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Abstract

This paper tests the hypotheses that (1) European colonization indirectly hinders the development outcomes, namely GDP per capita growth, by lowering institutional quality and encouraging corruption in colonized oil-rich countries, and (2) better macro institutional quality mitigates the historically-rooted resource curse. We constructed the instrumental variable by categorizing countries based on the evidence of settlers' mortality and the persistence of European colonial languages as official post-independence languages in oil-rich non-western countries. Also, we isolate the effect of giant oil discoveries with the depth of oil fields because of the plausible relationship with the geological characteristics of oil formation. We estimate a 2-Step GMM model that controls the lagged moments of GDP per capita using the data for 69 countries with at least a discovery of giant oil fields from 1960 to 2015. We show that oil-rich countries without colonial experience have better institutions, which translates to improving GDP per capita and reducing the corruption index. Our findings highlight the importance of historical factors associated with state origin when formulating policies to address the resource curse.

Keywords: Resource Curse, Colonialism, Institutions, Petroleum-resources

JEL-Codes: F54, E02, O43, Q35

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Colonialism, Institutional Quality, and the Resource Curse

1. Introduction

Following the observation that resource wealth fails to translate into development outcomes in many resource-rich countries, a large body of literature has emerged analyzing the causes and reasons for the poor development outcomes (Van der Ploeg, 2011). However, a grim outlook commonly termed the "resource curse" in many resource-rich countries sharply contrasts with the increased prosperity seen in others. For instance, Norway, the USA, Qatar, and the United Arab Emirates show development outcomes, measured by GDP per capita and Human Development Index (HDI), much higher than others like Nigeria, Angola, and Venezuela. Existing studies offer limited empirical evidence on whether these heterogeneities are systematically masked by the historical evolution of institutions supporting socially efficient economic development. This paper asks whether historical factors, such as the 16th to 19th-century European colonial intervention, created incentives for the resource curse through the colonial investment in institutional quality in former European colonies.

Within the resource curse literature, an accepted explanation of the disparity centers on the differences in institutional quality (Mehlum et al., 2006), which aggravates dysfunctional state behavior and public sector investment (Robinson et al., 2006). In the general economic literature, the role of historical institutions, such as the property rights and the system of legal law implemented in many European colonies, have been shown to affect contemporary economic outcomes (Acemoglu et al., 2001; Glaeser & Shleifer, 2002; Banerjee & Iyer, 2005). A significant objective of European colonialism was to expand the economic and power base of the metropole through the disruption and imposition of institutions that favored rent-seeking elites (Dell 2010, Aldrich and McCreery 2016). If such structures are inherited, they could persist and partly contribute to the resource curse by making the new indigenous elites less concerned about a socially efficient resource-rent allocation system.

Specifically, we test the hypotheses that (1) European colonization indirectly hinders the development outcomes, namely GDP per capita growth by lowering institutional quality and encouraging corruption in colonized oil-rich countries and (2) better macro institutional quality mitigates the resource curse, that is, the negative effect of oil discovery on development outcomes. The possibility that the European colonial experience could contribute to the resource curse could be helpful for meaningful policy recommendations for reversing the resource curse.

We focus on countries with at least a giant oil discovery and systematically identify institutional quality in these countries with colonial experiences. Methodologically, we leverage the European colonial experience to address the endogeneity problems with institutional quality. This is important since the basis for colonial annexation was not driven by giant oil discovery; it enables us to reduce the persistence of local geographical and environmental conditions that could systematically affect long-term outcomes in colonized and non-colonized states. A major limitation of relying on data on colonialism is that it is often unverifiable, as such events happened long ago. We categorized countries as European colonies if they experienced 16th- to 19th-century colonization using settler mortality estimates from Acemoglu et al. (2001) and/or if any European colonial languages persist as official post-independence languages. By observing colonialism with the persistence of the colonial language, we can distinguish colonies based on the depth of economic engagement that has a persistent effect[1]. Also, it could plausibly educe the measurement error associated with settler mortality for identifying colonialism, as it was difficult to get the exact information on the morality rates of European soldiers, bishops, and sailors in many colonies (Albouy, 2008, 2012).

Although giant oil discoveries are a relatively more exogenous measure of oil abundance (Arezki, 2017), we cannot rule out the potential correlation with other confounding factors. For example, oil fields are not located randomly but in areas with good institutions that facilitate the drilling process. Similarly, rich oil-endowed countries can afford better institutions and/or have the financial and technical capacity to engage in oil prospecting, leading to earlier discoveries than less rich ones. Our second variable in isolating the effect of giant oil discoveries relies on the geological characteristics of oil formation. We identify the size of giant oil discoveries with the geologic features associated with oil and gas formation, migration, and accumulation (Philippi, 1965; Tissot et al., 1971; 1974). Our approach improves on previous instruments used to identify the resource curse. In a recent study, the distribution of sedimentary basins (Cassidy, 2019) and subsooil-initially-in-place-in-place (Tsui, 2011) have been used to isolate the effect of oil discoveries.

Using a 2-Step GMM regression in 69 oil-rich countries with giant oil discoveries (40 colonized and 29 non-colonized) from 1960 to 2015, we show that oil-rich countries without colonial experience have better institutions and reverse the resource curse. We show that oil-rich, non-colonized countries can reverse the adverse impact of oil abundance on growth via a positive net effect on institutions, whereas countries with colonial experience cannot. We explore other mechanisms for how colonial heritage might support the resource curse. One plausible mechanism can be traced to inherited rent-seeking institutions favoring corruption. We measure corruption with individual surveys that ask what people think of it and the extent of the cost they are willing to pay to reduce it. We confirm that conditional on colonial experience, corruption is an important channel to explain oil-rich countries' slow growth and the resource curse.

We conduct additional validity tests to confirm the reliability of our instrumental variables (Angrist and Krueger, 2001). First, we show that the instruments are correlated with the endogenous regressor; second, we show that the instrumental variable is excludable as the direct cause of current economic development. Validating the second assumption requires more profound intuition reflecting theoretical and statistical criteria. Places with sophisticated technologies could have resisted colonial occupation, and such historical technologies may have a persistent long-term effect (Comin et al., 2010). On the contrary, many former

[1] Language imperialism was essential for successful colonization (Phillipson, 1992; Migge and Léglise, 2008). It was important in European settlers' colony countries and for fostering economic partnership in exploitative-colony countries. It was not important in non-economically important colonies (e.g. many Arab nations in the Gulf) as there was no effort to supplant the language of Arabic-speaking peoples with the European language (Weber, 2011).

superpowers could not resist colonizing; therefore, the early adoption and use of sophisticated technology plausibly had no direct effect on colonization. We run a reduced-form regression of colonial instruments on the historical 1500AD technology adoption using Comin et al. (2010) data to validate this argument.

Another threat to identification is the tendency for colonized countries to be more ethnically fractionalized (Alesina et al., 2011). Fractionalisation can cause more in-fighting over resource ownership and reduce productive activities (Hodler, 2006). However, since our sample countries were selected based on giant oil discoveries plausibly exogenous to European colonization, we show that fractionalization is unlikely to constitute outside channels for our sample of studies. Finally, we also employed a reduced-form regression of the instruments and other exogenous variables on the dependent variable to show that being a former colony or having deeper oil fields are not directly correlated to current economic performance (Angrist and Krueger, 2001; Murray, 2006; French and Popovici, 2011).

Following this introduction, the remainder of the paper is organized as follows. Section 2 presents the estimation strategy, and we describe the data. The main results are presented and discussed in Section 3, and in Section 4, we report another mechanism that explores corruption as an outcome. In Section 5, we investigate why the experience of colonialism frustrates institutional reforms by looking at education enrollment and Social trusts. We report additional robustness in Appendix III. We conclude in Section 6.

2. Estimation Strategy and Data Description

Institutional Quality and the gap in income per capita of oil-rich countries

Formal models on the conditional resource curse model suggest that institutions mediate the impact of natural resource endowment on development outcomes. Following Mehlum et al. (2006), we motivate our analysis on the moderating effect of institutional quality and oil abundance on the log of the ratio of income per capita five years after discovering giant oil reserves in oil-rich countries (1). Figure 1 shows the schematic diagram showing the relationships of the key variables used in the Model.

$$Y_{i,t} = \beta_0 + \beta_1 Disc_{i,} + \beta_2\, IQ_i + \beta_3(Disc_i \times IQ_i) + \beta_k R'_{\ i} + \beta_j F'_{\ i} + \varphi_t + \varepsilon_{it} \qquad (1)$$

where $Y_{i,t}$ is the GDP per capita growth in the period from four years before the discovery of giant oil reserves to five years after that, that is, the log of the long-run change in GDP per capita in a country $i\left(\Delta Y_{i,t} = \frac{GDP\ per\ capita_{\ t+5}}{GDP\ per\ capita_{\ t-4}}\right)$. We expect the effect of giant oil discovery not to be immediate but to materialize after a certain period. Oil production and processing take time after discovery (Arezki et al., 2017). A typical lag between oil discovery and oil production of five years is discussed by Arezki et al. (2017).

