP_{ct}$	α_{USA}	α_{INDO}	a_{NIGER}
USA_{2010}					
USA_{2011}					
Indonesia_{2010}					
Indonesia_{2011}					
Niger_{2010}					
Niger_{2011}					

Back to our example

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

- This is equivalent to

	g_{ct}	$TEMP_{ct}$	α_{USA}	α_{INDO}	a_{NIGER}
USA_{2010}	-0.1	-1			
USA_{2011}	0.1	1			
$Indonesia_{2010}$	-0.15	-0.5			
$Indonesia_{2011}$	0.15	0.5			
$Niger_{2010}$	0	0.5			
$Niger_{2011}$	0	-0.5			

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 α_c are country dummies as before, but now they also add γ_{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

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

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

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

- So τ 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

Heterogeneity and interactions

- Note: in general, in a regression like this you also want to include all first-order terms:

$$
\begin{aligned}
g_{crt} &= \alpha_c + \gamma_{rt} + \beta T_{rt} + \gamma POOR \\
&\quad + \tau T_{rt} \times POOR_c + \varepsilon_{crt}
\end{aligned}
$$

But since in this case, $POOR_c$ only varies by country, and you have α_c, which soaks up everything that only varies by country, it's not necessary

Findings

Table 2: Main panel results

	Dependent variable is the annual growth rate				
	(1)	(2)	(3)	(4)	(5)
Temperature	-0.325	0.261	0.262	0.172	0.561*
	(0.285)	(0.312)	(0.311)	(0.294)	(0.319)
Temperature interacted with…					
Poor country dummy		-1.655***	-1.610***	-1.645***	-1.806***
		(0.485)	(0.485)	(0.483)	(0.456)
Hot country dummy				0.237	
				(0.568)	
Agricultural country dummy					-0.371
					(0.409)
Precipitation			-0.083*	-0.228***	-0.105**
			(0.050)	(0.074)	(0.053)
Precipitation interacted with…					
Poor country dummy			0.153*	0.160**	0.145*
			(0.078)	(0.075)	(0.087)
Hot country dummy				0.185**	
				(0.078)	
Agricultural country dummy					0.010
					(0.085)
Observations	4924	4924	4924	4924	4577
Within R-squared	0.00	0.00	0.00	0.01	0.01
R-squared	0.22	0.22	0.22	0.22	0.24
Temperature effect in poor countries		-1.394***	-1.347***	-1.473***	-1.245***
		(0.369)	(0.361)	(0.396)	(0.404)
Precipitation effect in poor countries			0.069	-0.0677	0.0401
			(0.052)	(0.071)	(0.083)

Interpretation

- On average, no effect of temperature
- But temperature seems to negatively affect economic growth in poor countries
  - 1 degree Centigrade warmer -> 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?

One more example of a deep determinant

Nunn 2008: The Long-term Effects of Africa's Slave Trades

- 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

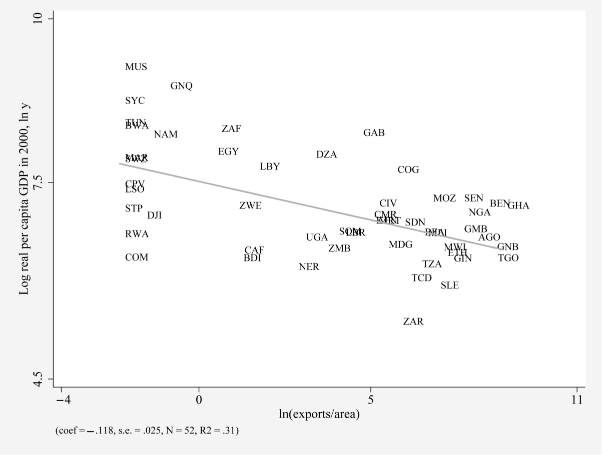


FIGURE III
Relationship between Log Slave Exports Normalized by Land Area, ln(exports/area), and Log Real Per Capita GDP in 2000, ln y

The slave trade's impact today

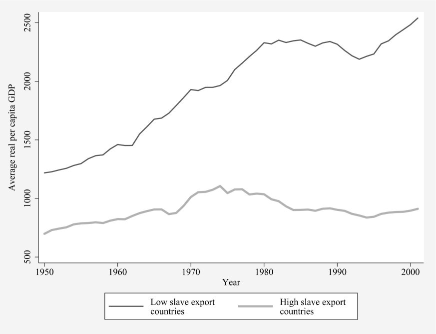


FIGURE VIII
Paths of Economic Development Since 1950

- What do these relationships this say? Do you find this persuasive? Given what we've seen so far, what else might you want to check?

