Legal Origin from Outer Space

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Abstract

This article advances the debate over legal origins by using satellite imagery of nighttime lights as a proxy for economic activity and by employing geographic regression discontinuity analysis to control for observable and unobservable factors correlated with location, such as climate and culture. The basic legal structure of most countries was imposed by colonial powers, but Great Britain, France and other European nations did not colonize in a random way. The lack of random assignment means that simple cross-country analysis may lead to erroneous conclusions because of unobservables correlated with legal origin. Regression discontinuity analysis is especially promising for Africa, because many borders were drawn in Europe by diplomats and bureaucrats who had only the haziest knowledge of local conditions, except in coastal areas. As a result, borders split ethnic groups, and areas on either side of the border are similar along observable dimensions and presumably on unobservable ones as well. By comparing African border regions with the same ethnic group on both sides, but which have civil law on one side and common law on the other, or where one side was colonized by one European country (e.g. Britain) and the other side by another (e.g. France or Portugal), one can partially disentangle the influence of law and other colonial policies, controlling for geography, climate, and pre-colonial culture. Analysis suggests that countries with common law legal origin do not perform consistently better than those with civil law.

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1 Introduction

This article advances the debate over legal origins by taking into account the non-random way legal regimes were spread. The basic legal structure of most countries was imposed by colonial powers, but Great Britain, France and other European nations did not colonize randomly. Britain was the dominant world power from at least the mid-eighteenth century, and it used that power to colonize many of the places that were most promising from an economic perspective. It is not a coincidence that the British took control of South Africa's vast mineral wealth (even though most of the country was initially colonized by the Dutch), while France colonized the Sahara, including countries that are today Mauritania, Mali, Niger, and Chad. The lack of random assignment of colonies to European powers means that simple cross-country analysis may lead to erroneous conclusions because of unobservables correlated with legal origin.

This article takes into account the non-random character of the colonization process by adopting a geographic regression discontinuity approach and focusing on Africa. While the colonization process was not random, the borders between African colonies and their successor states were largely arbitrary. The great powers drew most borders with only the haziest knowledge of local conditions, except in coastal areas. The borders they drew were often straight lines (as between Mozambique and Zambia) or followed natural features (such as lakes or watersheds). Such boundaries resulted in relatively similar geographic and climatic conditions on both sides of the border. In addition, the boundary lines often split ethnic groups, which meant that the two sides of the border were usually similar culturally as well as in their climate and geography. It is thus plausible to consider the location of the border as exogenous. By focusing on areas close to the border and by analyzing whether and how economic activity changed at the border, one can therefore identify the effect of colonial policies, including law, while holding geography, climate,

and culture constant.

Geographic regression discontinuity analysis of legal origin is made possible by satellite imagery that maps economic activity in roughly one square kilometer units. For about a decade, economists and other social scientists have been using satellite images of nighttime light as a proxy for economic development: the more light detected, the more economic activity. This proxy is especially powerful for Africa, where a key indicator of economic development is the provision and use of electricity: a village with no electrical power will ordinarily be dark at night; a village where only a few rich households have lights will be dim, but a village where nearly everyone has electricity will be relatively bright (Min et al., 2013).

Using nighttime light as a proxy for economic activity not only provides the high-resolution data necessary for geographic regression discontinuity analysis, but it also makes it unnecessary to rely on official, government-generated economic statistics, which are notoriously inaccurate for low-income countries, including most African nations. A further advantage of using night time lights as the primary dependent variable is that there are a wealth of other data that are available on a fine-grained geographic basis. These data include information on climate (such as temperature and rainfall), geography (distance to rivers and other bodies of water), soil quality, and ethnicity. By using these data, we can confirm that conditions on both sides of the relevant borders are indeed similar, and, where they are not, can control for differences.

A key challenge for any analysis of legal origin is disentangling law from other colonial influences. The colonial powers not only set up legal systems, but they established (or did not establish) schools, facilitated (or hindered) missionary activity, and drained (or did not drain) swamps. Even if former British colonies have done better economically than former French or Belgian colonies, it is not obvious that the difference can be attributed to law or legal origin rather than other colonial policies, such as education or

infrastructure construction. In this article, we follow the identification approach in Klerman et al. (2011). While the French always imposed French civil law on their colonies, several other countries (including Portugal and Belgium) had legal systems that were very similar to France's and imposed a variant of French civil law on their colonies. Nevertheless, French, Portuguese, and Belgian colonial policies differed in other significant ways, such as the extent to which they imposed forced labor on their subjects. By examining the differential performance of former French, Portuguese, and Belgian colonies, we can, at least partly, disentangle the effect of legal and non-legal colonial policy. In contrast, the British did not always impose the common law on its colonies. Especially when a colony was conquered from a previous colonial power (such as South Africa from the Dutch), the prior legal system, especially its core property and contract doctrines, were left in place. English law was only imposed gradually and in particular areas, such as corporate law and negotiable instruments (checks). Thus, by examining the difference between British colonies that received the common law and those that were governed by a hybrid of English and other laws, we can partly disentangle the influence of law and other colonial policies.

The debate over legal origins is important, because the literature has provided "a blueprint for policy reform" (La Porta, Lopez-de Silanes and Shleifer, 2008, p. 323). The finding that common law countries generally did better supplied an important argument for the World Bank and other institutions to encourage all countries to adopt policies with the features they saw as best in the common law tradition. Often Shleifer and his coauthors argued, "the direction of such reforms is simply less government intervention" (La Porta, Lopez-de Silanes and Shleifer, 2008, p. 324). In addition, the debate over legal origins implicates fundamental questions about the importance of history, institutions, geography, and colonization. For both theoretical and policy reasons, it is important to understand the relationship, if any, between legal origin and economic performance.

2 Literature

2.1 Night time lights

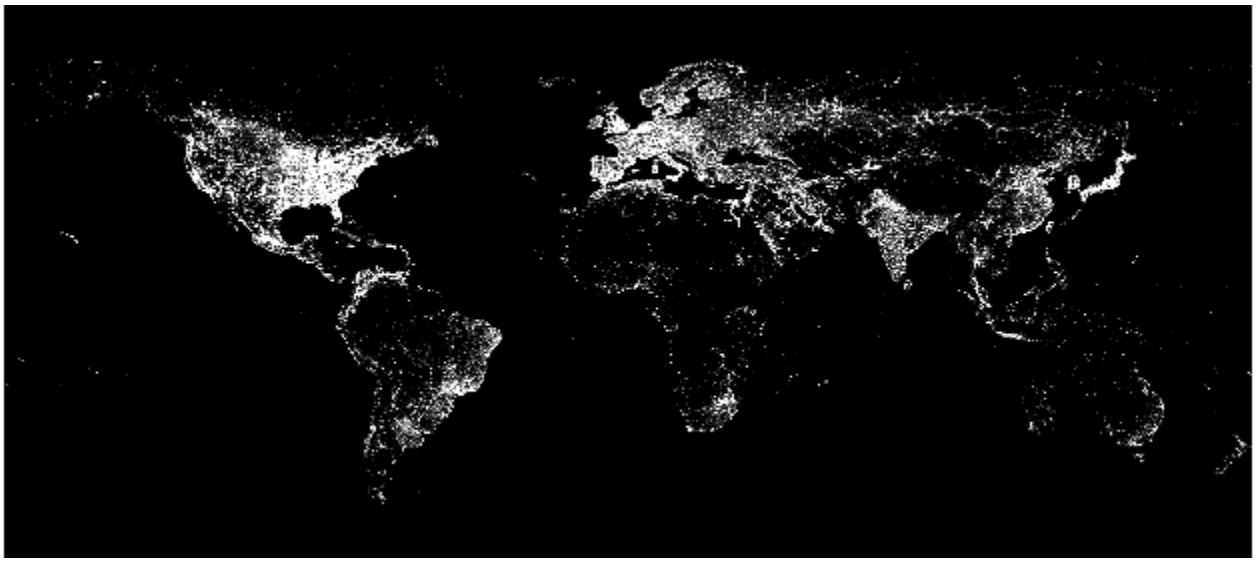
In 1961, the U.S. Defense Department set up the Defense Meteorological Satellite Program (DMSP) to provide weather information for military purposes. In the early years, the key motivation for the program was the desire to predict cloud cover and other weather-related phenomena that would interfere with reconnaissance photography of America's Cold War nuclear adversaries, Russia and China (Hall, 2001). While the system was primarily designed to detect clouds, the Operational Linescan System (OLS) produced fine-grained data on the amount of light emitted from the ground between 8:30 and 10:00 PM (Michalopoulos and Papaioannou, 2013, p. 120). In 1992, data collected from the satellites was declassified and made available to the scientific community. In 1998, control and maintenance of the satellites was transferred to the National Oceanic and Atmospheric Administration (NOAA) (Air, 2017). Light density is measured as an integer between zero and 63. For less developed countries, the main contrast is between pixels with value zero (minimal light) and 1-10 (some light). In major cities in developed countries, maximal values (63) are not uncommon.

Starting in with Paul Sutton and Robert Costanza's pioneering 2002 article, researchers have realized that these satellite nighttime light data could be used to estimate economic activity, especially if corrections were made to account for clouds, lightning, forest fires, gas flares, and similar phenomena (Sutton and Costanza, 2002, p. 512). In fact, nighttime lights have two significant advantages over official government GDP and related statistics. First, official GDP figures can be unreliable, especially in the developing world, where governments often lack the money and expertise to produce high quality statistics. Second, GDP numbers are usually compiled and published on a national basis, or, at best, at the level of large subnational governmental units, like Canadian provinces or

U.S. states. In contrast, the nighttime light data are published at 30 arc second resolution. 30 arc seconds is half an arc minute, and 60 arc minutes make a degree of longitude or latitude. Therefore, near the equator, a resolution of 30 arc seconds is about one square kilometer. Away from the equator, 30 arc second resolution covers a somewhat smaller area. The ability to map economic activity at such a fine resolution makes it possible to analyze local phenomena and to perform the geographic regression discontinuity approach employed in this paper.

The map below shows the global distribution of nighttime lights in 1994-95:

Figure 1: Distribution of Global Night Time Lights



Source: `https://eoimages.gsfc.nasa.gov/images/imagerecords/55000/55167/earth_lights.gif`

The correlation between economic activity and night lights is readily apparent. The eastern US, Europe, Japan, and coastal China are brightly lit. In contrast, the rocky mountain American west, non-coastal South America, and northwest Asia are significantly dimmer. The contrast between North and South Korea is particularly instructive. South Korea looks like an island due north of the southwestern tip of Japan. The land con-

necting South Korea to Russia is economically backward North Korea and thus dark and invisible. Differences in population density cannot account for the darkness of North Korea, because North Korea is more densely populated than Spain or France, both of which are clearly visible. In the map above, Africa seems to be almost entirely dark, but if one focuses just on Africa, differences within Africa emerge, as in the map below.

Figure 2: Distribution of Africa Night Time Lights

Source: `https://eoimages.gsfc.nasa.gov/images/imagerecords/55000/55167/earth_lights.gif`

High levels of economic activity along the Nile (upper right), in South Africa, and in parts of coastal West Africa stand out, while the Sahara is almost entirely dark. Of course, the use of nighttime lights is not without its own problems. Light data measure aggregate economic activity, so without good data on population, they cannot be used to measure

activity per capita. Light data also primarily measure the extent to which a population uses electric lights. That has proved to be a useful proxy for economic activity for low and moderate income countries, but for rich countries, increases in GDP do not correlate with greater use of electric lights. Nevertheless, because this paper focuses on Africa, measuring the extent of electrification is a very useful proxy for economic growth, and, by many accounts, more reliable than official government statistics.

