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Gov 2001: Advanced Quantitative Political Methodology

Paper Replication Assignment

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Colonial Institutions, Human Capital and Development Re-Examined

Abstract

We replicate Acemoglu, Gallego and Robinson's 2014 paper "Human Capital, Institutions and Development". In this paper, we explore competing theories regarding the relationship between colonial institutions and development in terms of the significance of institutions (rule of law) over human capital (education) in determining long-run development outcomes. Our major contributions include finding and correcting for model misspecification, a re-examination of the historical data used by the authors, the use of more recent data from 2014, and expanding the definition of development to include aspects of human development as well as economic growth. We find that, within the past ten years, the relationship between rule of law and development as expressed through GDP and other indicators becomes weaker, while the relationship between education and development becomes stronger and statistically significant. We discuss reasons why this phenomenon occurs, suggesting it may be linked to the recent growth in industrialization of post-independent states, in which value creation shifts from agricultural production to forms of wage labor that place higher value on education.

Introduction

The question of what exactly are the significant variables that drive development (be they endogenous or exogenous) is a prevalent debate in comparative politics. Among the literature that provide explanations for the persistent cycle of underdevelopment in many former colonies, some commonly discussed themes include weak institutions, corrupt government officials, geography, colonial legacies, varying forms of inequity and discrimination, histories of fractionalization and conflict, the "dependency" effects of the foreign aid industry, and poor infrastructure. A number of these themes that indicate levels of socio-economic and political development also serve as mechanisms through which development and growth are either realized or mitigated.[1]

Although imperialism and colonialism occurred in most parts of the world, the literature that studies patterns of underdevelopment and European colonialism in the nineteenth and twentieth centuries focuses primarily on developing nations in the Americas, Africa, and South Asia, many of which have suffered from the resource curse.[2] From a broad viewpoint, the World Bank reports various development indicators such as average levels of education, life expectancies, Gross National Income (GNI) per capita, and other factors, for countries as well as regions. As of 2014, the GNI per capita in sub-Saharan Africa was about $1, 638, while average life expectancy was 59 years. For South Asia, GNI per capita for the same year was $1,496, while life expectancy was 68 years.[3] For the Middle East and North Africa, GNI per capita was about

[1] It is important to note that these measures of development could be seen as controversial, depending on different ideological positions regarding the nature of wealth, public institutions, etc. – ideological positions that tend to emerge from Western governments and schools of thought.

[2] The resource curse here refers to the paradox of countries experiencing underdevelopment and slowed growth despite having an abundance of natural resources.

[3] Of course, these indicators are not sufficient in capturing all levels of development, but they help one to observe the varying levels of development between regions at a glance. There is also variation between countries in a region and within countries in terms of how wealth and resources are distributed among the general populace. Interestingly,

$4,752 while life expectancy was estimated at 72 years. It is no coincidence that many of the countries that suffer from the resource curse were also colonized at some point in their histories. These development outcomes are in essence what the literature is attempting to explain through the framework of colonial legacies and persisting institutions.

The paper that we replicate, *Institutions, Human Capital and Development* (2014) by Acemoglu, Gallego and Robinson, is one that draws on a debate regarding whether institutions or human capital (as impacted by European settler colonies) is a greater driving force of long run development outcomes. It is argued that political institutions and human capital are mechanisms through which colonialism affects long-run development and growth in former colonies. Before presenting the main arguments espoused by the paper we replicate and the work that we do to extend this research, we present the key debates regarding human capital and institutions in terms of which mechanism best explains development outcomes overtime.

Acemoglu, Johnson and Robinson (2001) study the effects of colonial legacies on long-run development outcomes by establishing a connection between European settler colonialism and institutions. In their paper, "The Colonial Origins of Comparative Development", Acemoglu, Johnson and Robinson (2001) study the relationship between the number of European settlers and the type of colonialism practiced in colonies.[4] They argue that countries that had conditions less conducive to European settlers usually experienced a more extractive form of colonialism. In an extractive type of colonialism, value created by society passes to the colonial power and to a small number of European settlers, of whom there are only a few due to unfavorable climate and high death rates caused by indigenous diseases.

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the data show a high percentage of primary school completion rates in South Asia (91%) and for Latin America and the Caribbean, GNI per capita and primary completion rate are high ($9,095 and 101% respectively). This is also perhaps due to country variation where certain countries skew the average values. Data from: http://data.worldbank.org/region/SAS

[4] For a similar argument applied to the western hemisphere, see Engerman and Sokoloff (1997)

In this type of scenario, the natural resources of the area are extracted and used primarily to build the wealth of the colonizer's home country instead of being retained in the colony. In a colonial system of this sort, institutions are set up that favor exploitation and authoritarian political regimes. In places where conditions were more favorable for colonizers to live, settler colonialism was practiced. In these locations, political and legal institutions that encouraged protected property rights were established, which positively affect long-term economic growth. As a result of this connection between colonial practices and institutions, it can be argued that there is a positive relationship between the number of original European settlers in a colony and the average level of socio-economic development today.

Easterly and Levine (2012) on the other hand, argue that it is not necessarily property rights institutions, but human capital in the form of settler inflow, that explains the correlation between the proportion of European settlers in a colony and socio-economic development. Acemoglu et al (2001) and Easterly et al (2012) both agree on the correlation between the number of settlers and long-run development outcomes. Where they differ is in their notion of what instrumental variable or mechanism chiefly drives these outcomes. The seminal Acemoglu et al. 2001 paper addresses the research puzzle regarding the connection between types of colonialism and colonial institutions and thus, economic development as measured by average income levels in former colonies. But the Acemoglu, Gallego and Robinson 2014 paper pushes their argument further to attest that it is really institutions and not human capital (as argued by Easterly and Levine) that has the most significant impact on long-run development patterns.

In "Institutions, Human Capital, and Development" (2014), Acemoglu, Gallego and Robinson study the relationship between institutions, human capital, and development using data

from 62 countries[5]. They argue that empirical models that treat institutions and human capital as exogenous are misspecified because of omitted variable bias problems and because of differential measurement error in these variables. According to the authors, this misspecification creates a mistakenly large impression of the effect of human capital, about four to five times greater than that found in previous literature.