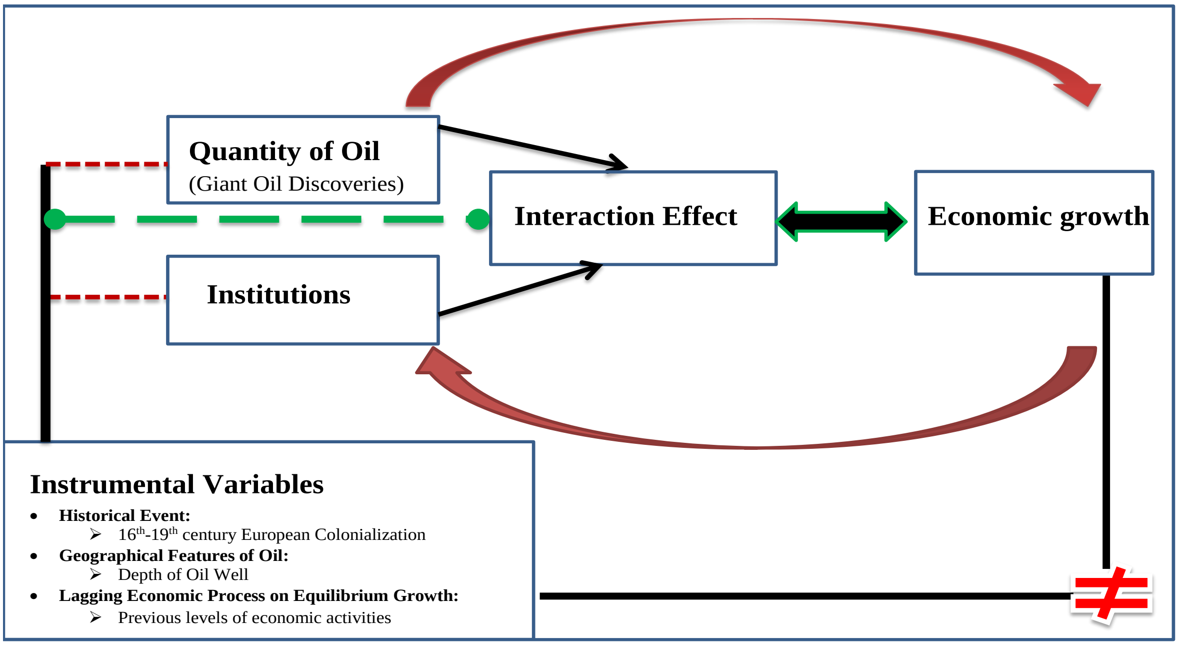

Figure 1: Analytical framework on the bidirectional causality of economic growth with institutions and resource abundance (authors' creation)

$Disc$ is the size and magnitude of the amount of ultimately recoverable Oil or gas equivalent discovery in the country *i*. A giant oil and gas discovery is discovering an oil and/or gas field containing at least 500 million barrels of ultimately recoverable oil equivalent (Horn, 2014; Arezki et al., 2017; Van der Ploeg and Poelhekke, 2017).

$IQ_i$the institutional quality index is the average of Executive constraints (Jaggers and Marshall, 2000), Average Protection against expropriation risk (Acemoglu et al. 2001), and Government effectiveness. $Disc_i \times IQ_i$captures the interaction term, which is the moderating effect of institutional quality on oil abundance or the deteriorating influence of oil discovery on institutional quality in country i (see Figure 1). The coefficient of the interaction term $Disc_i \times IQ_i$, has an important connotation. It represents the conditioning influence of institutional quality on the log of the change ratio in the GDP per capita five years after oil discovery. Equation (1) adds additional controls (R), including control for prior income change in GDP per capita for country *i* in the year of discovery and a year before discovery $_{t-1}Log\left(\frac{GDP\ per\ capita_{\ t}}{GDP\ per\ capita_{\ t-1}}\right)$, 1900s discovery of coal to control for early industrialization, a dummy to control if oil-rich country borders were drawn before major oil discoveries, and a dummy that controls for the sovereignty status of the country as of 1960, control for latitude and absolute latitude and the log of population growth. A dummy for sovereignty status in 1960 is important because some countries in our sample became independent after 1960, the year our analysis took effect.

Also, as a robustness check, we exclude these countries in the Instrumental Variable estimation. 1900s coal controls for the divergence associated with the Industrial Revolution affected the long-run economic performance. Prior income change captures how income change in the year of oil discovery affects long-term income change five years after discovery. Latitude controls how differences in economic growth are attributable to the physical environment (Mellinger et al., 2000; Nunn and Puga, 2012). Indeed, as Gallup et al. (1999) and Easterly and Levine (2003) noted, real GDP per capita levels also increase relative to the equator as latitude rises relative to the equator[2]. F_i controls for four regional dummies of country location in sub-Saharan (SSA), Latin America, Middle East, and North Africa and $South\ Asia$ geographical regions based on World Bank classification and $\varphi_t$controls for time dummies.

An equilibrium relation may exist in equation (1), implying a bi-directional relationship between the dependent and independent variables. We correct this bias by employing the Instrumental variable (IV) method, which allows us to estimate our variables consistently. We use colonial dummy instruments, lagged GDP per capita, and giant oil fields' depth as instrumental variables. Under the assumption that colonial experience and geographic variation in oil endowment affect income per capita change five years after discovering giant oil and gas institutional quality and magnitude/amount of oil discoveries, we can estimate the conditional resource curse hypothesis using an instrumental variables approach. Specifically, we re-estimate equation (1) after the first stage regression in eqn. (2).

$$X_i = \lambda_1 Dpt_i + \lambda_2 Dpt_i{}^2 + \lambda_3 Coly_i + \lambda_4 Y_{i,t-3} + \lambda_5 Y_{i,t-4} + \sum_{j=n}^{k} \beta_j M_i + \varepsilon_{it} \qquad (2)$$

Here, X_i stands for a vector of the endogenous regressors in eqn. (1), namely: (a) log of the amount of oil discovery in country i, (b) unweighted index of institutional quality in country i, (c) the interaction of oil abundance and institutional quality in country i, year t, and (d) the log of income per capita change prior in the year of oil discovery in country i, year t.
The instruments comprise:

1. Dpt is the log of the depth of oil reserves, and it is used as an instrument for oil abundance.
2. $Dpt_{it}{}^2$ is the log of depth(squared) to account for the possible non-linearities between oil abundance and depth; i.e., deeper wells could be more expensive to drill
3. $Coly$ is a dummy variable that measures a country's experience of colonial occupation. Coly is used as an instrumental variable to measure institutional quality and to identify the indirect effect of the heritage of European colonialism relative to non-colonized countries. Coly =1 if a country has data on settler mortality and/or if, despite being a non-European country, it adopts any other European languages of major colonial masters as an official language.
4. The variables, $Y_{i,t-3}$, and
5. $Y_{i,t-4}$ the lagged GDP per capita is used as an instrument for the log of the ratio of change in prior GDP per capita in the year of oil discovery.

M is a vector of other exogenous covariates. Estimating the 2-stage equations 1 and 2 becomes challenging, and the standard two-stage least squares are no longer consistent. First, we have nine over-identifying restrictions, and second, there is a serial correlation between the dynamic Model (additional lagged moments). Because of the introduction of the lagged

[2] The inverse relationship between closeness to the latitude and economic performance could be due to the correlation areas closer to the latitudes has with productivity and ecological conditions that favour infectious diseases and food security.

moments, using the 2-stage GMM estimator instead of the 2-stage SLS can provide more precise estimates of the parameters (Hayashi 2000, pages 206-227; Baum et al., 2003). Specifically, the GMM is well suited for obtaining efficient estimators that account for the serial correlation (Arellano and Bond, 1991; Wooldridge, 2001) and dynamic model estimation with additional moment conditions (Blundell and Bond, 1998; Hall, 2005).

Data description

Log GDP/capita GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. Data are in constant 2010 U.S. dollars, sourced from the World Bank national accounts data and OECD National Accounts data files. We estimated the log of change in income per capita as the ratio of GDP/capita five years after and four years before oil discovery $Log\left(\frac{GDP\ \ per\ capita_{t+5}}{GDP\ \ per\ capita_{t-4}}\right)$.

Colonial Experience[3]: To define the colonial experience, we considered countries described in Acemoglu et al. (2001) with settlement or exploitation colonization. Also, we use countries with evidence of substantial colonial direct rule during the 16^{th}-19^{th} European colonization, as evidenced by the official use of the European language as the post-colonial communication medium. In this regard, countries with only protectorate status and not with any direct control of the internal governance structures are not considered strictly European colonies.

Estimated Ultimate Recovery of Oil Equivalence in MMBOE (EUR) is the sum of the proven reserves at a specific time. Data on oil reserve discoveries include a column for the depth of oil fields (Horn, 2014). Data covers the period from 1960-2010, sourced from Horn (2014), Giant Oil and Gas Fields of the World.