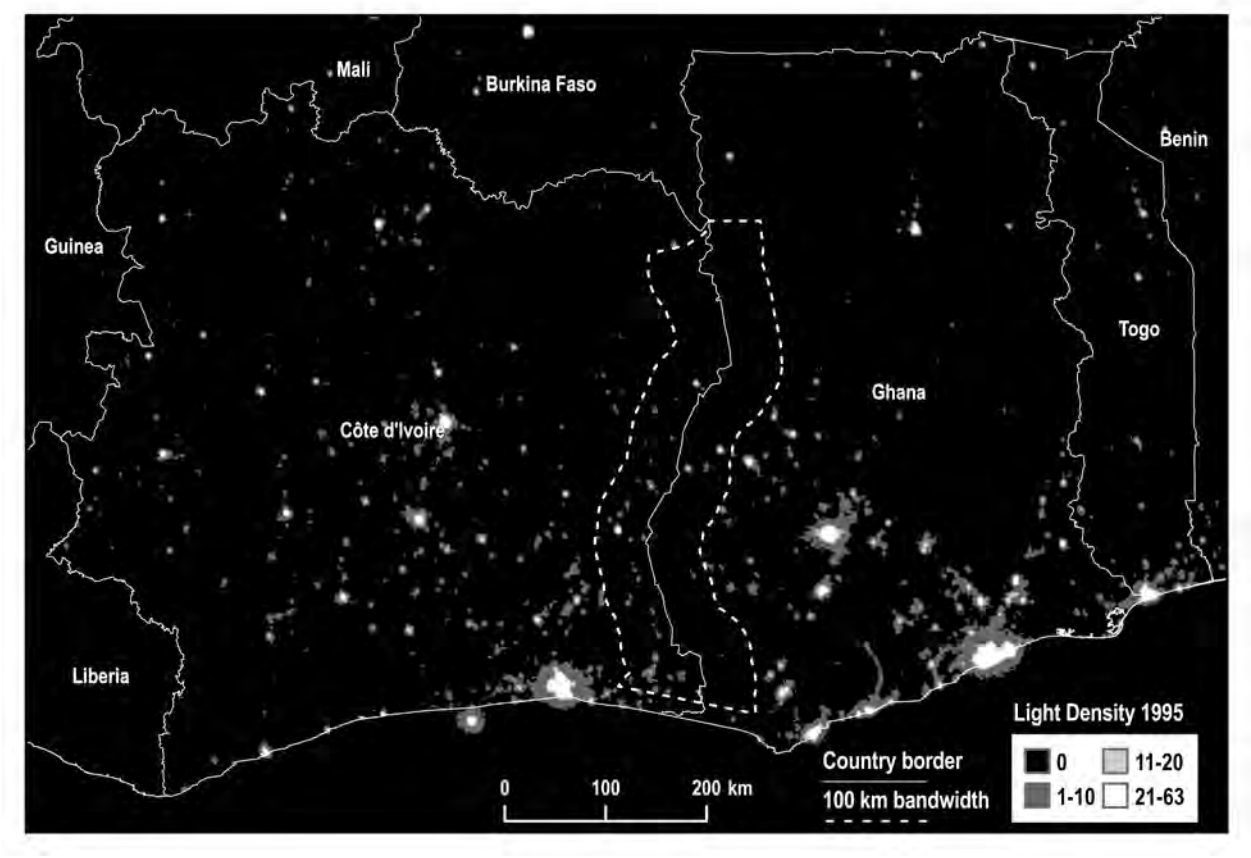
Because this paper focuses on borders, it is helpful to zoom in further. Figure 3 shows nighttime lights in Ghana, Cote-d'Ivoire and neighboring regions. Most of these areas are dark, but a few bright spots (cities) are visible. Fainter spots usually indicate small cities or villages with electricity. Of greatest interest is the area near the border between the Cote d'Ivoire and Ghana. The dotted lines show a 100 kilometer bandwidth (50 kilometers on each side of the border).[1] Cote d'Ivoire is a former French colony whose legal system is founded upon civil law. Ghana is a former British colony whose legal system is usually classified as common law. Most of the area near the border is dark, but the area on the Cote d'Ivoire (civil law) side is a little brighter.

On the other hand, if one looks in Figure 3 at the area near the Ghana-Togo border, there is somewhat more light on the Ghana (common law) side than on the Togo (civil law) side. If one looks at the borders between the Cote d'Ivoire, Guinea, Mali, and Burkina Faso, there is more light on the Cote d'Ivoire side, even though all four of these countries are former French colonies with civil law legal systems. These contrasts encapsulate the main points of this paper. There is no consistent advantage of common law over civil law, and there are considerable differences between countries that have nothing to do with their legal or colonial origins.

Figure 4 below shows a further close-up of one section of the border between Ghana

[1] As discussed below, the 20 km closest to the ocean are excluded from the 100 km bandwidth, because borders in this area are likely to have been drawn with knowledge of local conditions.

Figure 3: Nighttime Lights in the Ghana-Cote d'Ivoire Region, 1995

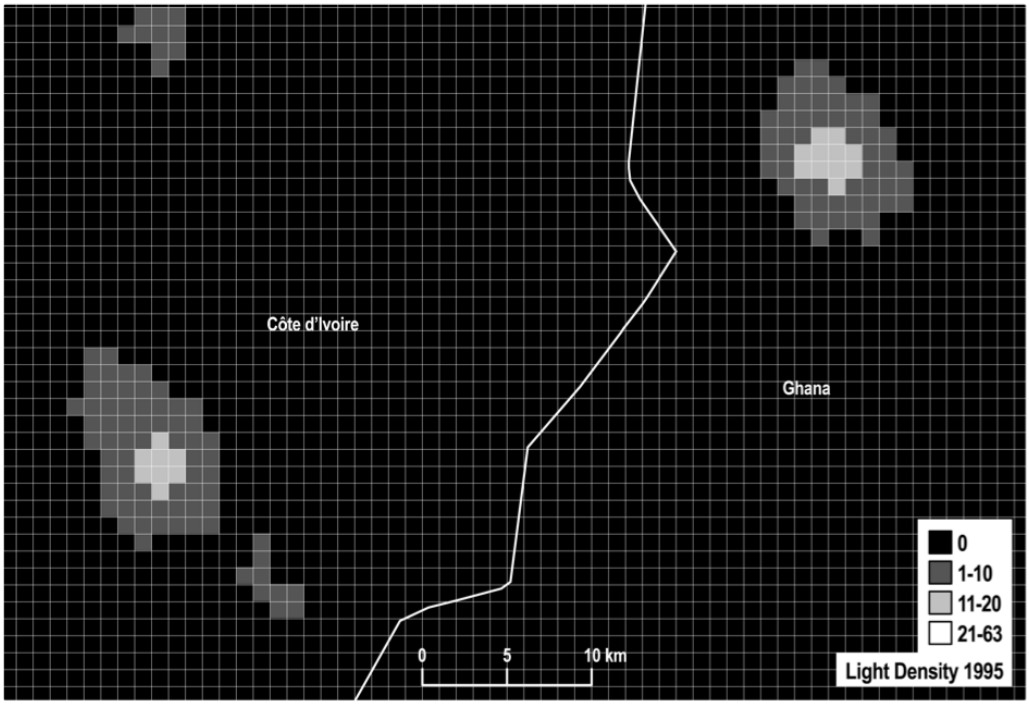


and the Cote d'Ivoire.

Figure 4 shows two medium cities, Agnibilekrou in Cote d'Ivoire and Dormaa Ahenkro in Ghana. Both had tens of thousands of inhabitants. Each square of the grid is roughly a square kilometer, the resolution of the light density data. Both cities had a small brightly light core of about ten square kilometers surrounded by about fifty square kilometers that are moderately lit. Areas outside the cities are almost completely dark.

Numerous studies have analyzed a variety of economic issues using nighttime lights, and several scholars have tested the accuracy of these data as a proxy for economic performance (Henderson, Storeygard and Weil, 2002; Chen and Nordhaus, 2011; Pinkovskiy and Sala-i Martin, 2016). The studies most similar to ours are Michalopoulos and Pa-

Figure 4: Lights in One Section of the Ghana-Cote d'Ivoire Border, 1995



paioannou (2013, 2014) and Pinkovskiy (2017). Michalopoulos and Papaioannou (2013, 2014) use nighttime light data and regression discontinuity analysis to examine the relationship between pre-colonial ethnic institutions and modern economic performance in Africa. In their 2014 article, they examine ethnic groups divided by national borders and investigate whether the quality of national institutions (principally rule of law and corruption) affect the amount of light across the national border. They find no effect. Although their approach is very similar to the one taken in this article, they do not study the effect of legal or colonial origin. In their 2013 article, Michalopoulos and Papaioannou find that the complexity of pre-colonial governments correlates highly with the amount of nighttime light and thus economic performance. Ethnicities that lacked "any form of centralized political organization," do worse today than those which were organized into "paramount chiefdoms," while those that were "part of large states" do best now

(Michalopoulos and Papaioannou, 2013, pp. 119, 126-131). Pinkovskiy (2017) uses nighttime lights to document the importance of national borders and thus of national policies and institutions. For example, he examines the difference in growth rates between eastern European nations that joined the European Union in the early 2000s (such as Poland and Romania) and those that did not (such as Ukraine and Moldova). He finds that there are often discontinuities in growth rates as measured by changes in nighttime light across borders, including borders in Africa. He also finds that differences in growth rates are better predicted by measures of rule of law than by education, trust, or infrastructure quality. Pinkovskiy (2017) therefore shares two key features with the approach in this paper: regression discontinuity analysis at modern state borders and explanation of differences in terms of national institutions. Unlike our analysis, however, he does not analyze legal origin or other colonial institutions.

2.2 Legal Origin

Starting in the late 1990s, an important literature in economics has documented pervasive correlations between economic outcomes, legal rules, and legal origin. In this literature, legal origin means whether a country's legal system is based on British common law, or French, German, or Scandinavian civil law (La Porta, Lopez-de Silanes and Shleifer, 2008). This literature argued that common law countries had better protection for investors and therefore larger capital markets, freer labor markets and therefore lower unemployment, better guarantees of judicial independence and therefore stronger property rights. The source of the common law advantage was either the flexibility derived from greater judicial discretion or the purportedly greater support the common law provided for free markets. Critics, however, pointed out that the principal articles in this literature miscoded key variables, including variables measuring the extent of investor protection and legal origin itself (Spamann, 2010; Klerman et al., 2011).

One strand of the legal-origin literature analyzed economic growth as its dependent variable. Mahoney (2001) showed that common law countries, on average, had higher GDP growth. Klerman et al. (2011) confirmed that finding, but argued that the superior performance of common law countries could be better explained by non-legal colonial policies, such as education. It also suggested, but could not definitively demonstrate that the common law advantage might reflect the non-random character of colonization, a hypothesis explored more intensively in this paper.

A recent article (Anderson, 2018), like this one, uses a regression discontinuity approach to analyze the effect of legal origin in sub-Saharan Africa. It concludes that the common law's weaker protection for female marital property rights led to higher rates of HIV infection.

2.3 Comparative Colonialism

The debate over legal origin is, at least in Africa, part of a long-standing debate about differences between colonial powers. Although Portugal and Belgium also had significant colonies in Africa, most of the debate has been about British and French colonialism and has focused on West Africa, where British and French colonies existed in close proximity. Early literature stressed differences in governance. The British formally adopted a policy of "indirect rule," which meant that they governed through existing chiefs and sought to "conserve what was good in indigenous institutions and [to] assist them to develop along their own lines" (Crowder, 1964, p. 198). While the French also ruled through chiefs, they undermined traditional authority by selecting as chiefs those who had learned French and had "rendered services to the French cause." Chiefs in French colonies were "reduced to . . . a mouthpiece for orders emanating from outside" (Crowder, 1964, p. 200). The French policy was initially to "assimilate" Africans to French culture and governance, and, although the policy of "assimilation" was replaced with a policy of

"association," even that newer policy had tendencies that aimed to teach Africans how to be good Frenchmen (Crowder, 1964, p. 200-202). Crowder's view on the differences between French and British colonial governance was challenged by those who argued that, in practice, the two colonizers were indistinguishable. By necessity, the French relied on traditional chiefs, and, in fact, the policy of "association" was very close to the British practice of indirect rule (Deshamps, 1963).