To measure human capital, the authors use data on protestant missionary activity, average levels of education in former colonies in the early twentieth century, and average years of schooling of the same countries in 2005.[6] In the authors' study, data on missionary activity and early education levels serve as instruments that predict their endogenous education variable, years of schooling in 2005, to which they link countries' 2005 GDP. To measure institutions, the authors choose as their endogenous variable the rule of law index for 2005. As instruments for this variable, they use the location's population density prior to colonization and the location's settler mortality rate during the early colonial period. The rationale for using 2005 rule of law scores as instrumented on these variables is two-fold. First, there is no sufficient data available that proxy for institutions during the early colonial period; however, there is strong reason to believe that the proportion of settlers, as influenced by settler mortality rates and pre-colonial population density, influenced early institutions. Second, institutions persist for long periods of time (which is part of the main argument); thus, indicators of rule of law in the modern era are likely influenced by those of the colonial period. Part of the argument relating type of colonialism to long-run development outcomes is that in settler colonies that set up more inclusive institutions to protect property rights, the persistence of these institutions over time

[5] The original sample had 64 countries that were colonized at some point by a West European power. However, while running regression, the authors took out Guinea and the Bahamas from their sample since there were no 2005 values for rule of law for these two countries.

[6] For their argument of long-run development, the modern era here is 2005- which is the data that they use for GDP, years of schooling and rule of law.

allowed citizens to continuously invest in value-creating assets, which benefited long-run development.

Using cross-country and cross-regional regressions, the authors show that when they focus on historically determined differences in human capital and control for the effect of institutions, the impact of institutions on long-run development is robust, whereas the estimates of the effect of human capital are much diminished and become consistent with micro estimates cited in prior literature. Using historical and cross-country regression evidence, the authors also show that there is no support for the view that differences in the human capital endowments of early European colonists have been a major factor in the subsequent institutional development of former colonies. Upon attempting to replicate portions of their data as relevant to our paper, we have found the authors' conclusions to be robust.

Our Contribution

In our paper, we pursue a number of methods and outcome variables that extend the authors' argument further. First, we note that the definition of development used in the Acemoglu et al. 2014 paper we replicate is limited to economic development in terms of Gross Domestic Product per capita. GDP per capita serves as a good indicator of economic development because it measures the average income earned by a population, which reflects the average standard of living in a country. GDP per capita is widely available for most countries, whereas many of the other indicators are not available for all countries. For this reason, it is the most frequently used measure of economic development.

We recognize the fact that there is not sufficient data that measures the distribution of wealth and income inequality in many nations (as commonly demonstrated by Gini coefficients) for

various years. This could explain why the authors limited the definition of economic development to GDP per capita. However, GDP does not adequately measure socio-economic and political development. There is of course, a relationship between a country's GDP per capita and other sectors of society, but the measure of development should encompass other indicators of standard of living such as health conditions, access to and quality of education, etc.

Indicators that are used to measure national levels of economic and socio-political development characteristically include GDP per capita, Gini coefficients, life expectancies, literacy rates, the rule of law, the Human Development Index (HDI) and several other measures. Although GDP per capita gives a picture of the economic situation in a country in terms of average income, it has a number of limitations. First, GDP per capita does not reflect all economic activity that occurs in an economy; it does not include household work, black market transactions, undocumented trade etc. Second, it does not distinguish between goods and services that benefit the society and those that harm the society such as pollution, war, etc.[7]

Third, and arguably the most notable drawback of GDP per capita as a measure of economic performance, is that it does not reflect the distribution of wealth and income within an economy. In order to address this shortcoming, we use the Gini coefficient as another measure of economic development. The Gini coefficient measures economic inequality; higher Gini values indicate a more uneven distribution of wealth among the population. The Gini index ranges between zero (which represents perfect economic equality) and one or one hundred (which represents perfect economic inequality where one person or household owns all the wealth/income).[8] We regress

[7] For more details on the limitations of GDP as a measure of development and its influence in policy decisions see Cha (2013)

[8] Although income represents a flow and wealth is a stock, they are used here interchangeably since they both represent standard of living in terms of money (or at least, what money can buy) and assets.

Gini (as an additional dependent variable) on indicators of human capital and institutions (as presented in the paper we are replicating).

In this paper, we also use HDI as another key indicator of development due to the fact that HDI captures more elements of development than many other indicators.[9] The Human Development Index measures performance based on indicators of health, education and the standard of living.[10] The HDI of countries is calculated by giving equal weight to each of the three components of the index. Health performance is evaluated by life expectancy, and education is evaluated based on adult literacy rates combined with gross school enrollment ratios. Standards of living are estimated from Gross National Income per capita values.[11] The notion of HDI as a measure of human development and wellbeing arises from the limitations of GDP per capita in capturing other elements of development, as well as reports that "there is no automatic link between economic growth and human progress" (Gallardo, 2009).[12] Although the HDI is limited in the sense that it does not encompass all indicators of wellbeing, it does include basic indicators, which strongly influence important dimensions of human development such as civil liberty, gender equality, and other indicators.

As we do with Gini, we also regress HDI on indicators of human capital and institutions. Thus, in addition to the GDP per capita values that Acemoglu, Gallego and Robinson use in their paper, we also test if there is a significant relationship between HDI or Gini with human capital or institutions. If the authors' argument holds in this case, we would expect to see a stronger

[9] Although HDI captures more elements of development than commonly used economic indicators, it still does not provide a comprehensive picture. Given the varying definitions of development, it could be argued that factors such as happiness quotients, culture, and systems of oppression as they relate to equity, and civil liberties, are not captured by HDI.

[10] The HDI is from the United Nations Development Project, available at http://hdr.undp.org/en/statistics/data/

[11] To measure the standard of living component of HDI, GDP (gross domestic product) or GNI (gross national income) is used, although the use of GNI per capita has become more standard. The United Nations Development Project (UNDP) uses GNI per capita in their calculation of HDI. For details on how they measure HDI, see http://hdr.undp.org/en/statistics/hdi/

[12] Additionally, there are no automatic links between GDP, inequality, and poverty.

(negative) correlation between Gini and institutions than between Gini and human capital.[13] We would also expect to see a stronger (positive) correlation between various dimensions of HDI and institutions than between dimensions of HDI and human capital[14].