Institutional quality is a measure of the quality of institutions, which is the index of an unweighted aggregate of Executive Constraints (1960-2000), average Protection against Expropriation Risk (1982-1997), and Government Effectiveness (1998-2000). It takes the value of zero to one, with 1 being the maximum value and 0 being the country with the lowest Protection against expropriation risk, government effectiveness, and constraint on the absoluteness of the authority of the executives.

$$Institutional\ Quality_i = \frac{((X_i) - \text{Min}\ (X_i))}{(\text{Max}(X_i) - \text{Min}(X_i)}$$

Where X_i is the average of the scores of Protection against the risk of expropriation, executive constraint, and government effectiveness for each country, Min (X_i) is the value for the

[3] List of 40 countries with giant oil discovery between 1960-2010 and colonial experience are: Algeria, Angola, Argentina, Australia, Bangladesh, Bolivia, Brazil, Brunei, Canada, Colombia, Congo, Rep, Cote d'Ivoire, Ecuador, Egypt, Equatorial Guinea, Ethiopia, Gabon, Ghana, India, Indonesia, Libya, Malaysia, Mexico, Morocco, Mozambique, Myanmar, Namibia, New Zealand, Nigeria, Pakistan, Papua new guinea, Peru, Philippines, Sierra Leone, Sudan, Trinidad and Tobago, Tunisia, United states of America, Venezuela, and Vietnam.
The 29 countries with giant oil discovery between 1960-2010 that were not considered with direct European colonial experience are: Albania, Azerbaijan, China, Denmark, France, Germany, Hungary, Iran, Iraq, Israel, Italy, Kazakhstan, Kuwait, Netherlands, Norway, Oman, Qatar, Romania, Russian, Saudi Arabia, Spain, Tajikistan, Thailand, Turkmenistan, Ukraine, United Arab Emirate, United Kingdom, Uzbekistan, and Yemen.

country with the lowest aggregate score, and $\text{Max}(X_i)$ is for the country with the highest aggregate score.

The executive constraint is the extent of institutionalized constraints on the decision-making powers of chief executives of the government. It ranges from one to seven, where higher values equaled a greater extent of institutionalized constraints on the power of chief executives and calculated as the average from 1960 through 2000 or for specific years (Jaggers and Marshall 2000).

Protection against Expropriation Risk is the Protection against "outright confiscation and forced nationalization" of property. This variable ranges from zero to ten, where higher values equal a lower probability of expropriation. This variable is calculated as the average from 1982 through 1997 or for specific years as needed in the tables. The source is from the International Country Risk Guide at http://www.countrydata.com/datasets/.

Government effectiveness is defined as the measure of the quality of public service provision, the quality of the bureaucracy, the competence of civil servants, the independence of the civil service from political pressures, and the credibility of the government's commitment to policies. This variable is the average from 1998 through 2000. Because of the difference in the years of availability of these data, we consider a robustness analysis where the institutional quality is disaggregated.

Log Annual Population Growth The Annual population growth rate for year t is the exponential rate of growth of the midyear population from year t-1 to t, expressed as a percentage. The population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship, and the data from the World Bank database.

1900s Coal Discoveries: The success of the Industrial Revolution was based on the availability of coal to power steam engines, which expanded international trade. Our main data is taken from recorded data on coal reserves in the 1900s, and we also supplement the data with official gazettes and coal-producing countries' official statistics on coal production in the 1900s.

Table I: Summary and descriptive statistics of Variables

	All countries				Colonized Countries				Non-Colonised			
Variable	Mean	Std. dev	Min	Max	Mean	Std.Dev	Min	Max	Mean	Std.Dev	Min	Max
log GDP/capita	8.40	1.55	4.87	11.65	8.83	1.65	4.87	11.65	8.01	1.34	5.10	10.91
Oil Discoveries (mmboe: million barrels of oil equivalent)	0.46	4.00	0.01	176.06	0.70	5.37	0.01	176.06	0.19	1.03	0.01	21.22
Institutional quality	0.48	0.30	-0.18	0.99	0.46	0.35	-0.18	0.99	0.49	0.22	0.17	0.97
Protection against Expropriation Risk (1982-1997)	7.34	1.66	2.40	9.98	7.77	1.83	2.40	9.98	6.96	1.37	4.01	9.97
Government Effectiveness (1998-2000)	0.03	1.02	-1.63	2.17	0.13	1.11	-1.63	2.17	-0.08	0.89	-1.47	1.89
Executive Constraints (1960-2000)	3.76	2.02	1.00	7.00	3.64	2.14	1.00	7.00	3.89	1.86	1.45	7
Depth of Oil fields	-3880	21713	-300000	17.42	-4292	22954	-300000	14.02	-3403	20178	-300000	17
Log Population Density	0.53	0.86	-6.44	2.87	0.41	1.10	-6.44	2.87	0.66	0.45	-3.44	1.6
Absolute Latitude	26.15	16.82	0.23	61.52	33.67	15.72	1.65	61.52	17.69	13.72	0.23	56.13

Results and Discussion

Giant oil discoveries, institutional quality, and economic growth

First-stage estimation

Table 2 presents the instrumental variable estimates corresponding to our main results in Model II of Table 3. As shown in Table 2, colonized countries have fewer amount oil discoveries, by 0.94 mmboe (million barrels of oil equivalent) (Columns A and C), and less institutional quality, by 0.76 mmboe (Columns B and C), than non-colonized. In essence, the quality of macro institutions in colonized oil-rich countries is lower than in non-colonized oil-rich countries. Also, possibly due to the weak institutions, colonized countries have fewer oil discoveries (Column C) than non-colonized countries. The first-stage results for Models III and IV are presented in Appendix 1.

Table 2: First stage Estimates of Model II[4] in Table 3

	First Stage for IV (GMM) estimates (Model II)			
	A	B	C	D
	Log Oil (mmboe)	Institutional Quality	Interaction term	Log Prior change GDP/Capita
Colonized (Dummy = 1)	-0.05**	0.13***	-0.89***	-0.001
	(0.3)	(0.01)	(0.14)	(0.004)
Log depth	2.66***	-0.01***	1.67***	0.001
	(0.05)	(0.004)	(0.09)	(0.002)
Log depth (squared)	-0.70***	-0.005	-0.28***	-0.0002
	(0.04)	(0.004)	(0.08)	(0.002)
Log GDP/Capita t − 3	0.16	0.11	-1.69	0.13***
	(0.11)	(0.1)	(1.15)	(0.04)
Log GDP/Capita t − 4	0.13	-0.01	0.66	-0.14***
	(0.11)	(0.09)	(1.14)	(0.03)
F-Statistics of Excluded instruments	6414	176.9	492.07	7.48
Under ID (SW)	52.57***	46.84***	52.30***	19.98***
Weak ID (SW F-test of Excluded Instruments)	25.59	22.8	25.46	9.72

Notes: Data covers 69 countries with the discovery of at least a giant oil field from 1960 to 2015, and the dependent variables are the endogenous regressors of log Oil, Institutional Quality, the Interaction term of Institutional Quality, and log of oil abundance and are the log of change in GDP per capita in the year of discovery$\left(log \frac{GDP\ per\ capita_{t}}{GDP\ per\ capita_{t-1}}\right)$. Variables on the left column are the instruments used. Robust standard errors are in parenthesis and are clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.

[4] The first stages for Models III and IV of Table 3 are presented in Appendix I

Our first stage findings extend several findings that rely on the unconditional influence of colonial heritage on institutions (Acemoglu et al., 2001, 2012; Dell, 2010). Countries will fail to reform inherited extractive institutions in the presence of exploitable resources. In this case, the oil windfall in the hands of the post-colonial elite will probably work at discouraging institutional reforms that would favor entrepreneurship and inclusive growth. As oil abundance increases (i.e., the log of Depth increases), colonized countries have deteriorating institutions compared to non-colonized (an estimate on the interaction term), suggesting the inability to reverse the economic curse associated with giant oil endowment. There is a higher tendency for post-colonial leaders in countries used as former extractive colonies to continue with the expropriation of resources and not create governance structures that would bring about an equally distributed welfare among the citizens. Also, we find that the depth of the oil field is correlated with the amount of estimates of recoverable Oil. The change in prior GDP per capita is influenced by the lagged values in the levels of GDP per capita, respectively.

In addition to institutional quality, we hypothesize that a log of oil discoveries is plausibly endogenous. This is because oil prospecting requires human and financial capital, and low-income countries might be unable to afford these. Subsequently, we treat the log of oil discoveries (in terms of mmboe) as endogenous and instrument it with the depth and depth logs (squared). We also find that depth and depth (squared) significantly correlate with the amount of oil discoveries (Column A) in Table 2. First, the formation and accumulation of petroleum in oil fields mainly depend on a source rock, which contains significant Oil, a depth range of 7000 to 18,000 ft (2100 to 5500m), and a temperature of about 150°F (65°C) and 300°F (150°C) (Philippi, 1965; Tissot and Welte, 2013) are important. Second, if the reservoir rock is too deep, it would be highly compacted, allowing for permeability and porosity and reducing migration to the reservoir rocks. Therefore, depth (squared) as an additional instrument is used to identify the non-linear relationship between the size of giant oil discoveries and depth.

In Model I (Table 3), we use the Ordinary Least Squares (OLS) regressions to test for the correlation between explanatory variables, such as oil discovery, institutional quality, and their interaction, and a dependent variable, namely, the log of change in GDP per capita in oil-rich countries with giant oil discoveries defined over the nine years before and after the oil discoveries in the data period from 1960 to 2015. Model I does not control for the plausible endogeneity or account for the indirect impact of colonialism on the resource curse via institutional quality. Table 1 reports the main findings of our estimation.