Even those, such as Crowder (1968), who stressed differences between the French and British politically, saw little difference between the two colonial powers in the economic sphere. Both French and British colonies were "subjected to an administrative system whose avowed purposes were to bring the material as well as the spiritual 'benefits' of Europe to the African, but saw these not in terms of the rational development of these colonies in their own interest, but in the interest of the mother country" (Crowder, 1968, p. 274).

A more recent strand of scholarship has taken a different approach and seems to conclude that British colonialism had better economic effects. Asiwaju (1976), Miles (1994), and Welch Jr. (1966) devoted entire monographs to a single ethnic group that had been divided by colonial and modern boundaries. Asiwaju (1976) examined the Yoruba, who straddle the border that is currently between Nigeria and Benin. Miles (1994) studied the Hausa, who live on both sides of the boundary between modern Nigeria and Niger. Welch Jr. (1966)) studied the Ewe, who were split between British and French colonies in lands now ruled by Ghana, Togo, and Cameroon. All three authors found that those who lived on the British side of the border did much better economically. For the Hausa, Miles (1994, p. 184) found, "whereas the British encouraged indigenous cultivation through free labor, the French implemented state control of production with compulsory cultivation." The resulting differences in economic growth led Hausa to consider villages on the Nigerian (British) side as "incarnating . . . wealth and good fortune," while viewing those on

the French side as places of "suffering and poverty" Miles (1994, p. 176). For the Yoruba, Asiwaju similarly concluded:

> The history of Western Yorubaland under colonial rule bore out the wisdom shown in the policy arguments of the British in West Africa, arguments that recall those of Adam Smith in support of free against slave labour; that in the development and exploitation of the sylvan and agricultural resources of colonies, indigenous cultivation should be preferred to controlled production as a method (Asiwaju, 1976, p. 173).

Of course, while this recent strand of literature tends to find that British colonialism had superior (or at least less deleterious) economic consequences, its hallmark is intensive study of relatively small areas. It would be improper to generalize to all of Africa based on three studies, all of which relate to Western Africa. In addition, these studies do not attribute economic differences to characteristics most often associated with the contrast between common and civil law. They emphasize the negative effects of forced labor and the benefits of liberal trading policies, rather than the effects of precedent, juries, or codes. On the other hand, the differences highlighted by Miles (1994), Asiwaju (1976), and Welch Jr. (1966) accord with La Porta, Lopez-de Silanes and Shleifer (2008, p. 286)'s "broad conception of legal origin as a style of social control of economic life [where] common law stands for the strategy of social control that seeks to support private market outcomes, whereas civil law seeks to replace such outcomes with state-desired allocations."

The conclusions of this more recent literature, which is historical and ethnographic in character, have been only partially confirmed by quantitative approaches. Bertocchi and Canova (2002) employed a cross-country regression approached and found that former British colonies in Africa grew faster than former French colonies. In contrast, Bubb (2013) analyzed adjacent areas of Ghana (a former British colony) and the Cote d'Ivoire (a former French colony) using regression discontinuity analysis. He found little difference between the strength of property rights near the border, even though formal law

in Cote d'Ivoire provided stronger protection. To the extent that there were differences in property rights, they were explained by soil suitability for cocoa production, a high value export crop. Areas suitable for cocoa developed stronger property rights, in accordance with Demsetz's (1967) theory that increases in land value lead to stronger property rights institutions. Bubb's work shares with this paper the use of regression discontinuity analysis to control for unobservable local variations, and his finding that soil quality was more important than law echoes the conclusion of this paper that, once one controls for geography and the non-random character of the colonization process, legal origin has little explanatory power.

3 Data and Methods

3.1 Data and Case Selection

This paper analyzes sixty-eight borders. These are nearly all the borders between sub-Saharan African countries.[2] A small number of borders was excluded because one or both of the relevant countries had legal origins or colonial history that would not fit into the categories used in our analysis.[3] Areas within 20 kilometers of the coast were also excluded, as borders in these regions were drawn with good knowledge of local conditions and therefore are not exogenous.

These borders share two important characteristics. First, the borders we examine were

[2]Sub-Saharan countries are those which, at least in part, are south of the Sahara. Our analysis thus excludes countries that border the Mediterranean (such as Algeria and Egypt) and Western Sahara. These countries have a radically different history from the remainder of Africa – including incorporation into the Roman and Ottoman empires – making their exclusion appropriate. Our analysis includes countries such as Niger and Mauritania, even though most of their territory is in the Sahara, because they have some territory south of the Sahara.

[3]Borders involving Liberia, Eritrea, and Ethiopia were omitted because these countries were not colonized. Borders involving Namibia were omitted because it was ruled by South Africa from 1920 to 1970. Borders involving Cameroon were omitted because it was formed the merger of French and British colonies. Somalia was omitted because it was formed by the merger of Italian and British colonies. Djibouti was excluded, because its only borders are with countries that are excluded (Eritrea, Ethiopia, and Somalia)

drawn mostly arbitrarily, in line with the empirical strategy that we propose. Second and relatedly, the borders show no obvious differences that privilege one side or the other with geographic endowments that would spur economic development. Covariate balance tests, described in greater depth in the next section, confirm that the areas on both sides of the border are similar in terms of key geographic variables.

This project combines geographic information, satellite data, and ethnicity maps with legal and colonial origin data. These data come from a variety of sources and allow us to test the effect of legal and colonial origins on contemporary economic development.

3.1.1 Geographic and Nighttime Satellite Data

The research design for our study requires fine-grained spatial data to measure economic development and geographic variables. The nighttime satellite data comes from NOAA's National Centers for Environmental Information Earth Observation Group (National Centers for Environmental Information Earth Observation Group, 2019). Although 1992 was the first year that satellite data was made available to the public, we focus on data from 1995, an early year where we find the data to be more reliable, and from 2013, the most recent year the data is available. The resolution of the data is 30 arc-seconds, which is approximately one square kilometer at the equator, but smaller as one approaches the poles.[4] The luminosity variable reports a composite created by overlaying all images for the calendar year, dropping images where clouds, the aurora, solar glare, lightning or fires would have distorted the data (Michalopoulos and Papaioannou, 2013). It should be noted that there are a number of shortcomings of luminosity data. Chen and Nordhaus (2011) point out some of the problems with using nighttime light data, but

[4] A "square" grid cell measuring 30 arc-seconds on a side measures 922 m by 928 m on the ground at the Equator (i.e. 0°latitude) and has an area of 0.86 km^2. A "square" grid cell measuring 30 arc-seconds on a side at 34°S, near the southern tip of Africa, measures 922 m north-south and 768 m east-west and has an area of 0.71 km^2.

nevertheless, they conclude that luminosity data have informational value, especially for regional analyses conducted in areas with poor data collection, which describes much of Africa.

The GMTED 2010 global digital elevation model (DEM) at 30-arc-second resolution (Danielson and Gesch, 2011) was the reference dataset used to construct a grid of cells for the African continent. Subsets of grid centroids were selected by country for subsequent analysis, and were used to extract other raster values and as origins for distance variables.

The topographic ruggedness index (TRI) is a measure of local topographic relief derived from the DEM; the TRI calculated residuals (i.e. elevation differences) between a grid cell and its eight neighbors to capture terrain variability.

WorldClim2 precipitation and temperature datasets (Fick and Hijmans, 2017) are 30-year annual averages created using thin-plate splines and covariates to interpolate raster surfaces from weather station observations.

GHS-POP population distribution and density data (European, 2015) approximate the number of people per grid cell; for these, GPWv4 residential population estimates (CIESIN; Center for Informational Earth Science Information Network) were disaggregated from census or administrative units and allocated to pixels, informed by the distribution and density of built-up areas as mapped in the Global Human Settlement Layer for the corresponding timeframe (Center for Informational Earth Science Information Network, 2018).

For geospatial analysis and modelling, conversions are often made between vector and raster data to combine them appropriately, with vector data interpolated to a gridded raster surface. Our models incorporate raster datasets which originated as both pixel-based and non-pixel-based data: nighttime lights, elevation, and terrain ruggedness are composites or derivatives of remotely-sensed data. Temperature, precipitation, and population data are interpolated from point-based observations or counts by unit.

3.1.2 Legal and Colonial Origin Data

Legal origin was initially coded by La Porta, Lopez-de Silanes and Shleifer (2008). That coding was extended and corrected by Klerman et al. (2011), who also coded for colonial origin, where colonial origin is the dominant colonial power in the period before independence. Table 1 shows the coding that we used to classify the legal and colonial origin of the 38 countries in our data set. Figure 5 maps the countries and borders.

Table 2 categorizes the sixty-eight border pairs by the legal and colonial origin of each border pair. There are eleven common law/French civil law borders, eleven common law/non-French civil law borders, five non-French civil law/French civil law borders, three borders between mixed law and non-French civil law countries, and one border between a common law and a mixed law country. As can be seen in the lower half of the table, there are also a large number of borders between countries with the same legal and colonial origin.

Following Klerman et al. (2011), we isolate the effect of colonial from legal origin by exploiting the imperfect overlap of colonial and legal origin. We exploit the variation in colonizers that brought civil law, since civil law was imposed not only by the French, but also by other colonizers in Africa such as Belgium and Portugal. Belgium, Portugal, and Spain imposed versions of the civil law on their colonies that were very similar to that which the French imposed. Similarly, we take advantage of the "mixed" legal regimes in Botswana, Eswatini (formerly Swaziland), Losotho, South Africa, and Zimbabwe, which were governed by a combination of British common law and Dutch civil law. By examining a similar legal regime (French civil law) imposed by different colonizers (France, Belgium, Spain, and Portugal) and by analyzing different legal regimes imposed by the same colonizer (mixed law and common law, both imposed by Britain), it is possible to partially disentangle the effect of law from other policies instituted by the colonial powers (such as education, religion, health, etc.).