Our second contribution is in exploring and remediating potential critiques of the authors' data gathering process. A number of critiques have been made, primarily centered on the settler mortality dataset that Acemoglu, Gallego, and Robinson use in their analysis.[15] This data was originally gathered in support of Acemoglu, Johnson, and Robinson's 2001 paper, "The Colonial Origins of Comparative Development: An Empirical Investigation." These critiques are based primarily on concerns regarding clustering as a result of extrapolations made in attempting to estimate settler mortality rates by country during the colonial period, prior to the solid formation of present state boundaries, and at a time when many sources reported mortality rates primarily by profession rather than for the populace as a whole.[16] To overcome these discrepancies, we investigate sources of revised settler mortality data, finding a source that incorporates portions of the authors' data which could be independently validated, in combination with revised estimates as recommended by a number of reputable outside sources.[17] Using this revised data source, we re-replicate the authors' results. We also incorporate the revised data into our investigation of model dependence, finding that the revised data transform first stage variable relationships from unidentifiably nonlinear to clearly quadratic, as we discuss in more detail below.

[13] Note that the correlation should be negative since higher Gini values indicate greater inequality, thus we would expect lower Gini (more equality) along with higher rule of law values (indicator of better institutions).
[14] Because we use mean years of schooling as a proxy for human capital, and that same variable is included in official calculations of HDI, it would be inappropriate for us to consider a simple positive correlation between the two elucidative. Hence, we prefer to use HDI's separate components when drawing conclusions regarding this part of the analysis.
[15] We discuss these in further detail in our Findings section.
[16] See Albuoy (2012).
[17] See Subramanian (2007).

Our third major contribution is in testing the assumed linear relationship between variables. Like many empirical studies in economics that use instrumental variables, Acemoglu, Gallego, and Robinson's 2014 paper is based on a first stage that is linear in its instruments. This focus on a linear first stage may miss important information that can impact arguments related to instrument validity and possibly affect heterogeneity. A 2014 analysis of several recently published studies found many of those relying on assumed linear first stages have significant nonlinearities, notably, quadratic terms, in the first stage.[18] In cases where linear and quadratic first stage results differ substantially, additional analysis and discussion become necessary.

We investigate the presence of nonlinearities, focusing our analysis particularly on the potential for nonlinear relationships between endogenous variables and their first stage instruments. Upon investigation, we discover the presence of quadratic relationships in first stage regressions used in the authors' analysis. We then incorporate these quadratic terms into our regression model, and compare the authors' original results with those of the quadratic model. This allows us to determine whether the authors' results are robust to issues of model dependence thus far unexplored in their paper.

Our final contribution is in gathering the most recent available data on institutions, human capital, and economic outcomes for those countries examined by the authors. We then replicate key portions of their analysis using the most recent available data (from 2014), and compare the results with the authors' outcomes obtained using 2005 data. We find the results of these analyses differ substantially, and explore what factors may have resulted in these differences.

[18] See Dieterle, S. and Snell, A. (2014), "It's Hip to be Square: Using Quadratic First Stages to Investigate Instrument Validity and Heterogeneous Effects" University of Edinburgh http://homepages.econ.ed.ac.uk/~sdieterl/researchpapers/DieterleSnellIV.pdf

Findings

Authors' conclusions: robust to model dependence, but not valid for 2014 data

Acemoglu, Gallego and Robinson's final model illustrates the comparative impact of institutions and human capital on GDP.[19] We first replicate their model and find their conclusions hold, given their existing data from 2005. We then update the data used to reflect most recent estimates for education, rule of law, and GDP per capita, from 2014. We find that when we use more recent data from 2014, the effect of rule of law on GDP diminishes. That is, the statistical significance is lost over time. This proves to be the case both when we retain the authors' original linear model, and when we substitute our quadratic model with the use of revised settler mortality data.[20] Our results are pictured in Tables 1 and 2, which depict the results of our linear model and quadratic model respectively. We then explore a line of reasoning that explains why this might be the case.

[19] The final model here refers to the one in which the authors control for colonizing country, region, and other possible explanatory variables while regressing GDP on the endogenous variables, rule of law and years of schooling, in the second stage regressions. The first stage regression includes the same controls but years of schooling and rule of law are regressed on their respective instrumental variables: missionary activity and primary school enrollment in the early twentieth century, log population density prior to colonization, and log settler mortality during the early colonial period. The intuition for this model is that log population density and settler mortality work through rule of law as a proxy for institutions to affect GDP, while early twentieth century missionary activity and primary school enrollment impact GDP through present-day mean years of schooling, a proxy for human capital.

[20] See Subramanian (2007).

Table 1: Full two-stage least squares (2SLS) estimates for linear model, cross-country sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Second-stage regressions								
	Dependent variable: log GDP per capita							
Year of data	**2005**		**2014**					
Years of schooling	0.161	0.140	0.187	0.217				
	(0.089)	(0.162)	(0.088)	(0.096)				
	p = 0.075	p = 0.391	p = 0.038	p = 0.027				
Rule of law	0.814	1.198	0.013	0.008				
	(0.328)	(0.510)	(0.007)	(0.005)				
	p = 0.016	p = 0.023	p = 0.060	p = 0.146				
First-stage regressions								
Year of data	**2005**				**2014**			
Dependent variables	**Years of schooling**		**Rule of law**		**Years of schooling**		**Rule of law**	
Primary school enrollment in 1900	0.063	0.047	0.01	0.571	0.050	0.037	0.106	0.005
	(0.010)	(0.018)	(0.005)	(0.560)	(0.011)	(0.017)	(0.277)	(0.006)
	p < 0.001	p = 0.011	p = 0.060	p = 0.361	p < 0.001	p = 0.032	p = 0.704	p = 0.435
Protestant missionary activity in the early twentieth century	0.734	1.187	-0.134	0.004	1.087	1.703	-5.881	0.085
	(0.389)	(0.429)	(0.158)	(0.006)	(0.414)	(0.382)	(8.442)	(0.162)
	p = 0.064	p = 0.008	p = 0.402	p = 0.518	p = 0.011	p < 0.001	p = 0.489	p = 0.601
Log capped potential settler mortality	-1.006	(0.540)	-0.474	-0.202	-1.128	-0.638	-19.64	-0.225
	(0.324)	(0.508)	(0.121)	(0.109)	(0.335)	(0.504)	(5.981)	(0.101)
	0.003	p = 0.293	p < 0.001	p = 0.069	p = 0.001	p = 0.469	p = 0.002	p = 0.031
Log population density in 1500	-0.14	0.053	-0.045	-0.095	-0.220	-0.064	(9.190)	-0.111
	(0.133)	(0.164)	(0.063)	(0.066)	(0.144)	(0.167)	(4.114)	(0.063)
	p = 0.299	p = 0.747	p = 0.479	p = 0.157	p = 0.124	p = 0.703	p = 0.029	p = 0.086
Adjusted R squared	0.654	0.691	0.523	0.607	0.629	0.684	0.413	0.614
Observations	62	62	62	62	62	62	62	62
	Control variables included in first and second stage							
Dummy for different source of protestant missions	No	Yes	No	Yes	No	Yes	No	Yes
Latitude	No	Yes	No	Yes	No	Yes	No	Yes
Continent dummies	No	Yes	No	Yes	No	Yes	No	Yes
Colonial origin dummies	No	Yes	No	Yes	No	Yes	No	Yes