The results based on Model I show that institutional quality is statistically correlated with the variation in the ratio change in GDP/capita. However, the log of oil discoveries and the interaction with institutional quality are statistically insignificant. Also, the underlying economic performance of oil-rich countries measured as the log of change in GDP/capita in the year positively correlates to GDP growth. The literature suggests that political and economic institutions explain economic performance. Institutional quality and economic development reinforce each other over the longer term (North, 1990; Hall and Jones, 1999; Knack and Keefer, 1995).

In Models II to IV, we can identify the direction of causality and the conditional resource curse theory with the colonialism experience and the oil fields' depth. In Model II, we do not control if the country's border was defined before oil discoveries and if the country was independent before 1960. Model III controls the country's sovereign status as of 1960 and if the border was drawn before major oil discoveries by including a dummy. Finally, in Model IV, we exclude countries that were not fully independent and sovereign states by 1960.

Table 3: Giant Oil Discoveries, Institutional quality, and the Resource Curse

Dependent Variable **Log ΔGDP=**$\left(\frac{GDP\ per\ capita_{t+5}}{GDP\ per\ capita_{t-4}}\right)$.	**Log ΔGDP** $_{i,t+5}$	**Log ΔGDP** $_{i,t+5}$	**Log ΔGDP** $_{i,t+5}$	**Log ΔGDP** $_{i,t+5}$
	Model I	**Model II**	**Model III**	**Model IV**
Log Oil Discovery (mmboe)	0.002	-0.06***	-0.06***	-0.04***
	(0.005)	(0.02)	(0.02)	(0.02)
Institutional Quality (IQ)	-0.24**	0.35	0.35	0.09
	(0.10)	(0.44)	(0.44)	(0.3)
Interaction Term (Log Oil Disc×IQ)	0.001	0.11***	0.11***	0.07***
	(0.007)	(0.04)	(0.04)	(0.03)
Prior change in GDP/Capita $Log\left(\frac{GDP\ per\ capita_{t}}{GDP\ per\ capita_{t-1}}\right)$	0.73***	2.62***	2.5***	3.83***
	(0.33)	(0.97)	(0.99)	(1.74)
1900s Coal Discoveries	0.02	0.09***	0.09***	0.06***
	(0.05)	(0.02)	(0.02)	(0.02)
Border before First discovery (Dummy =1)	-0.03		-0.004	
	(0.03)		(0.02)	
Country Independence after 1960 (Dummy =1)	-0.04		-0.04	
	(0.06)		(0.03)	
Net marginal effect of Oil Discovery	0.003	0.05***	0.05***	0.03***
Estimator	OLS	IV GMM	IV GMM	IV GMM
Number of instruments	None	5	5	9
All colonized countries since 1960 included?	Yes	Yes	Yes	No
Hansen J test (Over-identification test of all instruments)		1.76	1.63	3.9
Under-identification test (Kleibergen-Paaprk LM statistic)		35.1***	29.5***	10.9*
Weak-instrument-robust inference(Anderson-Rubin Wald F-stat)		75.31	73.32	27.62

Notes: Data covers 69 countries, discovering a giant oil field from 1960 to 2015. All models report robust standard errors (in parenthesis) clustered at the country level. Years with no significant discoveries were given the least value of 0.01 to take the Log.
*, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively. The dependent variable is the Log ΔGDP=$\left(\frac{GDP\ per\ capita_{t+5}}{GDP\ per\ capita_{t-4}}\right)$ and we allow for a five-year lag between discoveries and growth

We used the OLS estimator in Model I and did not account for the plausible endogeneity concerns.
Models II to IV use an Instrumental Variable (IV) GMM estimator to control endogenous bias.
Model I, II, and III include all colonized countries with giant oil discoveries.
Model IV only includes countries with independence on or after 1960
Model IV. Excludes 17 Countries. These countries have ongoing colonization as of 1960 (mostly Portugal colonies in Africa) and countries that split from mother countries (constituent countries that formed the USSR). All models control for Latitude, Latitude (squared), a log of population growth, absolute latitude and time, and regional dummies of Sub-sahara Africa (SSA), South America, the Middle East, and North Africa (MENA), and South Asia.

We document the negative impact of oil discoveries on income growth per capita. We show that the effect is moderated by the institutional quality drawn from the unweighted index of executive constraints, average Protection against expropriation risk, and government effectiveness. Our results based on Models II and III support our hypothesis in contrast to the OLS (Model I) results. The estimates in Models II and III (where we control for the border before discovery and if the country was independent as of 1960) indicate that when oil abundance (mmboe) increases by 10%, there is a 0.60% decline in growth in GDP per capita in the period from four years before the discovery of giant oil fields to five years after that. In Model IV, we exclude countries that were not fully independent and sovereign by 1960, and the estimates imply a 40% drop in GDP growth five years after the giant oil discovery.

Models II, III, and IV show that the country's better institutional quality can reverse the resource curse. Countries with an above-average quality of institutions (an institutional quality index higher than 0.46) can reverse the curse. In essence, given two countries (A and B) with the same amount of oil discoveries but different institutional quality, country A, with an institutional quality that is 10% above the average index, will have a 0.5% increase in growth in GDP per capita relative to country B that has an average institutional index.

4 Other Mechanism: Corruption as a Resource Curse Outcome Due to Weak Institutional Quality

The results in Table 3 are helpful in their rights. Still, it is also essential to understand other colonial mechanisms, such as corruption (Ades and Di Tella, 1999; Angeles and Neanidis, 2015). Measuring and quantifying a problem like corruption in resource-rich countries where corruption is endemic is potentially challenging (Donchev and Ujhelyi, 2014). There are two main approaches: one that relies on experts' opinions and the extent to which the legal-institutional framework for anti-corruption laws is improving. The other depends on answers to a survey asking adult citizens about their acceptance of corruption and the extent to which they are willing to prevent it. In a systemically corrupt setting, the collective action theory of corruption suggests that everyone, especially those who stand to gain more, will see corruption as the preferred strategy, and many corruption measures like Transparency International's Corruption Perceptions Index (CPI) will not reflect the progress made towards anti-corruption per se (Uslaner and Rothstein, 2012; Persson et al., 2013). More importantly, such survey questions evaluate society's standard of corruption and how supportive they are of corrupt practices (Uslaner, 2002; pp. 68-75).

Table 4: Giant Oil Discoveries, Institutional quality, and Corruption Indicators[5]

Dependent Variables	**Corruption Perception Gov Officials Most corrupt (% respondents)**	**Corruption Perceptions Index**	**Is it socially acceptable to report corruption: agree (% respondents)**	**Would spend a whole day in court to give evidence: agree (% respondents)**
	Model V	**Model VI**	**Model VII**	**Model VIII**
Log Oil Discovery (mmboe)	0.09***	8.62***	-0.04**	-0.12***
	(0.03)	(1.95)	(0.02)	(0.04)
Institutional Quality (IQ)	-1.39***	-64*	0.61**	2.11***
	(0.43)	(35.9)	(0.27)	(0.53)
Interaction Term (Log Oil Disc×IQ)	-0.15***	-14.6***	0.07**	0.18***
	(0.04)	(3.4)	(0.03)	(0.05)
Prior change in GDP/Capita $Log\left(\frac{GDP\ per\ capita_{\ t}}{GDP\ per\ capita_{\ t-1}}\right)$	-1.32	0.81	0.77**	0.87
	(14.13)	(53.5)	(0.35)	(0.53)
1900s Coal Discoveries	-0.04***	-5.51***	0.12***	0.05***
	(0.01)	(1.29)	(0.011)	(0.02)
Border before First discovery (Dummy =1)	-0.01	-2.89**	0.005	0.07***
	(0.01)	(1.01)	(0.10)	(0.02)
Country Independence after 1960 (Dummy =1)	0.01	5.39***	-0.21***	-0.29***
	(0.01)	(1.43)	(0.02)	(0.03)
Net marginal effect of size of Oil Discovery	-0.06***	-5.98**	0.03**	0.06**
Number of instruments	5	5	5	5
Hansen J test (Over-identification test of all instruments)	3.1	0.146	0.57	0.448
Under-identification test (Kleibergen-Paaprk LM statistic)	20***	22.1***	19.8***	19.8***
Weak-instrument-robust inference (Anderson-Rubin Wald F-stat)	14.5***	326.59***	4.32***	54.71***

[5] The corresponding first-stages regressions for Models V to VIII are presented in the Appendix III.

Notes: Data covers 69 countries discovering giant oilfields from 1960 to 2015. Years with no significant discoveries were given the least value of 0.01 to take the Log.
Models V to VIII use the Instrumental Variable (IV) GMM estimator to control for the endogenous bias of Oil discovery, Institutional Quality (IQ), the interaction term (Log Oil Disc×IQ), and Prior change in GDP $\left(\frac{GDP\ per\ capita_{t}}{GDP\ per\ capita_{t-1}}\right)$.
The dependent variables in Models V, VI, and VII are taken from the Global Corruption Barometer (GCB) of Hardoon and Heinrich (2013). All models control for Latitude, Latitude (squared)Log of population growth, absolute latitude and time, and regional dummies of Sub-sahara Africa (SSA), South America, Middle East and North Africa (MENA), and South Asia.
All models report robust standard errors (in parenthesis) clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.