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

Other controls

TABLE III
RELATIONSHIP BETWEEN SLAVE EXPORTS AND INCOME

	Dependent variable is log real per capita GDP in 2000, ln y					
	(1)	(2)	(3)	(4)	(5)	(6)
ln(exports/area)	-0.112^{***}	-0.076^{***}	-0.108^{***}	-0.085^{**}	-0.103^{***}	-0.128^{***}
	(0.024)	(0.029)	(0.037)	(0.035)	(0.034)	(0.034)
Distance from equator		0.016	−0.005	0.019	0.023	0.006
		(0.017)	(0.020)	(0.018)	(0.017)	(0.017)
Longitude		0.001	−0.007	−0.004	−0.004	−0.009
		(0.005)	(0.006)	(0.006)	(0.005)	(0.006)
Lowest monthly rainfall		−0.001	0.008	0.0001	−0.001	−0.002
		(0.007)	(0.008)	(0.007)	(0.006)	(0.008)
Avg max humidity		0.009	0.008	0.009	0.015	0.013
		(0.012)	(0.012)	(0.012)	(0.011)	(0.010)
Avg min temperature		−0.019	−0.039	−0.005	−0.015	−0.037
		(0.028)	(0.028)	(0.027)	(0.026)	(0.025)
ln(coastline/area)		0.085^{**}	0.092^{**}	0.095^{**}	0.082^{**}	0.083^{**}
		(0.039)	(0.042)	(0.042)	(0.040)	(0.037)
Island indicator				−0.398	−0.150	
				(0.529)	(0.516)	
Percent Islamic				-0.008^{***}	-0.006^{*}	−0.003
				(0.003)	(0.003)	(0.003)
French legal origin				0.755	0.643	−0.141
				(0.503)	(0.470)	(0.734)
North Africa indicator				0.382	−0.304	
				(0.484)	(0.517)	
ln(gold prod/pop)					0.011	0.014
					(0.017)	(0.015)
ln(oil prod/pop)					0.078^{***}	0.088^{***}
					(0.027)	(0.025)
ln(diamond prod/pop)					−0.039	−0.048
					(0.043)	(0.041)
Colonizer fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number obs.	52	52	42	52	52	42
R^2	.51	.60	.63	.71	.77	.80

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

Instrument example

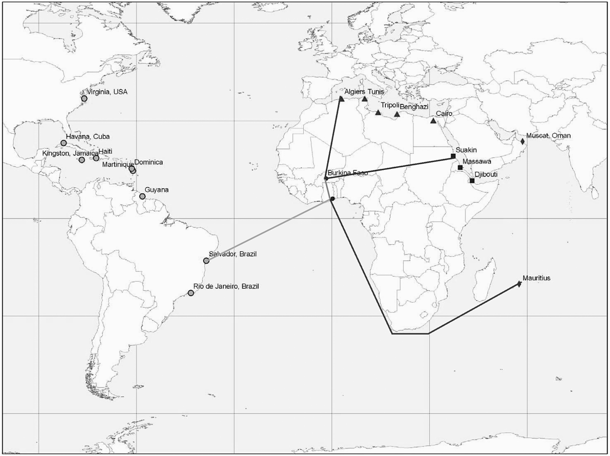


FIGURE V
Example Showing the Distance Instruments for Burkina Faso

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?

First stage

First Stage. Dependent variable is slave exports, ln(exports/area)

Atlantic distance	-1.31^{***}	-1.74^{***}	-1.32^{*}	-1.69^{**}
	(0.357)	(0.425)	(0.761)	(0.680)
Indian distance	-1.10^{***}	-1.43^{***}	-1.08	-1.57^{*}
	(0.380)	(0.531)	(0.697)	(0.801)
Saharan distance	-2.43^{***}	-3.00^{***}	-1.14	-4.08^{**}
	(0.823)	(1.05)	(1.59)	(1.55)
Red Sea distance	-0.002	-0.152	-1.22	2.13
	(0.710)	(0.813)	(1.82)	(2.40)
F-stat	4.55	2.38	1.82	4.01
Colonizer fixed effects	No	Yes	Yes	Yes
Geography controls	No	No	Yes	Yes
Restricted sample	No	No	No	Yes
Hausman test (p-value)	.02	.01	.02	.04
Sargan test (p-value)	.18	.30	.65	.51

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?
  2. *Exclusion restriction*. Is slave trade the only way that distance to slave locations could affect income today?

Results

TABLE IV

ESTIMATES OF THE RELATIONSHIP BETWEEN SLAVE EXPORTS AND INCOME

	(1)	(2)	(3)	(4)
Second Stage. Dependent variable is log income in 2000, $\ln y$				
ln(exports/area)	-0.208^{***}	-0.201^{***}	-0.286^{*}	-0.248^{***}
	(0.053)	(0.047)	(0.153)	(0.071)
	$[-0.51, -0.14]$	$[-0.42, -0.13]$	$[-\infty, +\infty]$	$[-0.62, -0.12]$
Colonizer fixed effects	No	Yes	Yes	Yes
Geography controls	No	No	Yes	Yes
Restricted sample	No	No	No	Yes
F-stat	15.4	4.32	1.73	2.17
Number of obs.	52	52	52	42

Conclusions

- What's the conclusion about the deep determinants of economic performance?
- What does this imply for the role of current institutions?