The top half of the table presents second-stage regressions with rule of law and years of schooling instrumented using the log capped settler mortality, log population density in 1500, Protestant missionaries, and primary enrollment in 1900, and the bottom half presents the corresponding first stage regressions, with one observation per country. All variables are

described in the main text. Standard errors robust to heteroskedasticity are in parentheses. Coefficients and standard errors for the constants and control variables are not reported to save space.

Table 2: Full two-stage least squares (2SLS) estimates for quadratic model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Second-stage regressions								
Year of data	**Dependent variable: log GDP per capita**							
	2005		**2014**					
Years of schooling	0.244	0.102	0.239	0.209				
	(0.064)	(0.156)	(0.058)	(0.098)				
	$p < 0.001$	$p = 0.516$	$p < 0.001$	$p = 0.037$				
Rule of law	0.468	1.202	0.007	0.006				
	(0.203)	(0.513)	(0.004)	(0.005)				
	$p = 0.025$	$p = 0.023$	$p = 0.072$	$p = 0.273$				
First-stage regressions								
Year of data	**2005**				**2014**			
Dependent variables	**Years of schooling**		**Rule of law**		**Years of schooling**		**Rule of law**	
Primary school enrollment in 1900	0.070	0.048	0.011	0.003	0.055	0.040	0.232	-0.832
	(0.009)	(0.019)	(0.007)	(0.007)	(0.010)	(0.018)	(0.345)	(0.380)
Protestant missionary activity in the early	0.607	1.332	-0.123	0.095	0.955	1.799	-7.123	-0.374
	(0.351)	(0.558)	(0.161)	(0.188)	(0.383)	(0.519)	(8.621)	(11.02)
Log settler mortality, revised data	-0.026	-0.0006	-0.013	-0.002	-0.033	-0.001	-0.684	-0.306
	(0.014)	(0.017)	(0.004)	(0.005)	(0.014)	(0.016)	(0.248)	(0.276)
Log settler mortality, quadratic term	0.00007	-0.000005	0.00004	0.000003	0.0001	0.000009	-0.002	0.0008
	(0.00004)	(0. 00005)	(0.00001)	(0.00002)	(.00005)	(0.00005)	(0.0008)	(0.0009)
Log population density in 1500	-0.269	-0.006	-0.131	-0.135	-0.371	-0.114	-11.29	-11.84
	(0.137)	(0.143)	0.077	0.075	(0.141)	(0.141)	(4.750)	(4.519)
Log population density in 1500, quadratic term	0.028	0.037	0.056	0.019	0.048	0.046	1.219	-1.421
	(0.047)	(0.059)	(0.024)	(0.024)	(0.047)	(0.063)	(1.368)	(1.508)
Adjusted R squared	0.608	0.668	0.547	0.585	0.593	0.669	0.411	0.523
Observations	62	62	62	62	62	62	62	62
	Control variables included in first and second stage							
Dummy for source of protestant missions	No	Yes	No	Yes	No	Yes	No	Yes
Latitude	No	Yes	No	Yes	No	Yes	No	Yes
Continent dummies	No	Yes	No	Yes	No	Yes	No	Yes
Colonial origin dummies	No	Yes	No	Yes	No	Yes	No	Yes

The top half of the table presents second-stage regressions with rule of law and years of

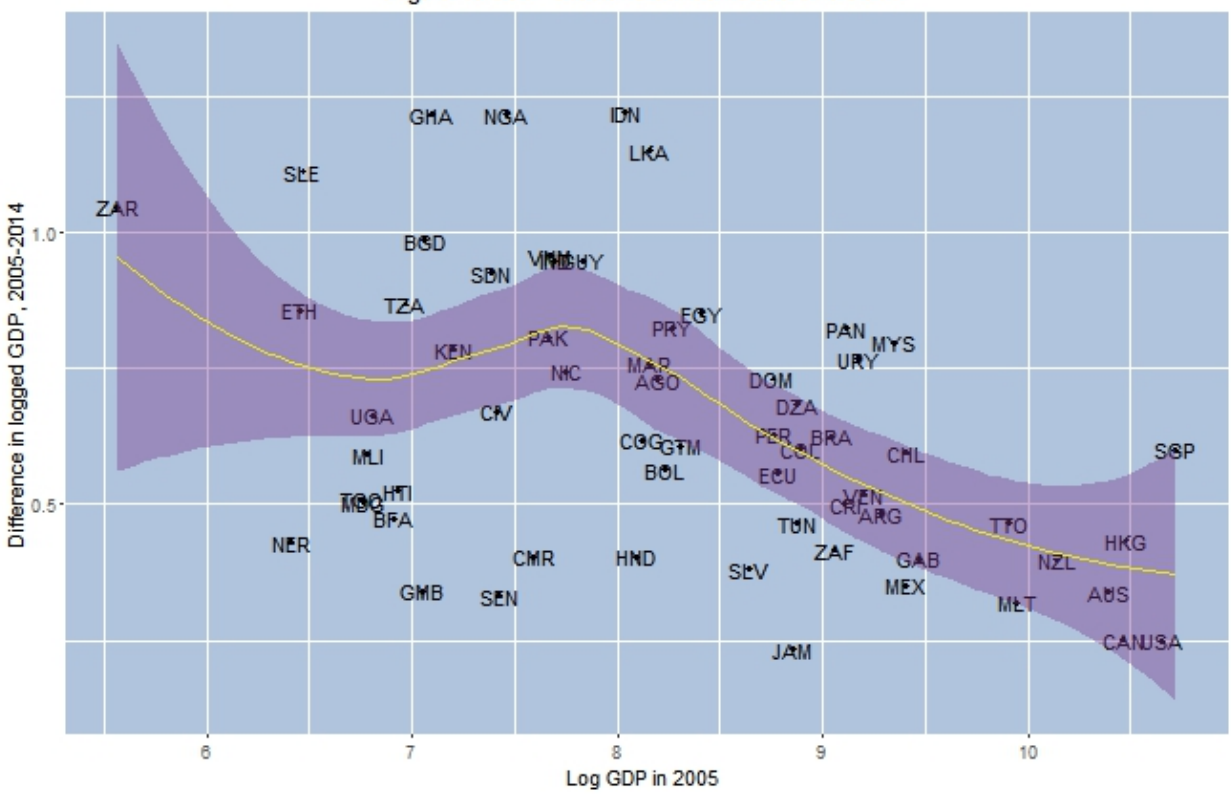
schooling instrumented using the log settler mortality and its quadratic term, log population density in 1500 and its quadratic term, Protestant missionaries, and primary enrollment in 1900, and the bottom half presents the corresponding first stage regressions, with one observation per country. All variables are described in the main text. Standard errors robust to heteroskedasticity are in parentheses. Coefficients and standard errors for the constants and control variables are not reported to save space. Note that, when endogenous variables are regressed only on their respective instruments in the first stage, results are statistically significant. Particular instrument choices are discussed in further depth in Acemoglu, Gallego, and Robinson's 2014 paper.