Table 1: Legal and Colonial Origin for Sample Countries

		Legal Origin		
		Common Law	Civil Law	Mixed Law
Colonial Origin	Britain	Gambia (GMB) Ghana (GHA) Kenya (KEN) Malawi (MWI) Nigeria (NGA) Sierra Leone (SLE) South Sudan (SSD) Sudan (SDN) Tanzania (TZA) Uganda (UGA) Zambia (ZMB)		Botswana (BWA) Eswatini (SWZ) South Africa (ZAF) Lesotho (LSO) Zimbabwe (ZWE)
	France		Benin (BEN) Burkina Faso (BFA) Central African Republic (CAF) Chad (TCD) Cote d'Ivoire (CIV) Gabon (GAB) Guinea (GIN) Mali (MLI) Mauritania (MRT) Niger (NER) R. of Congo (COG) Senegal (SEN) Chad (TCD) Togo (TGO) Benin (BEN)	
	Belgium		Burundi (BDI) D. R. Congo (COD) Rwanda (RWA)	
	Portugal		Angola (AGO) Guinea-Bissau (GNB) Mozambique (MZO)	
	Spain		Equ. Guinea (GNQ)	

Figure 5: Map of Legal and Colonial Origin

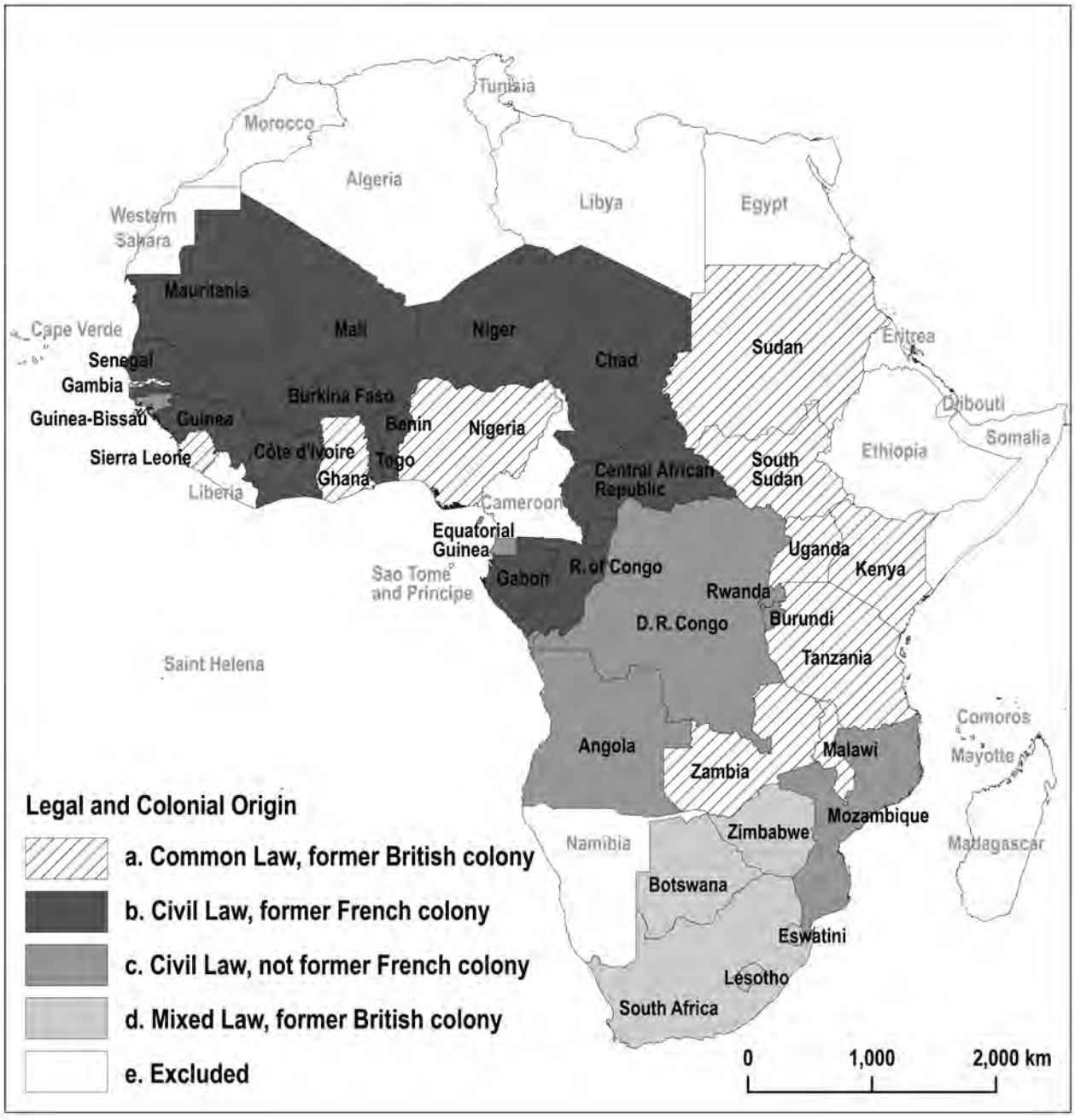


Table 2: Borders by Legal and Colonial Origin

Common Law and Civil Law, French	**Common Law and Civil Law, Not French**	**Civil Law, Not French and Civil Law, French**	**Mixed Law and Civil Law, Not French**	**Common Law and Mixed Law**
Gambia-Senegal	Malawi-Mozambique	D.R. Congo-C.A.R.	Eswatini-Mozambique	Zambia-Zimbabwe
Ghana-Burk. Faso	S. Sudan-D.R. Congo	D.R. Congo-Congo	S. Africa-Mozambique	
Ghana-Cote d'Ivoire	Tanzania-Burundi	Eq. Guinea-Gabon	Zimbabwe-Mozambique	
Ghana-Togo	Tanzania-D.R. Congo	Gin. Bissau-Guinea		
Nigeria-Benin	Tanzania-Mozambique	Gin. Bissau-Senegal		
Nigeria-Chad	Tanzania-Rwanda			
Nigeria-Niger	Uganda-D.R. Congo			
S. Sudan-C.A.R.	Uganda-Rwanda			
Senegal-Guinea	Zambia-Angola			
Sudan-C.A.R.	Zambia-D.R. Congo			
Sudan-Chad	Zambia-Mozambique			
Both Common Law	**Both Civil Law, French**	**Both Civil Law, Not French**	**Both Mixed Law**	
Kenya-S. Sudan	Benin-Burk. F.	Angola-D.R. Congo	Botswana-S. Africa	
Kenya-Tanzania	Benin-Niger	Burundi-D.R. Congo	Botswana-Zimbabwe	
Kenya-Uganda	Benin-Togo	Burundi-Rwanda	Lesotho-S. Africa	
Malawi-Tanzania	Burk. F.-Cote d'Ivoire	D.R. Congo-Rwanda	S. Africa-Eswatini	
Malawi-Zambia	Burk. F.-Mali		S. Africa-Zimbabwe	
S. Sudan-Sudan	Burk. F.-Niger			
S. Sudan-Uganda	Burk. F.-Togo			
Tanzania-Uganda	C.A.R.-Congo			
Tanzania-Zambia	Chad-C.A.R			
	Congo-Gabon			
	Cote d'Ivoire-Guinea			
	Cote d'Ivoire-Mali			
	Guinea-Mali			
	Guinea-Senegal			
	Mali-Mauritania			
	Mali-Niger			
	Mauritania-Senegal			
	Niger-Chad			
	Senegal-Mali			

3.1.3 Ethnicity Data

Our identification strategy relies partly on the anthropological work of George Murdock, who mapped ethnic groups in the last half of the nineteenth century (Murdock, 1959). This aspect of our identification strategy was also used by Michalopoulos and Papaioannou (2014). Specifically, we focus on regions where contemporary national borders split the same ethnic group. Thus, we can analyze the effect of different colonizers and their imposition of legal institutions on people with very similar cultural backgrounds.

Figure 6 shows the boundaries of ethnic groups as mapped by Murdock (1959), with

Figure 6: Ethnic and National Boundaries

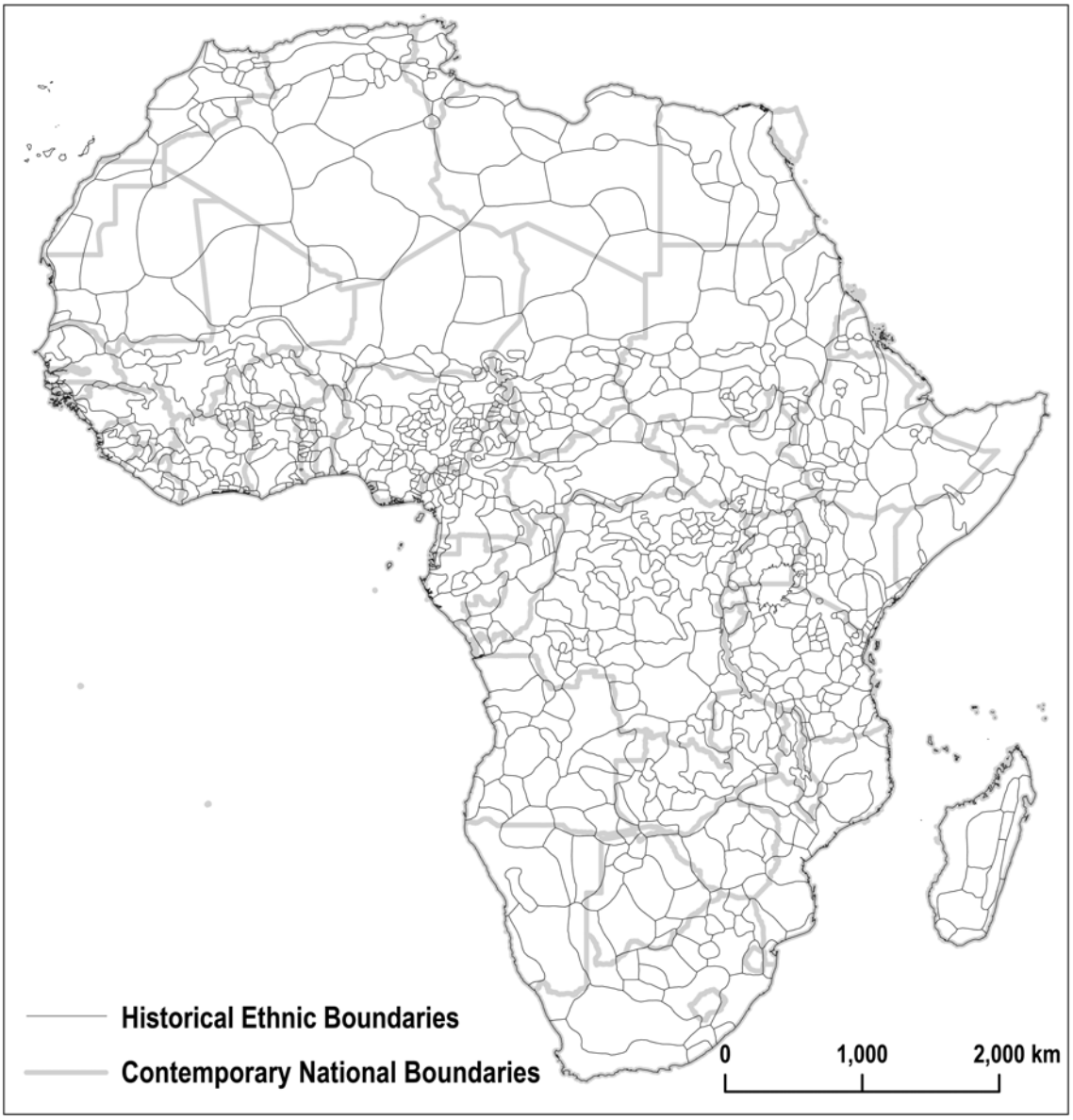
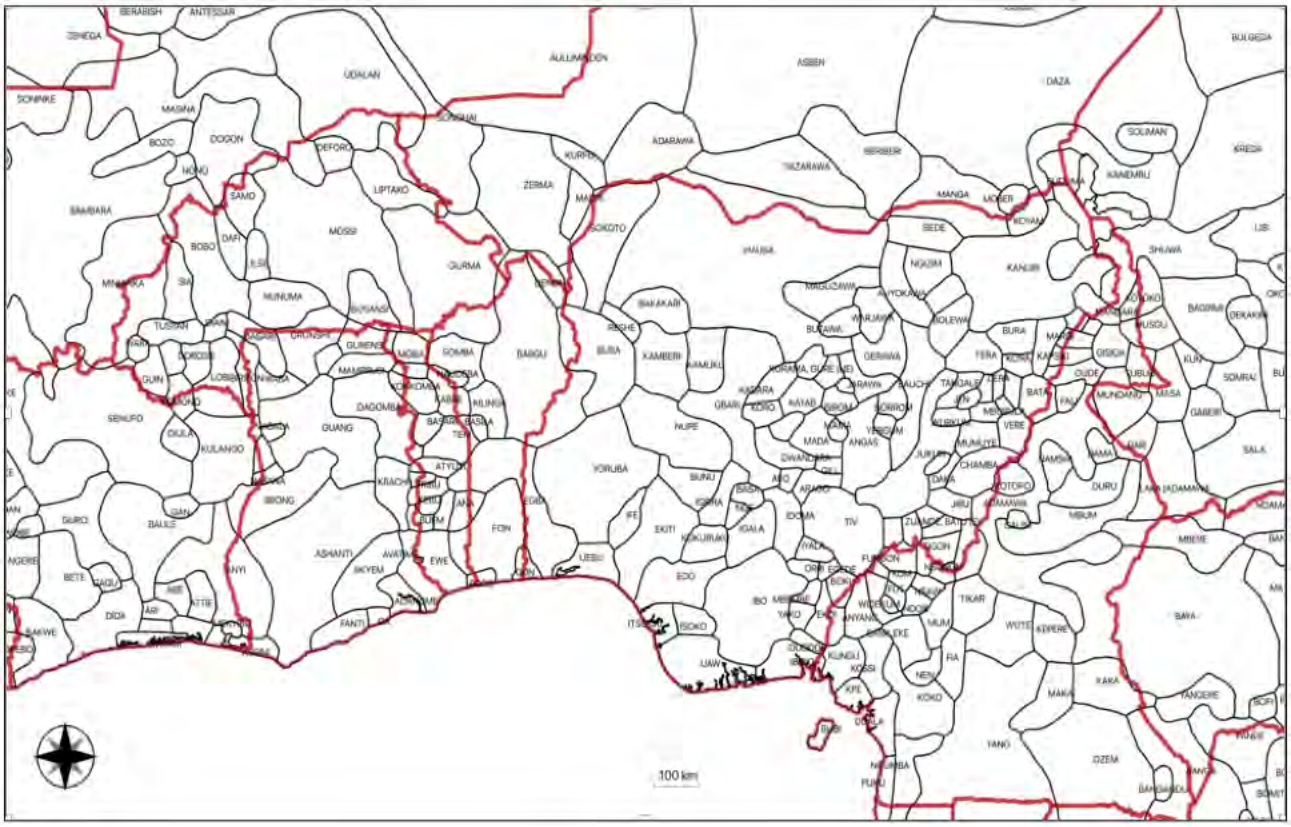