In Model VII, we find that citizens with more Oil agree less that corruption is a social problem, but improving institutions helps reduce the number of respondents who agree. In Model VIII, respondents in countries with more oil sizes are less likely to stay up in court to give evidence against corruption. The fight against corruption is costly, and information is needed to uphold social trust. In a recent study, Lee et al. (2019) found that distrust in institutions will result in less optimism about engaging in cooperative interactions that resolve corruption. Results of Model VII and VIII suggest that citizens in countries with more oil discoveries are less likely to be optimistic in the fight against corruption as it is seen as a collective action problem. Appendix III contains the corresponding first-stage regressions for Models V to VIII.

5 Colonialism, education and social trust in oil-rich countries

In this section, we explore the impact of the colonial experience on the level of illiteracy, defined as the percentage of adults (people aged 15 and above) who can read and write. Education and trust in others and the government are important in civic participation and how citizens effectively demand institutional reforms (Uslaner and Brown, 2005). The colonial educational system could have introduced theories supporting colonialism, insensitive to indigenous culture, and teaching language might not have been positively viewed in many quarters (Bolt and Bezemer, 2009). This may have denied a substantial part of the population access and introduced some inequality, which put the pro-colonial group, which eventually became the post-colonial indigenous elite, at a better advantage than the anti-colonial group, which ultimately became the non-elite.

We test this hypothesis in Table 5. We show in Model IX that colonized countries tend to have more adults who cannot read and write. Model XI shows the low number of literate channels through bequeathing weak institutions conditional on the colonial experience. Education matters for building trust, and trustworthiness is important for a successful institutional reform (Heinemann and Tanz, 2008; Bjørnskov and Méon, 2013). Trust has always been considered a measure of social cohesion in diverse societies, a necessary condition for the successful reform of institutions favoring accountability, and a keystone for successful economic development (Tilly, 1990; Algan and Cahuc, 2010). Trust and confidence among groups facilitated social cohesion in precolonial times and contributed to the legitimacy and survival of the administrative autonomy of the local states/kingdoms. A necessary step for the colonial imposition of weak institutions would be to break up traditions favoring social trust, cohesion, and administrative autonomy.

Table 5: Experience of Colonialism, Education enrolment, and Social trusts

Dependent Variables:	Log Illiteracy rate, adult total (% of people ages 15 and above)	Log Illiteracy rate, adult total (% of people ages 15 and above)	Log Illiteracy rate, adult total (% of people ages 15 and above)
	Model IX	**Model X**	**Model XI**
Colonized (Dummy = 1)	0.62***		
	(0.16)		
Institutional Quality (I.Q.)		0.049	-6.5***
		(0.66)	(0.78)
Log Depth	0.02	0.007	
	(0.03)	(0.04)	
Log depth (squared)	-0.016	-0.01	
	(0.02)	(0.03)	
Prior change in GDP/Capita	0.62	0.63	0.13
	(0.63)	(0.60)	(0.80)
Border before First discovery (Dummy =1)	-0.11	0.03	0.58***
	(0.16)	(0.18)	(0.10)
Country Independence after 1960 (Dummy =1)	-0.22	-0.27	-0.40**
	(0.21)	(0.21)	(0.12)
Pre-1900 Coal discovery	0.19	0.21	0.88***
		(0.20)	(0.12)
F-Statistics	28.47	23.25	26.27
First-stage F-stat			50.69
Under identification test			48.93
Weak identification test			29.58
Anderson-Rubin Wald test			257.13

Notes: Data covers 50 countries, discovering a giant oil field from 1960 to 2015. Years without significant discoveries were given the most negligible value of 0.01 for the depth to take the Log. All models control for Latitude, Latitude (squared) Log of population growth, absolute latitude and time, and regional dummies of Sub-sahara Africa (SSA), South America, Middle East and North Africa (MENA), and South Asia. Colonized dummy is defined as countries with settler mortality and non-European countries with European language as an official language.

Model IX is the reduced-form regression of illiteracy on the colonial experience. Model X regresses illiteracy in institutions, and Model XI shows that the colonial experience on the illiteracy level works through institutional quality.

All models report robust standard errors (in parenthesis) clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.

6 Conclusion

This paper examines the long-term link between European colonialism and contemporary institutional quality to provide a better understanding of the sharp disparity in cross-country observation of the resource curse across oil-rich countries. We test the hypotheses that (1) European colonization indirectly hinders the development outcomes, namely GDP per capita growth, by lowering institutional quality and encouraging corruption in colonized oil-rich countries and (2) better macro institutional quality mitigates the historically-rooted resource curse.

We test this hypothesis using a two-stage IV-GMM model and examine how European colonization indirectly reinforces the resource curse in 69 oil-rich countries with at least a discovery of giant oil reserves from 1960 to 2015. We show colonized countries have poorer institutional quality than non-colonized countries in the first stage. We also find that the oil fields' depth log correlates with the oil abundance's magnitude. The log of oil abundance negatively impacts income per capita after accounting for the initial level of economic performance and institutional quality. Countries with more oil abundance have negative growth in the second stage, but the institutional quality strongly impacts the resource curse.

Conditional on colonial heritage, we examine the channel of corruption. Corruption is a documented characteristic feature in many colonized oil-rich countries where corruption scandals are reported. Good institutions offer incentives for decision-makers to overcome "social dilemmas" arising from placing personal priorities (corrupt practices) above public interest (Ostrom, 2009). An increase in oil abundance is associated with the Corruption Index. After conditioning this relationship on institutional quality, the estimate suggests that the corruption index falls.

We explore the correlation between colonialism, education, and social trust. We find a big gap between primary and secondary education student enrolment in colonized and non-colonized countries, and countries with colonial heritage have less trust. These new empirical insights on the enduring impact of colonialism suggest that oil-rich countries wishing to reverse the resource curse should have structures that undo some of the negative implications of the colonial experience on the quality of institutions. For instance, by investing in education, social mobility would be enhanced, and the barriers to inequity introduced by colonial heritage could be reduced. In addition, institutions are likely to improve from informed and constructive debates, making both leaders and subjects learn, effectively communicate, and meaningfully collaborate continually, and strategies relating rent to socio-economic improvement.

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Appendix I

First stage Estimates of Model III of Table 3.1

	First Stage for IV (GMM) estimates (Model III)			
	A	B	C	D
	Log Oil (mmboe)	Institutional Quality	Interaction term	Log Prior change in GDP/Capita
Colonized (Dummy = 1)	-0.07**	0.12***	-0.81***	-0.002
	(0.3)	(0.01)	(0.13)	(0.004)
Log depth	2.66***	-0.01***	1.67***	0.001
	(0.05)	(0.004)	(0.09)	(0.002)
Log depth (squared)	-0.70***	-0.004	-0.30***	-0.0002
	(0.04)	(0.004)	(0.08)	(0.002)
Log GDP/Capita t − 3	0.15	0.09	-1.5	0.13***
	(0.11)	(0.09)	(1.12)	(0.04)
Log GDP/Capita t − 4	0.13	0.004	0.52	-0.14***
	(0.11)	(0.09)	(1.11)	(0.03)
F-Statistics of Excluded instruments	6537.18	173.65	483.61	7.74
Under ID (S.W.)	50.05***	42.98***	49.77***	18.77***
Weak ID (S.W. F-test of Excluded Instruments)	24.32	20.89	24.19	9.12

Notes: Data covers 69 countries with the discovery of at least a giant oil field from 1960-to 2015, and the dependent variables are the endogenous regressors of Log Oil, Institutional Quality, the Interaction term of

Institutional Quality and Log of oil abundance and are the log of change in GDP per capita in the year of discovery$\left(Log\,\frac{GDP\ per\ capita_{t}}{GDP\ per\ capita_{t-1}}\right)$. Variables on the left column are the instruments used. Robust standard errors are in parenthesis and are clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.