External factors that alter conclusions in 2014

In their paper "Unbundling Institutions", Acemoglu and Johnson (2005) find that property rights institutions serve as a primary determinate of the long run development outcomes of post-colonial states. This argument makes sense for a country's development to the extent that property rights are important to production, as is the case when a large proportion of GDP comes from agricultural activities. However, as low income developing nations begin to industrialize, these nations experience greater population migration to urban centers and a greater need for education in the workforce. Because of this, individuals' property rights become less important, because individuals' income is derived not form their property but from wage labor. As this industrialization occurs, human capital in the form of education becomes more significant than institutions, specifically; property rights institutions as indicated by rule of law. This is because, as nations industrialize, education becomes an asset in many manufacturing, information

technology, and other knowledge-based economies.[21] Thus, we see a shift from the importance of land rights institutions (an important component of rule of law) to education in determining development outcomes. This shift is illustrated in Figure 1, below, which highlights that the greatest increases in GDP growth in the past ten years have been in industrializing middle-income countries.

Figure 1: GDP Growth Between 2005 and 2014



The aforementioned finding suggests that the instrumental variable, rule of law (as the measure for institutions) loses its power to predict GDP per capita (as a measure of economic development) in more recent times. Although there is the argument that institutions persist over

[21] One could make the argument that, for particular manufacturing-based economies, such as the rise of the garment manufacturing industry in many post-colonial nations, education is not a necessity for participation, which would make education less of a significant factor in development. However, within these industries, competition for limited work opportunities still makes education an important competitive distinguishing factor for hiring. At the same time, within this wave of industrialization, the rule of law in the form of private property rights institutions ceases to be as significant as it would in an agrarian society. Thus, we would expect human capital to be more significant than institutions within an urbanizing society that emphasizes IT and the manufacturing industries.

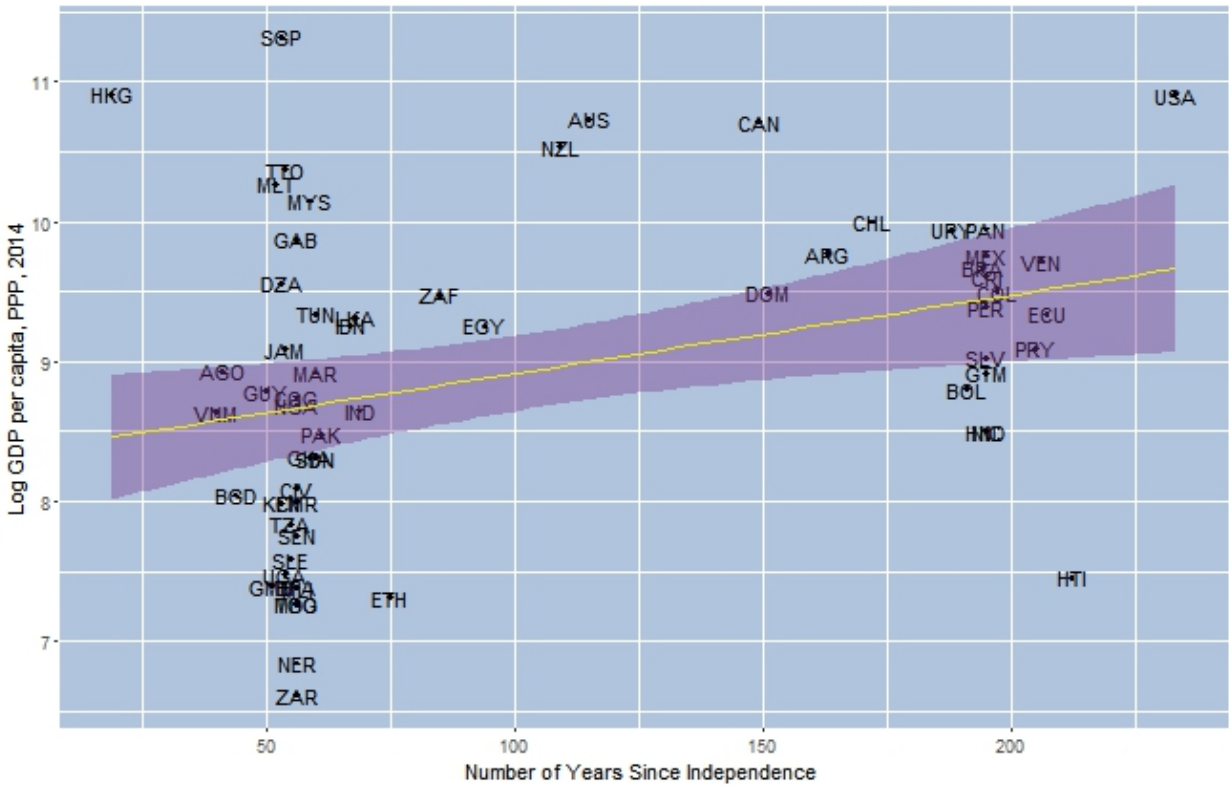
time, another reason for this finding might be the fact that institutions, despite their colonial origins are not set in stone. With waves of democratization and social mobilization, institutions evolve (albeit slowly) to reflect the times. An instance of this is seen in the Apartheid reforms of the 1980s that culminated in multi-racial democratic elections in 1994, which was won by the African National Congress under Nelson Mandela. The act of lifting apartheid laws impacted the nature of legal institutions in this post-independence period. Thus, we propose other factors that could impact institutional change overtime. These include number of years since a state has gained independence and the level of corruption in the state.