Figure 7: Ethnic and National Boundaries, West Africa



contemporary national borders superimposed, and Figure 7 shows a close up of West Africa, where the ethnicities are labeled and the way state borders divided ethnic groups is patent. In our primary specification, we analyze all areas where the same ethnic group was partitioned by a modern the border. In some cases, there are multiple ethnic groups split by the same contemporary border, which increases the external validity of our findings, since we are able to measure the impact of colonial and legal origin on economic development for multiple ethnic groups.

3.1.4 Summary Statistics

Table 3 below provides summary statistics for all variables used in this paper. Most of the means are unremarkable, but it is notable that both light density and logged light density per capita increased between 1995 and 2013.

3.2 Empirical Strategy

In the natural experiment we are exploiting, the reliability of causal inference rests on the assumption of "as-if" random assignment of the treatment at the border (Dunning, 2008; Keele and Titiunik, 2015; Mattingly, 2017). For our study, this would involve an actor drawing borders arbitrarily so that those living close to the border on one side were similar to those on the other side of the border, except for the treatment. We employ three important checks to ensure the presence of this "as-if" random assignment. First, we conduct covariate balance checks across a host of bandwidths to see if geographic variables show statistically and substantively distinguishable differences. Second, we exclude areas closer to the ocean, because these borders were more likely to be drawn with knowledge of local characteristics. Third, where possible, we examine historical sources to substantiate the random drawing of the border (Ajala, 1983; Brownlie, 1979; Touval, 1966).

3.2.1 Covariate Balance and Causal Inference Validity

The validity of our identification strategy depends on the location of borders not being influenced by circumstances that affect economic development (Angrist and Pischke, 2008; Michalopoulos and Papaioannou, 2014). In addition, areas across the border should be similar in determinants of economic development. These issues are discussed in greater detail throughout this section.

Table 3: Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	p25	Median	p75	Max
Light Density 1995	4,781,459	0.08	1.26	0.00	0.00	0.00	0.00	63.00
Light Density 2013	4,781,459	0.17	1.86	0.00	0.00	0.00	0.00	63.00
Ln(Light Density 1995+0.01)	4,781,459	-4.54	0.64	-4.61	-4.61	-4.61	-4.61	4.14
Ln(Light Density 2013+0.01)	4,781,459	-4.50	0.85	-4.61	-4.61	-4.61	-4.61	4.14
Population 1990	4,781,459	24.53	466.81	0.00	0.00	0.00	0.00	131,327[a]
Population 2000	4,781,459	31.21	515.10	0.00	0.00	0.00	0.00	152,337
Population 2015	4,781,459	46.82	688.91	0.00	0.00	0.00	0.00	217,594
Ln((Light Density 1995+0.01)/Population))	581,523	-6.73	3.03	-16.11	-8.70	-7.07	-5.50	8.32
Ln((Light Density 2013+0.01)/Population))	497,162	-7.78	2.74	-16.38	-9.64	-8.01	-6.58	11.07
Common Law	4,781,459	0.28	0.45	0.00	0.00	0.00	1.00	1.00
Civil Law, Not French	4,781,459	0.20	0.40	0.00	0.00	0.00	0.00	1.00
Mixed Law	4,781,459	0.12	0.32	0.00	0.00	0.00	0.00	1.00
Elevation (m)	4,781,459	653.35	461.47	0.00	317.00	508.00	945.00	5,778.00
Ruggedness	4,781,459	18.34	28.76	0.00	3.98	9.07	18.56	535.88
Average Annual Temperature (°C)	4,781,360	24.43	3.52	-5.13	22.19	24.87	27.26	30.74
Average Annual Precipitation (mm)	4,781,360	934.32	511.97	6.00	545.00	963.00	1,272.00	3,379.00
Distance to Capital (m)	4,696,753[b]	584,187	406,258	307	295,081	474,392	775,728	1,939,428

Notes. All statistics are for areas within 100 km of the 68 borders analyzed in this paper. The population in Ln(Light Density 1995 + 0.01/Population) is the average of the 1990 and 200 population. The Population in Ln(Light Density 2013 + 0.01/Population) is the 2015 population.[c] The omitted legal/colonial variable is "Civil Law, French," whose mean value is 0.41.

[a] This population value and the two below it are too high. We are investigating the source of the error.

[b] We are investigating why several thousand observations are missing from this variable.

[c] We are investigating alternative interpolation techniques.

First, as we previously mentioned, the extant historical literature shows that the colonizers drew African borders in an arbitrary or "quasi-random" manner. Asiwaju (1984), Wesseling (1996), Herbst (2000), and Engelbart (2009) provide reviews of this literature, while Michalopoulos and Papaioannou (2014) discuss the implications for geographic regression discontinuity analysis. A well-documented historical literature suggests that settlers and colonizers created "spheres of influence" on the continent without the intention of creating colonies. When they later expanded these spheres of interest into colonies, they did so without much information about the characteristics of the territories they were dividing. The main exception was areas close to the coast, where the colonizing powers knew the terrain well. The situation is admirably described by Lord Salisbury, British Prime Minister at the time of the partition of West Africa:

> We have been engaged in drawing lines upon maps where no white man's foot ever trod; we have been giving away mountains and rivers and lakes to each other, only hindered by the small impediment that we never knew exactly where the mountains and rivers were.[5]

These aspects of the historical record are borne out in statistical tests. Appendix Table A shows the covariate balance for four covariates for the legal/colonial origin border types that include all sixty-eight borders in our study at the 100 kilometer bandwidth. These covariates – elevation, ruggedness,[6] average precipitation, and average temperature – ensure that neither side of the border had particular geographic advantages that would assist with their economic development.[7] For the most part, there are no substantively distinguishable differences in these covariates across the borders. Note that we emphasize substantive differences. Because of the large number of observations, we have

[5] Lord Salisbury, cited in Asiwaju (1984, pp. 18-19).

[6] The topographic ruggedness index as proposed by Riley, DeGloria and Elliot (1999) is the average elevation change between the center cell in a three-by-three cell moving window and the eight cells immediately surrounding it. Nunn and Puga (2012) argue that ruggedness impeded the slave trade and led to favorable long-term outcomes.

[7] Future iterations will include about a dozen geographic covariates.

very high statistical power and so are able to obtain statistical significance at conventional levels in all of the balance specifications we run. Nevertheless, both common sense and climatology suggests that small differences (such as an additional twenty meters in elevation or a few centimeters of extra precipitation per year) are unlikely to matter. So we take into account not only statistical significance, but the sorts of differences that geographers and climatologists consider important when classifying regions or delineating them on maps. The table shows the results at standard bandwidths of 100 kilometers based on the extant literature (Michalopoulos and Papaioannou, 2013). All border types have less than a 20 meter mean difference in elevation, with the exception of one border type – the border between Mixed Law and Non-French Civil Law, which has a mean difference of 244 meters. This difference is being driven by the one border we have for that category – the Zambia-Zimbabwe border. The large differences for that border extend to the other three covariates. The differences for all other variables for all other border types appear to be balanced, with mean differences in the ruggedness index not exceeding more than 2 points on a 4,367-point scale where baseline means range from 10.2 to 34.1. Similarly, mean differences for average temperature are 1 degree Celsius and for average precipitation are less than 39 millimeters per year. The one border type that shows some imbalance on average participation are borders where both countries are former British colonies with mixed legal origins, which have a mean difference of 109.6 millimeters, relative to a baseline mean of 630.7 millimeters per year. Taken together, with the exception of the Non-French Civil Law-Mixed Law former British border, which is comprised of one country pair, the results are largely balanced on the covariates.

For robustness, we ran the covariate balance for a wider range of bandwidths and found the balance is largely stable across a wide range of bandwidths for the country borders in the data set.[8] In the current version of the paper, we have not excluded any

[8]Results available from authors upon request.

borders based on covariate imbalance. As we investigate further whether some cross-border differences are substantively meaningful, we may exclude a few borders from our analysis.

Covariate balance can also be seen more informally with satellite imagery. Consider Figure 8 below, which shows much of Western Africa. It is apparent that Niger (a French colony) is largely desert (tan), while Nigeria (a former British colony) has a mostly tropical savanna climate (much greener). Nevertheless, if one focuses on the areas close to the border between Nigeria and Niger, for example the 100km bandwidth indicated by the dotted lines, they are similar.

3.2.2 Estimation

We rely on two primary approaches to estimate the results in this paper: difference-in-means and GRD estimation. Difference-in-means tests require few assumptions, and allow for the straight-forward and transparent assessment of the design and results (Mattingly, 2017, p. 448). We also estimate the results using a local linear approach relying on ordinary least squares regression. Specifically, we estimate the following equation:

$$y_i = \alpha + \beta T_i + \eta X' + \gamma_i + \epsilon. \tag{1}$$

The dependent variable, y_i, reflects the level of economic activity in the geographic area as measured by light activity at night. We have three dependent variables at the pixel level of substantive interest: (1) a continuous measure of light density; (2) the log of light density, adding a small number to avoid the problem of taking the log of zero, ($y_i \equiv ln(0.01 + LightDensity_i)$), and (3) the log of light density (plus a small number) divided by population, where population is greater than zero. The first outcome provides a measure of light density with an untransformed outcome; the second outcome, by using

Figure 8: Satellite Image of Western Africa, 2019

Source: Google Maps

a log transformation, accounts for outliers and uses all of the data; while the last outcome provides a sense of economic development per capita. T_i is a treatment indicator coded by the legal origin of the country, and X' is a matrix of control variables that includes a rich set of key covariates such as elevation, ruggedness, average temperature, average precipitation, and distance to the capital. The distance to the capital is a proxy for central government control, as much of the literature shows that, all else equal, law enforcement and policy implementation more generally declines as distance from the capital increases (Michalopoulos and Papaioannou, 2014, pp. 190-196). We include fixed effects for all but

one legal/colonial origin type, with French civil law as the omitted category. We also include border pair and ethnic group fixed effects, captured by the term γ_i.[9] β is the quantity of interest, which gives the local average treatment effect (LATE) that we are seeking to estimate.