First stage Estimates of Model IV of Table 3.1

	First Stage for IV (GMM) estimates (Model IV)			
	A	B	C	D
	Log Oil (mmboe)	Institutional Quality	Interaction term	Log Prior change in GDP/Capita
Colonised (Dummy = 1)	-0.40	0.37***	-3.99***	-0.07**
	(0.33)	(0.07)	(0.83)	(0.03)
Log depth	2.73***	-0.035***	1.70***	0.0002
	(0.06)	(0.008)	(0.15)	(0.003)
Log depth (squared)	-0.68***	-0.02***	-0.25*	-0.0009
	(0.06)	(0.008)	(0.14)	(0.003)
Colonised × log Depth	-0.10	0.04**	0.09	-0.001
	(0.09)	(0.01)	(0.19)	(0.004)
Colonised × log Depth (squared)	-0.04	0.02**	-0.001	0.002
	(0.09)	(0.008)	(0.17)	(0.004)
Log GDP/Capita $t-3$	-0.20	0.34***	-4.26***	0.04
	(0.20)	(0.11)	(1.44)	(0.04)
Log GDP/Capita $t-4$	0.16	-0.21*	2.9**	-0.05
	(0.20)	(0.11)	(1.42)	(0.04)
Colonised × Log GDP/Capita $t-3$	0.09	-0.35**	4.33***	-0.03
	(0.25)	(0.13)	(1.67)	(0.06)
Colonised × Log GDP/Capita $t-4$	-0.05	0.32**	-3.91***	0.04
	(0.25)	(0.13)	(1.67)	(0.06)

F-Statistics of Excluded instruments	4245.08	123.27	247.38	2.56
Under ID (S.W.)	67.93	34.48	64.77	11.74
Weak ID				
(S.W. F-test of Excluded Instruments)	10.92	5.54	10.41	1.89

Notes: Data covers 69 countries with the discovery of at least a giant oil field from 1960 to 2015, and the dependent variables are the endogenous regressors of Log Oil, Institutional Quality, the Interaction term of Institutional Quality and Log of oil abundance and are the log of change in GDP per capita in the year of discovery$\left(Log\,\frac{GDP\ per\ capita_{\,t}}{GDP\ per\ capita_{\,t-1}}\right)$. Variables on the left column are the instruments used. Robust standard errors are in parenthesis and are clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.

First stage Estimates of Model V in Table 3

	First Stage for IV (GMM) estimates (Model V)			
	A	B	C	D
	Log Oil (mmboe)	Institutional Quality	Interaction term	Log Prior change in GDP/Capita
Colonised (Dummy = 1)	-0.027	0.03**	0.16	0.004
	(0.03)	(0.01)	(0.16)	(0.005)
Log depth	2.56***	-0.006	1.71***	-0.001
	(0.06)	(0.007)	(0.10)	(0.003)
Log depth (squared)	-0.76***	-0.004	-0.30***	-0.001
	(0.05)	(0.005)	(0.08)	(0.003)
Log GDP/Capita t − 3	-0.20*	0.16	-2.2*	0.13***
	(0.11)	(0.10)	(1.16)	(0.04)
Log GDP/Capita t − 4	0.19*	-0.06	1.24	-0.14***
	(0.11)	(0.1)	(1.15)	(0.03)
F-Statistics of Excluded instruments	6872.72	131.35	382.79	9.58
Under ID (S.W.)	40.94***	33.13***	41.03***	16.29***
Weak ID				
(S.W. F-test of Excluded Instruments)	19.70	15.95	19.75	7.84

Notes: Data covers 69 countries with the discovery of at least a giant oil field from 1960 to 2015, and the dependent variables are the endogenous regressors of Log Oil, Institutional Quality, the Interaction term of

Institutional Quality and Log of oil abundance and are the log of change in GDP per capita in the year of discovery$\left(Log\,\frac{GDP\ per\ capita_{\,t}}{GDP\ per\ capita_{\,t-1}}\right)$. Variables on the left column are the instruments used. Robust standard errors are in parenthesis and are clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.

First stage Estimates of Model VI in Table3

	First Stage for IV (GMM) estimates (Model VI)			
	A	B	C	D
	Log Oil (mmboe)	Institutional Quality	Interaction term	Log Prior change in GDP/Capita
Colonised (Dummy = 1)	-0.03	0.12***	-0.9***	-0.006
	(0.02)	(0.01)	(0.13)	(0.005)
Log depth	2.64***	-0.02**	1.71***	-0.001
	(0.05)	(0.01)	(0.10)	(0.002)
Log depth (squared)	-0.70***	-0.006	-0.31***	-0.002
	(0.05)	(0.005)	(0.1)	(0.002)
Log GDP/Capita $t-3$	-0.16*	-0.06	0.37	0.16***
	(0.09)	(0.10)	(1.13)	(0.04)
Log GDP/Capita $t-4$	0.14	0.17*	1.5	-0.17***
	(0.09)	(0.1)	(1.12)	(0.04)
F-Statistics of Excluded instruments	6376.21	140.18	329.99	12.80
Under ID (S.W.)	35.25***	32.02***	35.14***	23.43***
Weak ID (S.W. F-test of Excluded Instruments)	17.09	15.52	17.03	11.36

Notes: Data covers 69 countries with the discovery of at least a giant oil field from 1960 to 2015, and the dependent variables are the endogenous regressors of Log Oil, Institutional Quality, the Interaction term of Institutional Quality and Log of oil abundance and are the log of change in GDP per capita in the year of discovery$\left(Log\,\frac{GDP\ per\ capita_{\,t}}{GDP\ per\ capita_{\,t-1}}\right)$. Variables on the left column are the instruments used. Robust standard errors are in parenthesis and are clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.

First stage Estimates of Model VII in Table 3

	First Stage for IV (GMM) estimates (Model VII)			
	A	B	C	D
	Log Oil (mmboe)	Institutional Quality	Interaction term	Log Prior change in GDP/Capita
Colonised (Dummy = 1)	-0.03	0.11***	-0.63***	0.003
	(0.04)	(0.01)	(0.17)	(0.005)
Log depth	2.57***	-0.01	1.9***	0.001
	(0.06)	(0.006)	(0.10)	(0.002)
Log depth (squared)	-0.75***	-0.001	-0.43***	0.0004
	(0.06)	(0.005)	(0.09)	(0.002)
Log GDP/Capita $t-3$	-0.19	0.17	-2.87**	0.26***
	(0.14)	(0.12)	(1.45)	(0.04)
Log GDP/Capita $t-4$	0.17	-0.01	1.34	-0.27***
	(0.14)	(0.1)	(1.44)	(0.04)
F-Statistics of Excluded instruments	4753.50	356.08	507.39	12.09
Under ID (S.W.)	29.75***	27.36***	29.67***	38.13 ***
Weak ID (S.W. F-test of Excluded Instruments)	14.06	12.93	14.02	18.01

Notes: Data covers 69 countries with the discovery of at least a giant oil field from 1960 to 2015, and the dependent variables are the endogenous regressors of Log Oil, Institutional Quality, the Interaction term of Institutional Quality and Log of oil abundance and are the log of change in GDP per capita in the year of discovery$\left(Log\,\frac{GDP\ per\ capita_{\ t}}{GDP\ per\ capita_{\ t-1}}\right)$. Variables on the left column are the instruments used. Robust standard errors are in parenthesis and are clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.

First stage Estimates of Model VIII in Table 3

	First Stage for IV (GMM) estimates (Model VIII)			
	A	B	C	D
	Log Oil (mmboe)	Institutional Quality	Interaction term	Log Prior change in GDP/Capita
Colonised (Dummy = 1)	-0.03	0.14***	-0.93***	0.003
	(0.04)	(0.01)	(0.17)	(0.005)
Log depth	2.59***	-0.01**	1.9***	0.0001
	(0.06)	(0.006)	(0.10)	(0.002)
Log depth (squared)	-0.73***	-0.003	-0.40***	-0.001
	(0.06)	(0.004)	(0.09)	(0.001)
Log GDP/Capita $t-3$	-0.19	0.04	-1.74	0.28***
	(0.14)	(0.15)	(1.73)	(0.05)
Log GDP/Capita $t-4$	0.16	0.15	-0.13	-0.28***
	(0.14)	(0.15)	(1.73)	(0.04)
F-Statistics of Excluded instruments	4598.30	494.11	458.35	10.18
Under ID (S.W.)	30.28***	27.97***	30.21***	35.71***
Weak ID (S.W. F-test of Excluded Instruments)	14.17	13.09	14.14	16.72

Notes: Data covers 69 countries with the discovery of at least a giant oil field from 1960 to 2015, and the dependent variables are the endogenous regressors of Log Oil, Institutional Quality, the Interaction term of Institutional Quality and Log of oil abundance and are the log of change in GDP per capita in the year of discovery$\left(Log\frac{GDP\ per\ capita_{t}}{GDP\ per\ capita_{t-1}}\right)$. Variables on the left column are the instruments used. Robust standard errors are in parenthesis and are clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.

Appendix II

Tests of Validity of the Instrumental Variables

Validity of the instruments

A necessary condition for the reliability of instrumental variables rests on two conditions. First, the instruments are correlated with the endogenous regressor once the other exogenous explanatory variables from the structural equation have been partialled out. Second, the instruments are excludable as direct causes of current economic development (Angrist and Krueger, 2001). The instruments do not directly enter the equation (Eqn. 1) except through institutions. We can show that the instruments statistically correlate to the endogenous regressors through the first stage (Eqn.2) regression for the first assumption. Also, we can show that incentives of the post-colonial elite to reform the inherited institutions weakens as more giant oil reserves with significant oil wealth are discovered[6].

However, validating the second assumption, i.e., direct excludability and the correlation of the instruments with the error term, requires more profound intuition. The question is how the instrument's independence from an unobservable error process can be ascertained. There are no straightforward answers to this question, but we can deduce if this condition is fulfilled by testing. First, we use the commonly employed J statistic (Baum et al., 2003) to test for over-identification—i.e., whether the instruments are uncorrelated with the error process. Because our Model is overidentified, i.e., we have more excluded instruments than included endogenous variables, the Hansen j statistics tests whether the excluded instruments are appropriately independent of the error process by regressing the residuals from the 2SLS regression on all instruments (Baum et al., 2003).