When we regress present day rule of law on years since independence and levels of corruption, while controlling for previously accounted for variables (such as region, colonizer, etc.), we find that the R squared value improves significantly. We also find that controlling for corruption is the single most significant and influential factor on a nation's rule of law post-independence. This makes sense because control of corruption factors directly into the measurement of the rule of law of a given country, according to the indicators we used. At the same time, it functions separately from the existence of institutions themselves. When corruption and rule of law are controlled for separately, the amount of time since a nation's independence also has a statistically significant impact on the GDP in that nation. This may be in part because many countries were prevented from engaging in industrialization during colonial rule. The number of years since independence would thus also indicate the amount of time nations have had engage in industrialization, the growth of which we suggest serves to partially decouple property rights institutions from growth in GDP.

Figure 2, below, serves to illustrate this GDP growth and its dependency on the number of years since a nation's independence. Taken together, these findings imply that a nation's

course of growth can change over time, thus diverging from the course predicted by the state's original colonial institutions.

Figure 2: GDP Increases with Number of Years Since Independence



Because we cannot reasonably make the case that corruption and years since independence are as if random (that is, they are determined by a number of other factors including institutions themselves), we refrain from using either of these as instruments for the rule of law. However, the finding does help to explain why we may not be finding statistically significant results when we regress more recent GDP per capita values from 2014 on rule of law. Our finding that GDP is impacted by both corruption and the number of years since independence thus suggests that, perhaps through avenues to institutional change, a variety of other outcomes of interest have the potential to improve. This has profound implications for the focus of development work, which has thus far focused largely on human capital and community

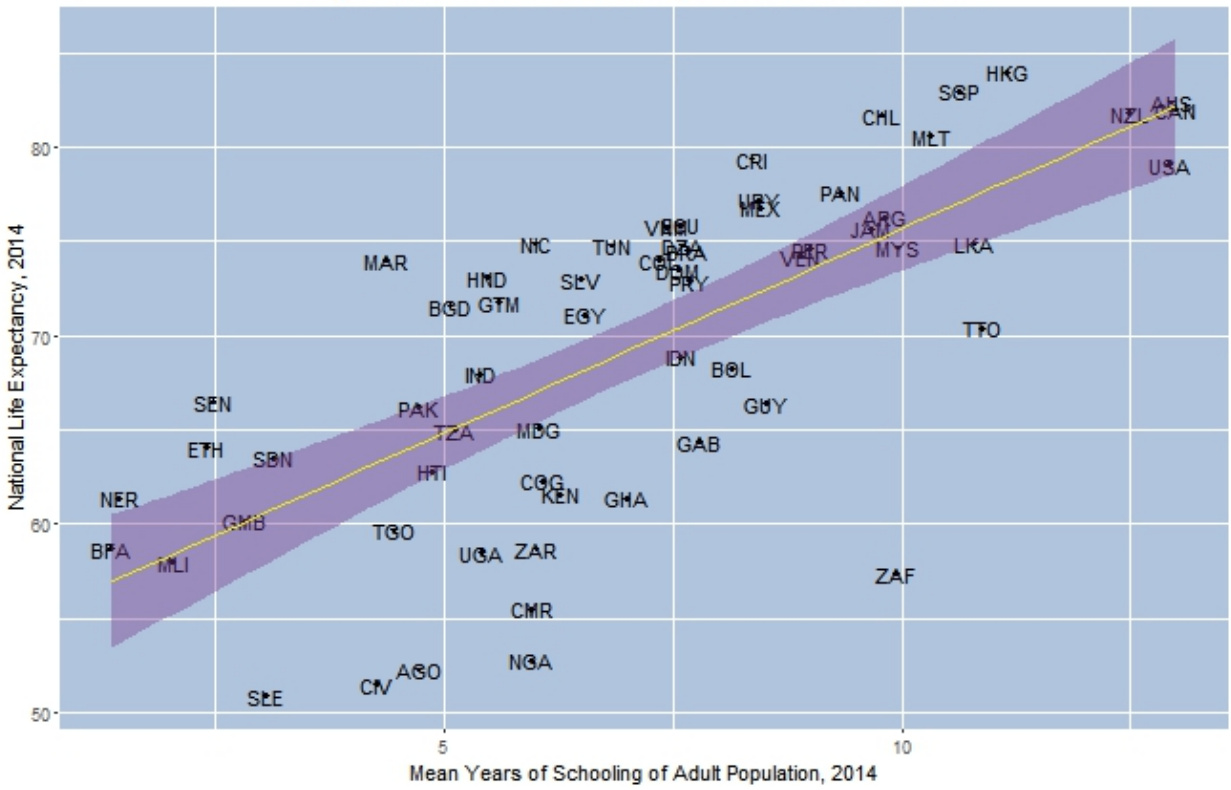
resource based interventions. These are indeed important, but they represent symptoms of a larger problem, which is one that necessitates institutional change.

Impact of education and rule of law on other development metrics

In terms of the new dependent variables that we introduce, gini and HDI, we found a few interesting results. First, income inequality, as indicated by the gini coefficient, is actually positively correlated with rule of law. That is, with increasing rule of law, we noticed higher levels of inequality, which is surprising. Since the argument is that higher rule of law is correlated with higher GDP per capita, it might actually be the case that gini is also high in these contexts given that increases in average incomes can increase wealth gaps. The data demonstrates a situation where the increasing GDP per capita is mostly going to the rich, and this could explain why we have the surprising result of gini being positively correlated with rule of law and GDP per capita. Rule of law was not significant for other factors, including HDI, life expectancy, polity score, and climate vulnerability (when other necessary factors were controlled for).