For specifications with ethnic groups, we cluster on the border pair and the ethnic group relying on a multiway clustering approach developed by Cameron, Gelbach and Miller (2011). This approach is used in order to mitigate the concern of spatial autocorrelation, and has been incorporated in similar designs by Nunn and Wantchekon (2011) and Michalopoulos and Papaioannou (2013, 2014). To improve the precision of our estimates, we include specifications with covariates.[10]

4 Results

4.1 Graphical Analysis by Border

The simplest way of showing the effects of legal and colonial origins across borders is graphically. Figure 9 shows the average difference in light across representative borders. The horizontal axis shows the bandwidth in kilometers. A bandwidth of 100 kilometers (indicated by a vertical dotted line) means analysis of the 50 kilometers on either side of the border. The vertical axis shows the difference in light. As discussed above, light intensity is measured on a scale from 0 to 63, but in Africa, ninety-nine percent of areas are unlit, and the average lit area has light density of ten. So a difference of 0.5 (the maximum on all graphs but the shaded ones in the lower right-hand corner) means that, on average, one more pixel out of twenty was lit on one side of the border (assuming aver-

[9] For specifications that are for the entire borders, we drop ethnic group fixed effects.

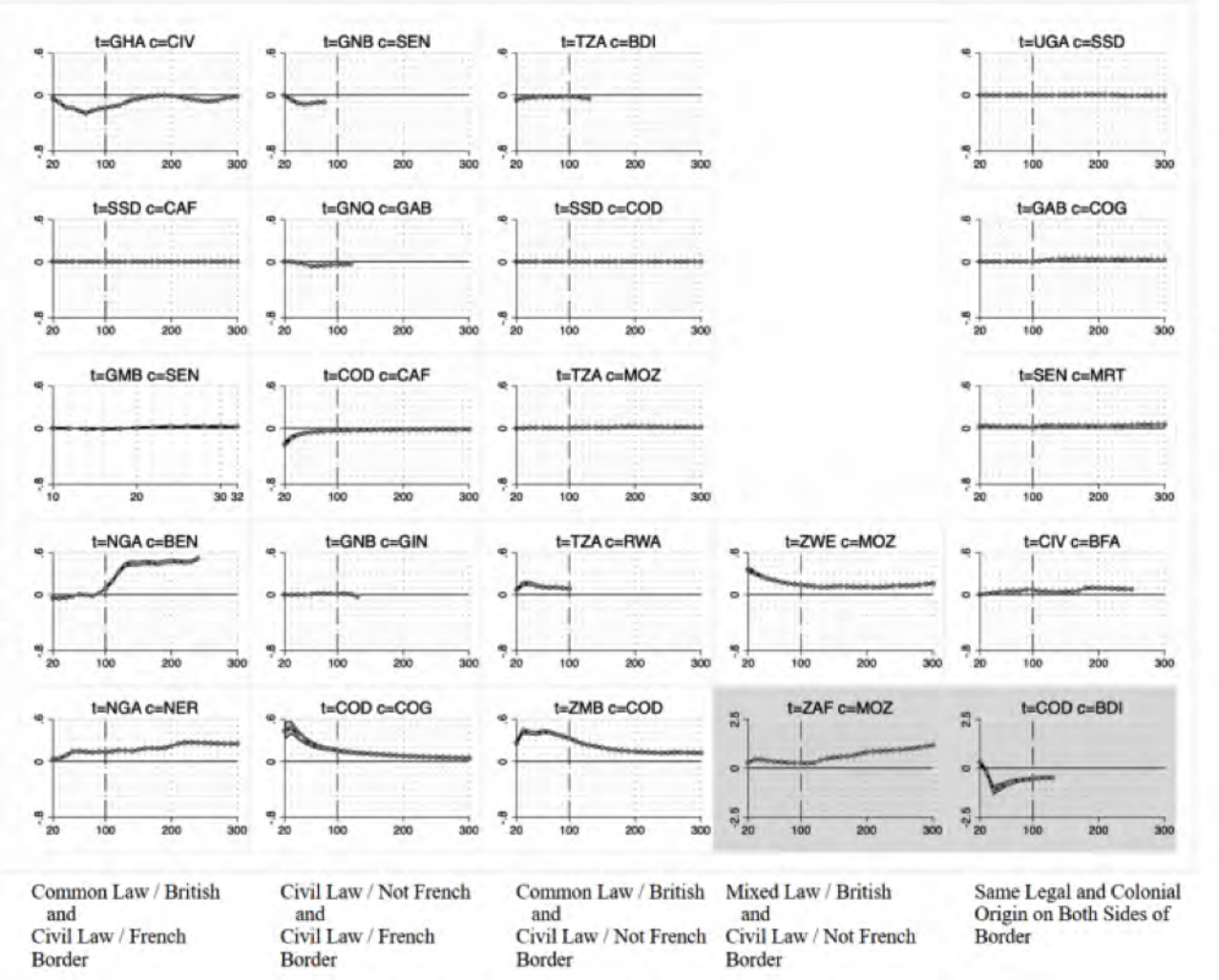
[10] Covariates used in this version are average elevation, average annual precipitation, average annual temperature, distance to capital, and terrain ruggedness (Riley, DeGloria and Elliot, 1999; Nunn and Puga, 2012).

age light value of ten). Treatment and control were chosen so that positive values (graph above the horizontal axis) indicate a result consistent with the hypothesis that common law legal origin and/or British colonial heritage resulted in more light and thus better economic performance, and/or that French colonialism and/or civil law led to less light. That assignment of treatment and control was not possible for the last column, where legal and colonial origin were the same, so "treatment" is just the country whose name is later in the alphabet. Positive and negative coefficients in the last column therefore have no direct implications for legal or colonial origins, but merely show the magnitude of the differences across the border.

The first column of five graphs is for borders between common law countries (which are all former British colonies) and civil law countries that were colonized by France. The five borders were chosen to be representative of the eleven borders between such countries. The top graph, for Ghana (GHA) and Cote d'Ivoire (CIV), depicts the border which, at a 100 kilometer bandwidth, shows the largest French civil law advantage in terms of light. The bottom graph, for Nigeria (NGA) and Niger (NER), represents the border where the common law country had biggest advantage. The three graphs in between represent the twenty-fifth percentile, median, and seventy-fifth percentile. It is notable that only the extremes (top and bottom graphs, Ghana-Cote d'Ivoire and Nigeria-Niger) show any effect for bandwidths less than 100 kilometers. It is also notable that there are outliers on both extremes, showing that sometimes common law countries do better, but also sometimes civil law countries do better. Altogether, the graphs show little evidence that the common law provides economic benefits.

It is also notable that the two outliers have both been the subject of single-border studies discussed above. Miles (1994) studied the Nigeria-Niger border and found that economic conditions were much better on the British side, which is consistent with the light analysis in Figure 9. Of course, the analysis here suggests that that border is atypical, as

Figure 9: Average Nighttime Lights Near Borders, 1995



Notes: The horizontal axis is the bandwidth of the analysis in kilometers. The vertical axis shows the difference in average light intensity between the two sides of the border. Except in the last column, positive values (graphs above the horizontal axis) mean results consistent with the hypothesis that common law and/or British colonialism is associated with more light, and that civil law and/or French colonialism is associated with less light. Shaded background indicates a different scale for the vertical axis.

that is the border with the largest difference in light among all eleven borders between former French and British colonies. Bubb (2013) examined property rights on the Ghana-Cote d'Ivoire border and found little difference, a fact that may be surprising, given the greater light density on the Cote-d'Ivoire side, which one might think would be correlated with stronger property rights. In any case, the examination in this paper of multiple borders helps put the single-border studies in perspective. While single-border studies have the advantage of richer in-depth analysis, there is a danger in generalizing from borders that seem to be outliers.

The second column of graphs in Figure 9 is similar to the first column, except that it examines representative borders involving civil law countries that were colonized by France and civil law countries that were colonized by countries other than France. Positive values (plots above the horizontal axis) indicate that the country that was colonized by a country other than France had more nighttime light. Again, the main result from these graphs is that, except for the outliers (top and bottom panels) there is hardly any effect. This is contrary to Klerman et al. (2011), which found that, among civil law countries, those that had been colonized by France generally did worse in terms of economic development. This may reflect the fact that Klerman et al. (2011) involved a worldwide sample, where non-French colonizers included the Netherlands and Spain, whose former colonies have done relatively well since independence. In contrast, in Africa, the dominant non-French colonizers that imposed civil law were Belgium and Portugal, which were known for particularly brutal and exploitative colonial policies. It is not surprising that those countries have not, in general, outperformed former French colonies.

The third column of graphs in Figure 9 shows the effect of light at borders between common law countries (colonized by the British) and civil law countries colonized by countries other than France. There are only five such borders, so all are depicted. Here there is some evidence of a common law advantage, in that both at the 75th percentile

(Tanzania (TZA)/Rwanda (RWA)) and at the maximum (Zambia (ZMB)/Democratic Republic of Congo (COD)) the common law side of the border had more light, as indicated by the fact that the graph of the graph is above the horizontal axis. Although this is consistent with the legal origin hypothesis, it is notable that Rwanda and the Democratic Republic of Congo were both former Belgian colonies, and their weaker performance probably reflects the lingering effect of King Leopold's brutal colonial policies rather than differences between civil and common law. The fact that the effects in these two graphs are so much bigger than the effects in the corresponding graphs in the first column also reinforces the view that it was not law but other colonial policies that made a difference. After all, the graphs in both columns contrast civil and common law. The only difference is that in the first column, the civil law countries had been colonized by France, whereas in the second column, the civil law countries had been colonized by Belgium, Portugal, or Spain. If legal origin were the key determinant of economic performance, the graphs in the first and third columns should look similar. The fact that they do not suggests that factors other than legal origin are more important.

The fourth column shows light at the border between mixed law former British colonies and civil law countries that were formerly not French colonies. Unfortunately, there are only three such borders, and all involve Mozambique, so results should be interpreted with caution.[11] The mixed law, British sides of the borders are much brighter. The bottom panel – South Africa (ZAF)/Mozambique (MOZ) – is on a gray background to highlight the fact that the scale had to be different to accommodate the much larger difference in light. Although the Zimbabwe/Mozambique border fits on the same scale, it shows among the largest effects in Figure 9. The fact that there is a larger contrast between

[11]The border between Eswatini and Mozambique was inadvertently left out. It will be included in future revisions of the paper. It would show much more light on the Eswatini (mixed law) side of the border, which is consistent with results for the other two borders between mixed law and civil law countries not colonized by France.

mixed law and civil law (column 4) than between common law and civil law (columns 1 and 3) is inconsistent with the legal origins hypothesis.

The last column depicts borders where the countries on both sides have the same legal and colonial origin. For example, the countries in the top panel – Uganda (UGA) and South Sudan (SSD) – are both former British colonies whose laws are (at least in part) based on the common law. The countries in the second highest panel – Gabon (GAB) and Congo (COG) – were both French colonies and both have civil law legal systems. For all but the bottom panel, the graphs in this fourth column are essentially flat, indicating that there is little difference between the two sides of the border. This suggests that legal and colonial origin do have some predictive power. Countries with the same legal and colonial origin tend to have similar levels of economic development, at least near the border and as measured by nighttime lights. Such borders are less likely to show differences in economic development than those where legal and/or colonial origins are different.