Second, we estimate a reduced form model to determine causality from the correlation and test if current economic performance significantly influences colonization and the depth of oil fields. Strict exogeneity of the instruments implies that the causal effect in the conditional Model should operate entirely through endogenous regressors. Still, we can get the underlying background knowledge on the relationship between the instruments and the dependent variable with the reduced-form regression. Also, by employing reduced-form regressions of the instruments and other exogenous variables on the dependent variable (Angrist and Krueger, 2001), we can test if the instruments are significantly correlated with the income growth in Eqn. 3. The absence of statistical significance could imply that the instruments do not affect the outcome (Murray, 2006; French and Popovici, 2011).

$$Y_{i,t} = \lambda_1 Dpt_t + \lambda_2 Dpt_i{}^2 + \lambda_3 Coly_i + \lambda_4 Y_{i,t-1} + \lambda_5 Y_{i,t-2} + \sum_{j=n}^{k} \beta_j M + \varepsilon_{it} \quad 3$$

[6] This might probably explain why non-resource rich former colonies (e.g. Singapore) have been able to emerge from poverty and accumulate human capital. The lack of oil windfall endowment could have created a strong government that worked at creating reforms that are conducive for growth and entrepreneurship.

Where $Y_{i,t}$ is the measure of the Log of the long-run change in GDP per capita in a country, $i\left(\frac{GDP\ per\ capita_{\ t+5}}{GDP\ per\ capita_{\ t-4}}\right)$ as discussed in Eqn. 1.

Third, we use data from Comin et al. (2010) that documents the historic technology adoption to validate the colonial dummy instrument as not correlated with long-term development arising from precolonial technology adoption by running a separate regression to show that being a technologically advanced nation prior to colonization was not correlated with whether a country was colonized or not. Countries with early discoveries, adoption, and military, agricultural, transportation, and communication technologies could have avoided colonizing. Because these technologies can have an enduring impact on current economic activities (Comin et al., 2010), the validity of the colonial instruments could be invalidated. An alternative hypothesis upon which we validate our instrument is that while historical technology adoption matters for current development, it does not directly affect the decision to colonize. To illustrate this, consider the invention of gunpowder and shipbuilding technologies, which were well-developed in ancient China and the Middle East. Yet, these countries did not colonize other countries, nor were they able to successfully resist the invasion from European countries that later developed such technology. In essence, colonization was driven mainly by the socio-political competition among European superpowers, making them innovate, improve upon existing technologies, and colonize others. We argue that being a colony is not associated with the residual effect arising from historical technology adoption.

In Eqn. 4, we estimate the partial effect of precolonial agricultural, communication, military transportation, and industry technology adoption (circa 1500AD-2000AD) adjusted for international migration on the probability of being a European colony. We also include controls for the 1500AD urbanization index, log population, a dummy for landlocked nations, latitude and absolute latitude, and pre-1900 coal discoveries. The absence of statistical significance between colonial experience and these early (1500AD to 2000AD) technology adoption could validate our assumption.

$$Coly_i = \lambda_1 Tech_{i,t\geq 1500AD} + \lambda_2 \log Pop_{i,t\geq 1500AD} + \lambda_3 L_{\ i} + \lambda_4 U_{\ i} \sum_{j=5}^{7} \lambda_j M_{\ i} + \varepsilon_{it} \qquad 4$$

Where $Coly_i$ is a binary variable T_i is the index of technology adoption for agriculture, communication, military transportation, industry, and urbanization in a country circa 1500AD using Comin et al. (2010).

Fourth, to rule out other possible channels like ethnic, religious, and language fractionalization outside of institutions that can cause differences in the resource curse between colonized places and places that were not, we estimate a reduced-form regression to see if there is any correlation between these in Eqn. 5.

$$Fract_i = \lambda_1 Dpt_{it} + \lambda_2 {Dpt_{it}}^2 + \lambda_3 Coly_i + \lambda_4 Y_{i,t-3} + \lambda_5 Y_{i,t-4} + \sum_{j=n}^{k} \beta_j M_{\ i,t} + \varepsilon_{it} \qquad 5$$

Where $Fract_i$ is the degree of ethnic, language, and religious fractionalization in the country i.

Finally, we validate the use of depth as an instrument for the size of discoveries and show, using reduced-form models, that deeper wells are not found in richer countries and that depth is not correlated with the initial endowment level (Oil initially in place). In contrast to geological features that rely on the Fraction of the country covered by sedimentary basins (Cassidy, 2019), we show that the geologic features are relatively uncorrelated with GDP and may provide a better approach to isolating the effect of the size of oil discoveries.

In this section, we consider various arguments that might affect the validity of our instrument. To test that being a colony and that the other instruments of depth and lag GDP do not directly affect current economic growth and corruption, we run a reduced form specification in Table 6. The result confirms that the relationship between the instruments on the outcomes (main Model) is uninformative (Angrist and Krueger, 2001; Murray, 2006; French and Popovici, 2011). Table 6 gives us two possible reasons to justify our instruments choice. First, the instruments are not significantly correlated with the outcome measure of income growth. Second, the estimates tell us the causality of the colonial experience and the Log of oil fields' depth on income per capita growth in oil-rich countries. Second, from the signs on the instruments, we can deduce the plausible causal ordering of our instrumental variable on the observed outcome (Cartwright, 1989; Bazinas and Nielsen, 2015).

Table 6: Reduced-form regressions for the test of the validity of instruments on economic and corruption outcomes

Dependent Variables	**Log ΔGDP $_{i,t+5}$**	**Corruption Perception Govt Officials Most (% respondents)**	**Corruption Perceptions Index**	**Would spend a whole day in court to give evidence: agree (% respondents)**
	Model XII	**Model XIII**	**Model XIV**	**Model XV**
Colonized (Dummy = 1)	-0.04	-0.09	5.36	0.13
	(0.04)	(0.09)	(3)	(0.11)
Log Depth	0.006	0.006	-0.56	-0.004
	(0.014)	(0.008)	(0.50)	(0.009)
Log depth (squared)	-0.009	0.006	-0.45	-0.004
	(0.01)	(0.006)	(0.36)	(0.005)
Log GDP 3 − year lagged	0.19	-0.06	-2.49	0.006
	(0.21)	(0.09)	(6.10)	(0.08)
Log GDP 4 − year lagged	-0.28	0.08	11.59	0.04
	(0.22)	(0.09)	(5.91)	(0.09)
F-stat	82.47			
Root MSE	0.26	0.11	10.54	0.11

Notes: Data covers 69 countries, discovering a giant oil field from 1960 to 2015. All models control for two years lagged levels of GDP per capita, Latitude, Latitude (squared) log of population growth, absolute latitude and time and regional dummies of Sub-sahara Africa (SSA), South America, Middle East and North Africa (MENA) and South Asia.
All models report robust standard errors (in parenthesis) clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.

Because colonized countries are likely to be artificial states that are more fractionated in terms of ethnicity, language, or religion than non-colonized states (Alesina et al., 2011), this can constitute additional channels outside of institutions that affect how the resource curse (Hodler, 2006) because our samples were selected based on giant oil discoveries. We expect this selection to be exogenous to European colonialization and other recognized residual effects of colonization that can constitute channels for development. In Table 7, we show that regression of the instruments on the ethnic, religious, and language fractionalization is insignificant and adds no additional information.

Table 7: Colonial Experience and Fractionalisation

Dependent Variables	**Ethnic fractionalization**	**Language fractionalisation**	**Religious fractionalisation**
	Model XVI	**Model XVII**	**Model XVIII**
Colonized (Dummy = 1)	0.03	-0. 03	0.02
	(0.09)	(0.09)	(0.07)
Log Depth	-0.008	-0.009	0.002
	(0.01)	(0.01)	(0. 009)
Log depth (squared)	-0.004	-0.003	-0.006
	(0.007)	(0.007)	(0. 007)
Log GDP 3 − year lagged	-0.19	-0.17	-0.06
	(0.13)	(0.12)	(0.18)
Log GDP 4 − year lagged	0.2	0.15	0.09
	(0.13)	(0.12)	(0.17)
Root MSE	0.16	0.18	0.18

Notes: Data covers 69 countries discovering giant oil fields from 1960 to 2015. All models control for the year of independence dummy, Latitude, Latitude (squared) log of population growth, absolute latitude and time, and regional dummies of Sub-sahara Africa (SSA), South America, Middle East, and North Africa (MENA), and South Asia. All models report robust standard errors (in parenthesis) clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.

Consistent estimation of the long-run effects of oil discoveries requires depth, as instruments for the size of discoveries are orthogonal to institutional quality and other important country characteristics. Previous cross-country studies have relied on initial subsoil assets (e.g., Van der Ploeg and Poelhekke, 2010; Tsui, 2011) and geological features like the proportion of sedimentation basins as instruments. These could be problematic if initial endowments and the distribution of oil basins respond to economic or political factors (Cassidy, 2019).

Table 8 shows that depth as an instrument for the size of discoveries is not found in richer countries. In contrast to geological features that rely on the Fraction of the country area covered by sedimentary basins (Cassidy, 2019) and initial level of endowment (oil initially in place) (Cotet and Tsui, 2013), we show that the geologic features of depth are relatively uncorrelated with GDP and may plausible provide a better approach to isolating the effect of size of oil discoveries.