Education, however, had a statistically significant impact both on a country's polity score and on national life expectancy in 2014. When we regressed life expectancy on education, as instrumented through primary school enrollment in 1900 and early twentieth century protestant missionary activity, we found a large coefficient, of 1.94, significant at $p < 0.001$. This variable relationship is illustrated in Figure 3, below.

Figure 3: National Life Expectancy Increases with Education



This finding provides support for a previous report by the UN, which cites education of women as a "silver bullet for sustainable growth".[22] Women, in particular, may be the critical link between education and increasing life expectancy: Previous findings, as cited by the UN report, correlate women's education with greater child survival and healthier children. Thus education, and women's education in particular, is important to HDI because it not only factors into overall HDI as a direct indicator but impacts a number of other areas of development, such as health.

Accounting and correcting for critiques of the authors' settler mortality data

[22] See United Nations (2013) "FEATURE: Developing countries experiencing unprecedented growth, says UN report" UN News Centre http://www.un.org/apps/news/story.asp?NewsID=44371

While investigating the data that is used for the replication, we found a number of critiques of the settler mortality data used by Acemoglu, Johnson and Robinson (2001), which is the same data that is used in the Acemoglu, Gallego and Robinson (2014) paper. Albuoy (2012) argues that there are several reasons to doubt the reliability and comparability of the European settler mortality data used by AJR[23] and the conclusions that were drawn from this data. First, Albuoy finds that only 28 countries out of the 64 countries in the sample have mortality rates that originate from within their own borders. The other 36 countries are assigned settler mortality rates based on speculations the authors make regarding which countries have similar disease environments. Since the authors did not have settler mortality data for all countries and use few data points to generalize for the countries in each region, there is a clustering effect. The use of regional level data for mortality thus leads to higher actual standard errors than those the authors report. Albuoy (2012) concludes that the significance of the authors' results is reduced since they did not correct for clustering.

A second major critique of the authors' data is in terms of its origin. The settler mortality data used by AJR and AGR comes primarily from European and American soldiers in the nineteenth century. According to Albuoy (2012), the mortality rates never come from actual European settlers, even though some settler rates are available in the sources used by the authors. For some countries, the data is of soldiers at peace in barracks, while in others; the rates apply to soldiers on campaign (who typically have higher mortality from disease).[24] This, of course, skews the results obtained by AJR and AGR. Albuoy also finds that AJR uses mortality rates for

[23] For simplification purposes, AJR refers to the 2001 Acemoglu, Johnson and Robinson paper while AGR refers to the 2014 Acemoglu, Gallego and Robinson paper. Both cited in the reference section.
[24] Soldiers on campaign refers to soldiers involved in a series of military operations that are undertaken to achieve a large scale objective during a war or conflict.

soldiers on campaign more often for countries with greater expropriation risk (an indicator of the quality of institutions) and lower GDP, which artificially favors their hypothesis.

There are a number of other issues with the data used by AJR, which include, but are not limited to the partial use of mortality rates from African laborers who were coerced to move to foreign environments under harsh conditions. The authors compiled their data from several sources, only some of which reported the mortality rates of African laborers, soldiers, and actual settlers. Due to the lack of sufficient settler mortality data for certain countries, they filled this gap using data on laborers and soldiers. They used Curtin (1968) data for part of this, which reports mortality rates of harshly treated black laborers, but reports for neither European settlers nor soldiers. Additionally, all of the mortality rates taken from Curtin et al. (1995) are maximum mortality rates, not average rates, as in Curtin (1968). Thus, the data that they use is not only inconsistent, but casts a number of doubts on their conclusions.

Although these criticisms recommend that the settler mortality data be revised, this does not mean that the theoretical implications of the authors' argument are insignificant. In his thesis investigating and correcting for these data problems, Karti Subramanian uses data on settler mortality that was compiled from the British life insurance industry of the mid-19th century.[25] The data is based on European civilian mortality instead of soldier mortality. Using this new data set, Karti finds that European settler mortality rates are still strong predictors for institutions. His findings suggest that the mortality rate of European settlers is correlated with current institutions, and under the assumption of exogeneity, institutions are still a viable instrumental variable through which colonial experiences affect long-run development outcomes.

[25] See Subramanian, K. (2007) " The Colonial Origins of Comparative Development: New Settler Mortality Data" Amherst College Department of Economics https://www.amherst.edu/media/view/18871/original/Subramanian.pdf

Investigation and revision of the linear model

Beyond the problems with the data that are raised by Albuoy and are revised by Subramanian, we do find evidence of model misspecification within the AGR paper. Initially with setter mortality data used by AGR, we found strong evidence for nonlinearity, but it was not clear whether the relationship was quadratic or something more difficult to model. However, when we used the revised settler mortality data, as compiled by Subramanian, it became clear that the relationship between settler mortality and rule of law was quadratic. To detect this, we fitted a generalized additive model (GAM) onto the regression of rule of law and settler mortality, and rule of law and log population density. For the original AGR dataset, both of those relationships were nonlinear, but we were unable to specify the relationship between settler mortality and institutions. Using the revised data from Subramanian, however, the relationship between settler mortality and institutions became clearly quadratic. The relationship between population density and institutions was also shown to be quadratic. Figures 4 and 5, below, illustrate the quadratic nature of these relationships. Following this investigation, we incorporated quadratic terms for settler mortality (with Subramanian's revised data) and logged population density into the regression of rule of law. Both terms significantly impacted the outcome for rule of law.