Figure 9 does not show borders between former French colonies with civil law and former British colonies with mixed law, because there are no such borders. Figure 9 also does not show borders between former British colonies with mixed law and former British colonies with common law, because there is only one such border (Zambia/Zimbabwe). Lights are brighter on the Zimbabwe (mixed law) side, which is again inconsistent with the legal origins hypothesis. The hypothesis noted above, that countries with the same legal and colonial origin tend to have similar levels of economic development is largely confirmed by Table 4, which shows the average absolute value of the difference in light across different types of borders in 1995 at the 100 kilometer bandwidth:

The average difference in light between bordering common law countries was 0.032, which is smaller than the difference in light between bordering common law countries and civil law countries (whether former French colonies or not) and mixed law countries (0.066 and 0.071). Similarly, the average difference in light between bordering civil law

Table 4: Absolute Value of Difference in Light Density Across Borders, 100km, 1995

	Common Law	Civil Law, French	Civil Law, Not French	Mixed Law
Common Law	0.032			
Civil Law, French	0.066	0.019		
Civil Law, Not French	0.071	0.069	0.235	
Mixed Law	0.071	None	0.198	0.195

countries that were former French colonies was 0.019, which is smaller than the difference in light between civil law countries that were not French colonies or countries that had common law (0.066 and 0.069). The pattern breaks down a bit when one considers civil law countries that were not French colonies and mixed law countries, but that probably reflects the fact that there are fewer such borders, so one or two outliers have a large effect. The fact that borders between mixed law and between civil law, not former French colonies sometimes show larger differences in light also reflects the fact that these two categories – civil law, not French, and mixed law – are by their nature more heterogeneous. For example, the civil law, not French category, includes both former Belgian colonies and former Spanish colonies.

4.2 Pooled Regressions for Partitioned Ethnicities

While the graphs show the heterogeneity of the borders vividly, it is also worthwhile to explore differences across borders using a regression framework because regression analysis allows more rigorous testing of whether there are differences overall across borders depending on legal and colonial origin. In general, consistent with the graphical analysis, we find no consistent common law advantage or other legal origin effect.

We start with what we consider our strongest set of regressions. In these regressions, we restrict our analysis to areas with ethnicities that straddle borders. By doing so, we

essentially hold culture constant across the border, bolstering our identification. Thus, for example, our regressions consider those parts of Nigeria and Niger that were inhabited by the Hausa in the colonial period and that are close to the border. Conversely, the regressions exclude areas of Nigeria and Niger that were inhabited by ethnicities present only on one side of the border. This analysis has the downside of excluding some observations, but we believe the gains in identification outweigh the loss in sample size. Nevertheless, we show in the next section that results are broadly similar when one considers all areas close to borders, regardless of ethnicity.

Table 5 displays regression results with light density as the dependent variable, and Table 6 shows results with light density per capita. The first two models in Table 5 have a linear specification with unlogged light density as the dependent variable. The omitted legal/colonial origin category is Civil Law, Former French Colony, so the first three coefficients reflect differences from that category. Common Law and Mixed Law have positive coefficients, indicating better performance for countries that were former British colonies, whether they received common law or a mixture of common and civil law. The coefficient for Common Law reaches conventional levels of statistical significance, but the coefficient for Mixed Law is not statistically significant. The magnitudes are rather small. As noted above, light density varies from zero to 63, but in Africa ninety-nine percent of pixels are zero (unlit) and the average lit pixel is about ten. Thus a coefficient of 0.09 (such as for common law in 1995) would mean that, as compared to civil law countries that were former French colonies, on average, an additional nine out of one thousand pixels (square kilometers) were lit on the common law of the border, assuming lit pixels had an average light value of ten. The differences are also small when compared to the differences in other studies of Africa, such as Michalopoulos and Papaioannou (2013), which found that light density "in the homelands of ethnicities that were part of centralized states before colonization is 0.993" compared to light densities of about 0.3 for homelands that were

Table 5: Regressions with Light Density as the Dependent Variable from Ethnically Homogenous Regions

Dependent Variable	**Light Density**		**Ln(Light Density+0.01)**			
Year	1995	2013	1995	2013	1995	2013
Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Common Law	0.089*	0.140**	0.048*	0.068*	0.034	0.048
	(0.046)	(0.067)	(0.026)	(0.038)	(0.023)	(0.037)
Civil Law,						
Not French	-0.055	-0.066	-0.052	-0.041	-0.032	-0.015
	(0.075)	(0.083)	(0.032)	(0.040)	(0.033)	(0.035)
Mixed Law	0.085	0.062	0.079**	0.033	0.116**	0.084
	(0.068)	(0.100)	(0.040)	(0.055)	(0.048)	(0.059)
Elevation					-0.000	-0.000
					(0.000)	(0.000)
Precipitation					0.000*	0.000
					(0.000)	(0.000)
Temperature					-0.007	-0.007
					(0.023)	(0.032)
Ruggedness					-0.000	-0.000
					(0.000)	(0.000)
Distance to Capital					-0.000	-0.000
					(0.000)	(0.000)
Constant	-0.319***	-0.202	-4.695***	-4.658***	-4.476***	-4.420***
	(0.099)	(0.173)	(0.032)	(0.055)	(0.637)	(0.910)
Obs.	4,390,760	4,390,760	4,390,760	4,390,760	4,388,522	4,388,522
R^2 adjusted	0.027	0.037	0.058	0.065	0.060	0.068

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$

Notes. All regressions with border country pair and ethnic group fixed effects and with Cameron, Gelbach and Miller (2011) standard errors clustered on border country pair and ethnic group. The dropped legal/colonial origin category is Civil Law, French. Some of the covariates are collinear, so we ran permutations of the covariates, and the results did not change substantially. We also ran the same specifications with a second-order polynomial for the distance to the border, and the results, which are available from the authors, are virtually identical.

"stateless," petty chiefdoms," or "paramount chiefdoms." The contrasts in Michalopoulos and Papaioannou's article therefore involve differences of about 0.7 in light density which is an order of mangitude higher than those in Table 5.

The fact that the coefficient on Civil Law, Not French is small and not statistically significant indicates that there is little difference between civil law countries formerly colonized by France and those formerly colonized by Belgium, Portugal, and Spain. This contrasts with Klerman et al. (2011), which found that civil law countries that were colonized by countries other than France tended to do better. As noted above, the difference probably reflects the fact that, in Africa, one of the key non-French colonizers was Belgium, which was notorious for its harshly exploitative colonial policy. It is probably not a coincidence that two out of the three former Belgian colonies, Rwanda and the Democratic Republic of Congo, have had major civil wars. Nevertheless, former Belgian colonies are only half of the six countries in the "Civil Law, Not French" category, so this category is rather heterogeneous, and it is not surprising that the coefficient is not statistically significant, although in some other specifications (below) it is.

The Mixed Law coefficient is similar to the Common Law coefficient for 1995, but much smaller in 2013, and neither is statistically significant, making it difficult to disentangle the effect of law from that of British colonization.

The results for 1995 and 2013 are similar, although the Common Law coefficients are, surprisingly, usually a little larger in 2013. One might have expected that the effect of legal and colonial origin would attenuate over time, but instead, they seem to intensify.

Models 3 and 4 present results for a logged specification. Such a specification is appropriate because most light density values are less than 10, but there are a few observations with light density up to 63. A logged specification reduces the potential influence of a few outlying observations. The results are similar, although the r-squareds more than double and the Mixed Law coefficient is now statistically significant for 1995.

Models 5 and 6 add covariates to the logged specifications. The signs remain the same, but all coefficients become smaller, except, oddly, Mixed Law in 1995. The fact that the Mixed Law coefficient is now much larger than the Common Law coefficient is inconsistent with the legal origins hypothesis, which would predict that mixed law countries would have economic performance in between those of civil and common law. It is reassuring that the coefficients on the covariates, except temperature, are essentially zero, and that adding covariates increases r-squareds by only a tiny amount. This confirms the covariate balance analysis in section 3.2.1.

Table 6 shows results with light density per capita. Just as it is usually better to measure economic performance with GDP per capita, so it is better here to use light per capita. Because of the skewed distribution of this variable, a logged specification is again appropriate. The Common Law coefficients are now negative, but not statistically significant. The negative coefficients suggest that French civil law countries performed better economically than common law countries, but, since none of the coefficients are statistically significant at conventional levels, one should not make too much of the negative sign. In fact, the only coefficient in Table 6 that is statistically significant is Civil Law, Not French for 2013, which is negative and of high magnitude. As mentioned above, this probably reflects the poor economic performance of former Belgian colonies, such as the Democratic Republic of Congo. The covariates in regressions 3 and 4 are tiny and do not meaningfully change the results, except, as noted above, for Civil Law, Not French. [Note. We are investigating why the r-squareds and number of observations are surprisingly high for Models 1 and 3.]

4.3 Pooled Regressions for Entire Borders

We consider the regressions in the prior section to be the most informative because, by analyzing only ethnicities that straddle borders, they hold culture constant and thus allow

Table 6: Regressions with Logged Light Density Per Capita as the Dependent Variable from Ethnically Homogenous Regions

Dependent Variable	**Ln((Light Density+0.01)/Population)**			
Year	1995	2013	1995	2013
Variable	Model 1	Model 2	Model 3	Model 4
Common Law	-0.401	-0.286	-0.232	-0.122
	(0.283)	(0.353)	(0.268)	(0.299)
Civil Law, Not French	0.278	-0.496	-0.080	-1.172**
	(0.455)	(0.581)	(0.419)	(0.515)
Mixed Law	-1.685	-0.182	-1.774	-0.502
	(1.353)	(0.873)	(1.133)	(0.645)
Elevation			0.000	-0.001
			(0.001)	(0.001)
Precipitation			-0.001**	-0.000
			(0.000)	(0.000)
Temperature			0.051	-0.139
			(0.094)	(0.153)
Ruggedness			0.001	0.001
			(0.001)	(0.001)
Distance to Capital			0.000**	0.000***
			(0.000)	(0.000)
Constant	-14.947***	-10.503***	16.792***	-7.132*
	(0.678)	(0.899)	(2.688)	(4.308)
Obs.	794,487	455,664	794,428	455,577
R^2 adjusted	0.726	0.390	0.729	0.396

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$

Notes. All regressions with border country pair and ethnic group fixed effects and with Cameron, Gelbach and Miller (2011) standard errors clustered on border country pair and ethnic group. The dropped legal/colonial origin category is Civil Law, French. Some of the covariates are collinear, so we ran permutations of the covariates, and the results did not change substantially. Observations with zero population are excluded from the analysis, both because it does not make sense to measure economic activity per capita where population is zero, and because it is not possible to divide by zero. We also ran the same specifications with a second-order polynomial for the distance to the border, and the results, which are available from the authors, are virtually identical.

fderor better identification. Nevertheless, it is also worthwhile to consider all areas close to the border, regardless of whether the area is populated by an ethnicity also present across the border. Doing so allows us to include more areas and provides support for external validity.

Table 7 displays regression results with light density as the dependent variable, and Table 8 shows results with light density per capita. The first two models in Table 7 have linear specification with unlogged light density as the dependent variable. The results are similar to regression discussed above for divided ethnicities. Common Law and Mixed Law have positive coefficients, indicating better performance for countries that were former British colonies, whether they received common law or a mixture of common and civil law. The Common Law coefficients are both statistically significant, but only one of the Mixed Law coefficients is. The coefficient on Civil Law, Not French is small, negative, and not statistically significant.

Models 3 and 4 present results for a logged specification. The results are similar, although statistical significance for the common law variables is marginal.

Models 5 and 6 add covariates. For Common Law and Civil Law, Not French, this causes the coefficients to become closer to zero and to become less statistically significant. For Mixed Law, adding covariates strengthens the effects and the statistical significance. It is reassuring that the coefficients on the covariates are all tiny.