Table 8: Geological Features and Economic and Institutions

Dependent Variables	Log Depth of oil fields.	Log Depth of oil fields (squared)	Total oil-initially-in-place (ln) (Cotet&Tsui, 2013)	Fraction of country area covered by sedimentary basins (Cassidy 2019)
	Model XIX	**Model XX**	**Model XXI**	**Model XXII**
Log GDP	0.06	-0. 03	0.44**	0.04*
	(0.04)	(0.05)	(0.2)	(0.02)
Institutional index	-0.18	0.08	-1.28	-0.09
	(0.18)	(0.17)	(0.82)	(0.13)
F-stat	42.47	36.55	62.16	232.75
Root MSE	0.95	1.03	1.26	0.19

Notes: Data covers 69 countries discovering giant oil fields from 1960 to 2015. All models control for Latitude, Latitude (squared)Log of population growth, absolute latitude and time, and regional dummies of Sub-sahara Africa (SSA), South America, Middle East and North Africa (MENA), and South Asia.
All models report robust standard errors (in parenthesis) clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.

Historical technology adoption may affect subsequent economic development by facilitating pre-and post-industrial revolution technologies (Comin et al., 2010). It is also possible that places with significant technology adoption may be difficult to colonize and resist because of the sophisticated military technology usage. Finally, we verify that early technology adoption and urbanization *circa* 1000BC, both of which could have a persistent long-term effect, are uncorrelated to being a colony. We run a reduced-form regression of the status of being a colony on each technology adoption in agricultural, military, industry, and the sectoral indexes in 1500 AD while also controlling for other covariates in Table 8.

Our results in Table 9 show that the colony dummy is uncorrelated to historical technology adoption. Early access and use of technology (military, agriculture, communication, transportation, and industry) around 1500AD, which could also have an enduring impact on subsequent economic performance (Comin et al., 2010), are uncorrelated to what made a location a colony (Table 8).

Table 9: Historical (1500AD) Technology Adoption and Urbanisation and the Resistance to Colonial Invasion

	Independent Variables			
	Average technology adoption in	Average Military Technology	Average technology adoption in	Average of the sectoral technology

	agriculture in 1500AD	Adoption in 1500AD	industry 1500AD	adoption indexes 1500AD
Dependent variable	**Model XXIII**	**Model XXIV**	**Model XXV**	**Model XXVI**
Colonized (Dummy = 1)	-0.19	-0.009	-0.12	-0.16
	(0.26)	(0.16)	(0.17)	(0.21)
R(Squared)	0.71	0.72	0.7	0.71
F-stat	28	29.5	30	29.08

Notes: Data covers 47 countries with the discovery of at least a giant oil field. The technology adoption variables in Models XXIII, XXIV, XXV, and XXVI are taken from Comin et al. 2010 https://www.aeaweb.org/aej/mac/app/2008-0131_app.pdfand are adjusted for 1500AD international migration.
All models control for log population (1500AD), urbanization index (1000BC to 1AD), landlocked country dummy, pre-1900 coal discovery dummy, absolute latitude and regional dummies of Sub-sahara Africa (SSA), South America, the Middle East and North Africa (MENA) and South Asia.
All models report robust standard errors (in parenthesis) clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.

Appendix III

Additional Robustness: Oil wealth and Disaggregated Institutional Index components

This section examines specific issues with measurements employed and whether alternative measurement options would change the results. First, the oil abundance measured is the magnitude of the number of oil discoveries. This measurement does not take into account the monetary value of the discoveries. As shown by Brunnschweiler and Bulte (2008) and Van der Ploeg and Poelhekke (2010), using the value of resource wealth (the value of the subsoil resources) is a better measure of resource abundance. Oil discoveries could shock the economy via the potential contribution to government finances. Accounting for the monetary value of the oil abundance might be a better way to check the robustness of the impact of oil discoveries on the income per capita. Low prices of oil reserves may not be as stimulating as when the reserves per barrel are high. Table 10 (Model XXVII), using the value of oil wealth, does not change our result.

Also, we disaggregate institutional quality and consider each component to assess its relative impact on reducing the change in income per capita (Models XXVIII, XXIX, and XXX). However, from a practical perspective, it is important to identify which institution matters. The aggregated institutional quality tells us little about specific governance reforms that will reliably improve poverty and development outcomes (Acemoglu and Johnson, 2005). Importantly, changing the entire institutional regime from a political and social perspective may be impossible. In contrast, efforts can be intensified by identifying which aspects of institutions are beneficial.

From a measurement perspective, our measure of institutional quality is the unweighted average component of three institutional quality indicators of unequal years; it is possible to have introduced a measurement bias in the unit of institutional quality used. For instance, a country might have a higher risk of expropriation but low government effectiveness. Besides, a country can have limited observations for a particular component in years where it performed better and more when it performed poorly.

We unbundled the institutional quality indicators and ran separate regressions for the disaggregated indicators of average risk against expropriation, executive constraints, and government effectiveness in oil-rich countries (Table 10). Taken independently, the components of the institutional quality are not as important and offer limited information in translating the impact of oil discoveries on growth. Nevertheless, countries with higher executive accountability constraints (Model XXVIII) can significantly reduce the lower growth associated with oil discovery.

This result is surprising because it contrasts with previous evidence pointing to property rights that guarantee private and domestic ownership as the most important institution (Luong and Weinthal, 2010)—changing property rights only tinkers institutions at the economic margins. In contrast, imposing restraint that improves accountability facilitates an infinite variety of interactions that allows more efficient and transparent utilization of the available resources.

If restraints placed on the chief executive's scope for unilateral action increase due either to "answerability," liability," or the expectation of account-giving, fewer rents will be less incentive for "the misuse or the abuse of public office for private gains." Importantly, if constraints are imposed on the executive, there will be a limit to corrupt practices, misappropriation of public funds, and less exposure of private investments to executive predation.

Table 10: Measures of Oil wealth, Oil Discoveries, and Disaggregated Institutional quality

Dependent Variables	**Log ΔGDP $_{i,t+5}$**	**Log ΔGDP $_{i,t+5}$**	**Log ΔGDP $_{i,t+5}$**	**Log ΔGDP $_{i,t+5}$**
	Model XXVII	**Model XXVIII**	**Model XXIX**	**Model XXX**
Log Oil-Wealth (US$/barrel)	-0.06**			
	(0.02)			
Log Oil Discovery (mmboe)		-0.06**	-0.05	0.0002
		(0.02)	(0.08)	(0.004)
Institutional Quality (I.Q.)	0.19			
	(0.38)			
Executive constraints		0.05		
		(0.05)		
Expropriation risk			-0.01	
			(0.17)	
Government effectiveness				-0.21
				(0.13)
Interaction Term (Log Oil ×I.Q.)	0.10**	0.02***	0.007	0.002
	(0.04)	(0.005)	(0.01)	(0.01)
Prior change in GDP/Capita $Log\left(\frac{GDP\ per\ capita_t}{GDP\ per\ capita_{t-1}}\right)$	2.6***	1.96**	6.43	2.91***
	(0.98)	(0.98)	(5.92)	(0.96)

1900s Coal Discoveries	0.09***	0.04**	0.08	0.10***
	(0.02)	(0.02)	(0.08)	(0.02)
Border before First discovery (Dummy =1)	-0.006	-0.05***	-0.04	0.02
	(0.02)	(0.02)	(0.02)	(0.02)
Country Independence after 1960 (Dummy =1)	-0.04	0.06**	0.01	-0.05
	(0.03)	(0.03)	(0.04)	(0.03)
Net marginal effect of Oil Discovery	0.04**	-0.04**		
Estimator	IV (GMM)	IV (GMM)	IV (GMM)	IV (GMM)
Hansen J test				
(Over-identification test of all instruments)	1.90	0.923	1.095	2.088
Under-identification test				
(Kleibergen-Paaprk LM statistic)	28.443	14.949	1.624	18.164
Weak-instrument-robust inference				
(Anderson-Rubin Wald F-stat)	73.32	63.07	64.78	73.32

Notes: Data covers 69 countries, discovering a giant oil field from 1960 to 2015. Years with no significant discoveries were given the least value of 0.01 to take the log.

All models control for Latitude, Latitude (squared) log of population growth, absolute latitude and time, and regional dummies.

All Models use an Instrumental Variable (IV) GMM estimator to control for the endogenous bias of Oil discovery, Institutional Quality (I.Q.) (both in aggregates Model XX) and disaggregated (Models XXI, XXII, and XXIII), the interaction term (Log Oil Disc×I.Q.) and Prior change in GDP $\left(\frac{GDP\ per\ capita_{t}}{GDP\ per\ capita_{t-1}}\right)$. The instruments are Colony (Ci) dummy, log depth of oil field, log depth field(squared), and 2-year lagged levels of GDP, respectively.

Model XXVII measures oil abundance with the monetary value of the discovery in terms of US$ per barrel.

Models XXVIII to XXX measure the disaggregated institutional index individually.

All models report robust standard errors (in parenthesis) clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.