Figure 4: Rule of Law Regressed on Settler Mortality and Population Density

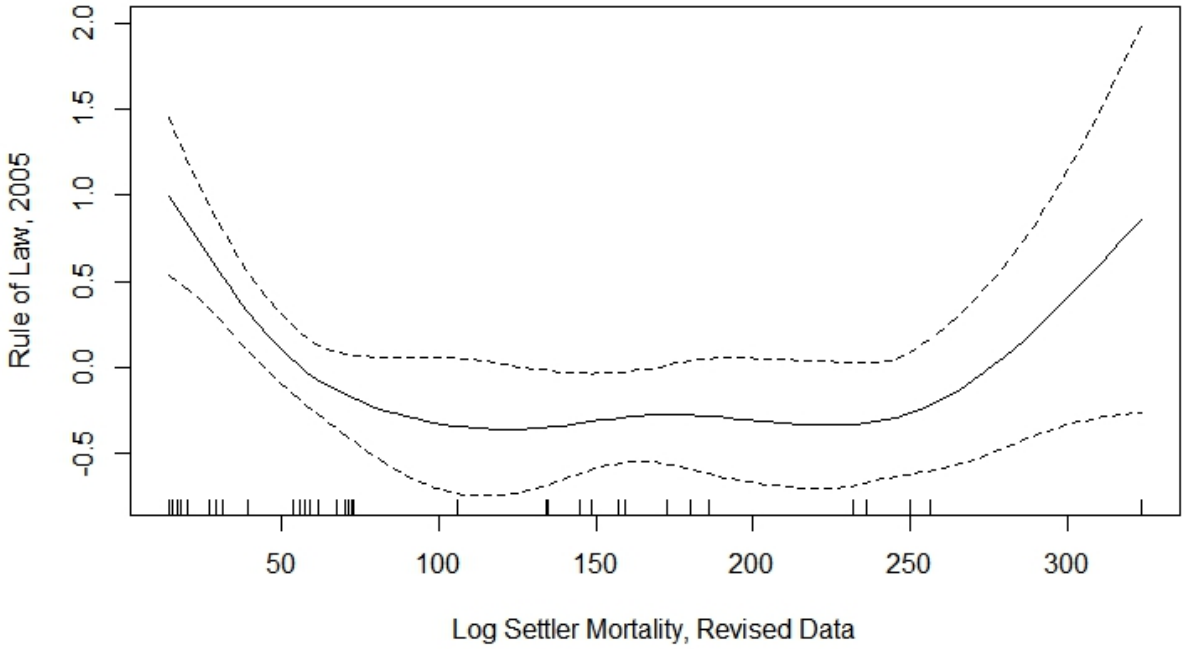
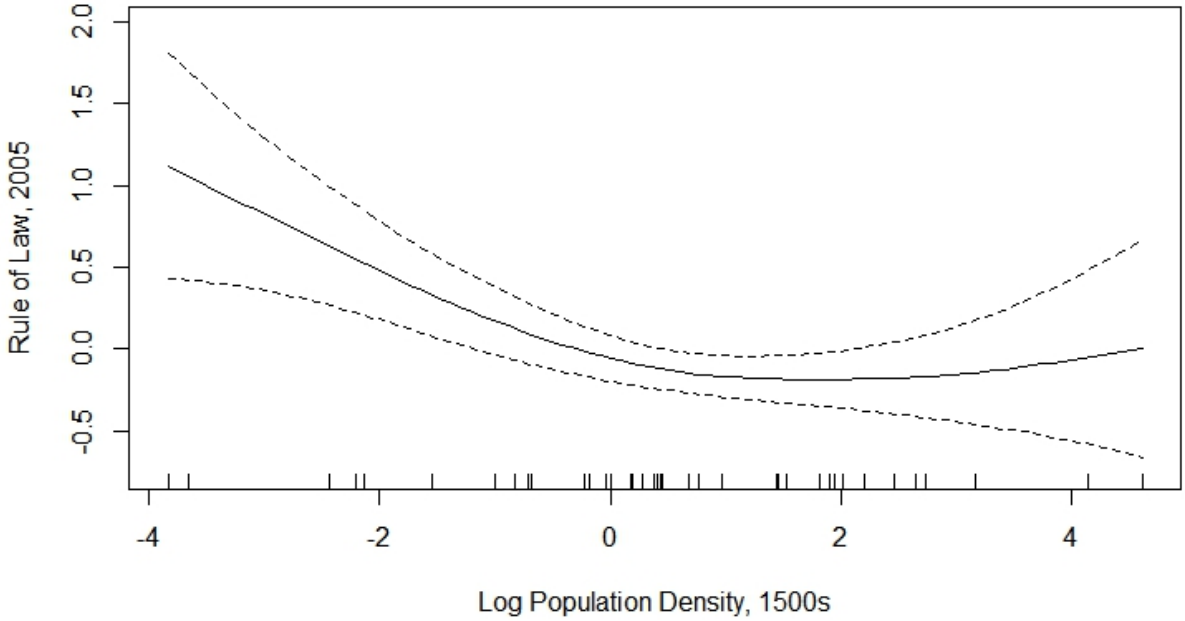


Figure 5: Rule of Law Regressed on Settler Mortality and Population Density



While replicating model 4 in table 6 of the AGR paper (in which the authors control for all dummy variables for continent, protestant missionaries, colonial origins and latitude), as with their linear model, we found that the coefficient for rule of law remained higher than that for education even when we changed the model to a quadratic function, as suggested by the above GAM plots. As in the linear regression, the results using the quadratic model were still statistically insignificant. These are illustrated in Table 2, as noted earlier.

When we updated the data to use 2014 GDP values, we replicated the linear model in table 6 using this information as well. But, interestingly here, the results were flipped, That is, education had a higher coefficient than rule of law. Also, the coefficient for education was significant while the coefficient for rule of law was not. Using the quadratic model, the result is the same. That is, the education coefficient remains larger than the rule of law coefficient. The coefficient for education was statistically significant while that for rule of law was not. These results might be due to the fact that many low-income post-colonial states experienced rapid growth and industrialization within the 2005 to 2014 period. For example, Sri Lanka (a former British colony) experienced sharp growth in garment manufacturing and the IT services industry starting after the end of the Sri Lankan civil war in 2009.[26] As discussed previously, these sectors require a higher level of education. Their growth and impact on GDP are also more impacted by recent labor laws than by Sri Lanka's colonial legacy regarding property rights institutions. This evidence further supports our initial finding that the significance of rule of law as an instrumental variable for development is lost over time. Using the quadratic model, not only does rule of law lose its significance with the addition of control variables used by the authors, but also, the

[26] Arguably, the fastest growing industry in Sri Lanka is tourism, but the IT services and garment industries are also significant in this respect.

education coefficient, whose statistical significance remains robust to the addition of control variables, becomes larger than rule of law.

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