Table 8 shows results with light per capita. Like the regressions restricted to partitioned ethnicities, the Common Law coefficient is negative, but not statistically significant at conventional levels. The coefficients on the Civil Law, Not French and Mixed Law variables do not have consistent signs and are never statistically significant, suggesting that legal and colonial origin has little explanatory power once one takes population into account. Adding covariates does not change the main result – no statistically significant differences between legal and colonial origin categories. As in Table 7, the coefficients on

Table 7: Regressions with Light Density as the Dependent Variable

Dependent Variable	**Light Density**		**Ln(Light Density+0.01)**			
Year	1995	2013	1995	2013	1995	2013
Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Common Law	0.0705**	0.1102**	0.0379*	0.0509*	0.0254	0.0315
	(0.0337)	(0.0451)	(0.0217)	(0.0279)	(0.0198)	(0.0282)
Civil Law,						
Not French	-0.0273	-0.0338	-0.0350	-0.0254	0.0039	0.0357
	(0.0518)	(0.0527)	(0.0263)	(0.0277)	(0.0295)	(0.0329)
Mixed Law	0.1489***	0.1377	0.1154***	0.0880	0.1373***	0.1232*
	(0.0484)	(0.0901)	(0.0395)	(0.0549)	(0.0493)	(0.0693)
Elevation					-0.0001**	-0.0002*
					(0.0001)	(0.0001)
Precipitation					0.0001**	0.0002**
					(0.0000)	(0.0001)
Temperature					-0.0150	-0.0191
					(0.0111)	(0.016)
Ruggedness					-0.0002	-0.0005
					(0.0003)	(0.0004)
Distance to Capital					0.0000**	0.0000**
					(0.0000)	(0.0000)
Constant	0.0533**	0.1299***	-4.5579***	-4.5173***	-4.1513***	-4.0084***
	(0.0206)	(0.0238)	(0.0118)	(0.0149)	(0.3032)	(0.4411)
Obs.	4,781,459	4,781,459	4,781,459	4,781,459	4,696,654	4,696,654
R^2 adjusted	0.0006	0.0005	0.0013	0.0007	0.0034	0.0036

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Notes. All regressions with border country pair fixed effects and with standard errors clustered on border country pair. The dropped legal/colonial origin category is Civil Law, French. Some of the covariates are collinear, so we ran permutations of the covariates, and the results did not change substantially. We also ran the same specifications with a second-order polynomial for the distance to the border, and the results, which are available from the authors, are virtually identical.

Table 8: Regressions with Logged Light Density Per Capita as the Dependent Variable

Dependent Variable	**Ln((Light Density+0.01)/Population)**			
Year	1995	2013	1995	2013
Variable	Model 1	Model 2	Model 3	Model 4
Common Law	-0.4491	-0.2845	-0.0072	-0.1644
	(0.3622)	(0.3687)	(0.4048)	(0.3716)
Civil Law,				
Not French	0.1721	-0.2291	-0.8813	-0.5221
	(0.6889)	(0.6657)	(0.7744)	(0.6166)
Mixed Law	-1.0782	0.5313	-1.2899	0.2874
	(0.9468)	(0.8911)	(0.8007)	(0.8023)
Elevation			-0.0002	0.0002
			(0.001)	(0.0008)
Precipitation			-0.0029***	-0.0011**
			(0.0009)	(0.0005)
Temperature			-0.0953	0.0480
			(0.197)	(0.1361)
Ruggedness			0.0001	0.0017
			(0.0021)	(0.1361)
Distance to Capital			0.0000**	0.0000***
			(0.000)	(0.0000)
Constant	-6.4594***	-7.6944***	-2.7302	-8.3586***
	(0.2174)	(0.3059)	(5.7383)	(3.7502)
Obs.	581,523	497,162	563,020	478,433
R^2 adjusted	0.0049	0.0014	0.1145	0.0150

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Notes. All regressions with border country pair fixed effects and with standard errors clustered on border country pair. The dropped legal/colonial origin category is Civil Law, French. Some of the covariates are collinear, so we ran permutations of the covariates, and the results did not change substantially. Observations with zero population are excluded from the analysis, both because it does not make sense to measure economic activity per capita where population is zero, and because it is not possible to divide by zero. We also ran the same specifications with a second-order polynomial for the distance to the border, and the results, which are available from the authors, are virtually identical.

the covariates are very small, although sometimes statistically significant.

5 Caveats and Limitations

Although the empirical strategy deployed in this article has notable strengths, it is also important to discuss its weakness and limitations.

It is possible that legal origin makes a difference only for major urban areas, which are generally far from the border. If this is the case, then regression discontinuity would underestimate or completely fail to detect the positive effect of the common law. While this is possible, it also seems implausible. The last forty years of Chinese economic history show the importance of property rights and incentives for economic development in rural as well as urban areas. If the common law was really better at securing property rights and providing free-market incentives, the effects should be apparent in rural as well as urban areas.

It is also possible that legal origin is not important for Africa because, from colonial times to the present, customary and Islamic law have remained important parts of the legal system. While this is true, it is also true for nearly all of the world except Europe and the settler colonies, such as the United States and Australia. Proponents of the legal origin hypothesis have argued for its near universal application, and an argument that it does not apply where customary or Islamic law are important would sharply contract the relevance of legal origin.

An explanation related to the prior two is that governments in most of Africa are so weak that official law has little effect outside the capital or major urban centers. In those areas, customary law, Islamic law, and unofficial institutions dominate. This would suggest that our analysis is not capturing the effect of common or civil law, because those laws are not really enforced near the border. This would be consistent with Michalopou-

los and Papaioannou (2014), who find that governmental institutions decline in influence with distance from the capital. On the other hand, (Anderson, 2018) finds effects of legal origin on property rights and HIV even close to the border.

It is also possible that spillover effects mute the effect of legal origin when measured at the border. Perhaps the common law truly leads to superior outcomes, but these superior outcomes generate positive externalities for neighboring regions of civil law countries. While this is possible, it would suggest that the benefit of the common law would become apparent (or stronger) at wider bandwidths, which is not something we observe.

Finally, the regression discontinuity approach assumes that each section of a country has an economic trajectory relatively unaffected by the geographic features of other parts of the country. So the fact that most of Niger is in the Sahara does not drag down the performance of the wetter parts of Niger near the Nigerian border, and the fact that Nigeria has ports on the Atlantic ocean whereas Niger does not is assumed not to affect areas close to the Niger-Nigerian border. To some degree, these assumptions must be false. Yet is should be noted that they largely bias results towards finding a positive common law effect, because, as a result of Britain's military dominance and ability to largely choose its colonies, common law counties, like Nigeria, are less likely to be landlocked and are more likely to have large natural resource endowments. The fact that we find little or no positive common law effect in spite of this issue reinforces the strength of our conclusions.

6 Conclusion and Future Research

Our research design offers a number of important advantages over the extant literature. First, in contrast to cross-national regressions, we are able to control for a number of factors, many unobservable, by focusing on areas close to the border, where conditions are likely to be similar. Second, by using rich geographical data, we are able to directly

control for observable differences across borders. Third, we use light intensity as a proxy for economic development, which is likely to be more accurate than official economic data for Africa, because most poor countries lack the expertise and administrative capacity to measure economic performance precisely. Fourth, by focusing on areas where the same ethnicity straddles the border, we can hold culture constant.

We find little support for the idea that common law legal origin led to superior economic performance. Although common law countries sometimes show more light closer to their borders with civil law countries, the effect is neither consistent nor large, and disappears when economic performance is measure by light per capita.

The conclusions in this paper can be interpreted in a hopeful way. The hypothesis that legal origin is of decisive importance for modern economic development attributes long-lasting effects to decisions made long ago by foreigners. The view in this paper, that economic performance reflects a myriad of other factors, reinforces the idea that modern policy decisions are decisive and that peoples and their governments can control their own destinies.

That said, we would like to emphasize the preliminary nature of these results. There is much more we would like to do with these data to further investigate the influence and importance of legal and colonial origins and, more generally, to improve the paper. In particular, we plan:

- To supplement the nighttime light data with survey data on electricity at the household level and other survey indicators of household economic well-being.
- To investigate the reliability of the population numbers, especially for 1995
- To include a number of falsification tests and robustness checks to strengthen the credibility of the research design. In particular, we plan to exclude borders between landlocked and non-landlocked countries, to exclude borders where covariate bal-

ance is questionable, to exclude areas close to the border (e.g. within 10km), and to check years other than 1995 and 2013

- To analyze a wider range of covariates
- To analyze economic growth through changes in light density between 1995 and 2013
- To produce graphs that show more clearly the discontinuity (or lack thereof) across borders
- To use nighttime light data to estimate GDP and GDP growth for whole countries in order to explore the extent to which the results hold up away from borders and in order to explore the differences between the results in this paper and in Klerman et al. (2011)

Appendix

Table A: Covariate Balance by Legal-Colonial Origin

Border Pair Type		Elevation	Ruggedness	Avg. Temp.	Avg. Precip.
Civil Law, French–	Mean Difference	18.69	1.90	-0.11	13.08
Common Law	Std. Error	1.38	0.10	0.01	0.71
	p	0.00	0.00	0.00	0.00
	Baseline Mean	882.75	20.62	24.25	832.00
	Obs.	528,426	528,426	528,426	528,426
Civil Law, Not French–	Mean Difference	-10.17	1.78	-0.13	39.18
Common Law	Std. Error	0.93	0.08	0.01	0.48
	p	0.00	0.00	0.00	0.00
	Baseline Mean	1,016.21	22.81	21.88	1,110.21
	Obs.	747,175	747,175	747,175	747,175
Civil Law French–	Mean Difference	-13.70	1.26	0.20	-6.85
Civil Law, Not French	Std. Error	0.59	0.06	0.00	0.84
	p	0.00	0.00	0.00	0.00
	Baseline Mean	418.36	14.77	24.87	1,633.97
	Obs.	380,378	380,378	380,378	380,378
Civil Law, Not French–	Mean Difference	-244.02	-10.26	1.35	24.37
Mixed Law	Std. Error	1.56	0.16	0.01	0.87
	p	0.00	0.00	0.00	0.00
	Baseline Mean	628.03	31.06	21.40	690.94
	Obs.	187,090	187,090	187,090	187,090
Common Law–	Mean Difference	-126.54	-5.91	0.73	-43.93
Mixed Law	Std. Error	1.75	0.23	0.01	0.47
	p	0.00	0.00	0.00	0.00
	Baseline Mean	840.00	35.42	22.62	749.88
	Obs.	70,109	70,109	70,109	70,109
Both	Mean Difference	18.69	1.90	-0.11	13.08
Common Law	Std. Error	1.38	0.10	0.01	0.71
	p	0.00	0.00	0.00	0.00
	Baseline Mean	882.75	20.62	24.25	832.00
	Obs.	528,426	528,426	528,426	528,426
Both	Mean Difference	-1.68	0.51	0.03	9.31
Civil Law, French	Std. Error	0.27	0.03	0.00	0.98
	p	0.00	0.00	0.00	0.00
	Baseline Mean	344.17	10.21	27.17	751.31
	Obs.	1,384,009	1,384,009	1,384,009	1,384,009
Both	Mean Difference	18.63	-2.17	-0.18	-26.98
Civil Law, Not French	Std. Error	1.86	0.13	0.01	0.71
	p	0.00	0.00	0.00	0.00
	Baseline Mean	941.98	34.09	22.37	1,410.25
	Obs.	287,334	287,334	287,334	287,334
Both	Mean Difference	-17.01	-1.46	0.75	-109.61
Mixed Law	Std. Error	1.53	0.13	0.01	0.82
	p	0.00	0.00	0.00	0.00
	Baseline Mean	1,155.96	29.19	18.92	630.69
	Obs.	455,435	455,435	455,435	455,435

Notes. All common law and mixed law countries are former British colonies. "Civil Law, French" means a former French colony with civil law. "Civil Law, Not French," means a former Belgian, Portuguese or Spanish colony with civil law. Differences are for the 100 km bandwidth.

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