# Oil and Development: Technology, Geology, and the 'Curse' of Natural Resources

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## Abstract

In this paper we build upon our earlier research (Brooks and Kurtz 2016) to challenge the conventional wisdom about the putative 'curse' of natural resources. In doing so, we make a potentially controversial claim: that not all "oil wealth" is a curse. Rather, we argue that it is only the "easy to get" oil that can be associated with the pernicious developmental outcomes, while "hard to get" oil, such as that extracted through higher technologically-intensive methods, is not a curse for political development. Our empirical analysis employs a novel approach, by starting with the characteristics of more than 7,000 oil fields around the world to understand the technological intensity, and hence 'rent' possibilities for each field. We aggregate these data by country and find that indeed the oil that is extracted through highly capital-intensive processes has a positive, rather than detrimental, effect on democratic development. In making the argument, we emphasize the importance of domestic technological development, human capital, and the interdependence of regime types.

Work in progress – Comments Appreciated!

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Nearly twenty years after Sachs and Warner's seminal papers (1995, 1999) detonated a discussion about the relationship between natural resource endowments and slow economic growth, a veritable cottage industry of "resource curse" scholarship has emerged. Since that time scholars have linked substantial natural resource wealth to myriad political ills, from corruption and administrative bloat, to civil conflict, to pervasive clientelism, and ultimately to authoritarian rule. This has been especially the case for one particular (and particularly important) natural resource: oil. And it takes only a brief glance at the political characteristics of the petro-states of the Middle East and Central Asia for a *prima facie* foundation for the linkage between oil and authoritarianism to become apparent.

At the same time, however, serious cracks have begun to emerge in the one-regnant consensus linking oil to pernicious and authoritarian politics. Indeed, the most recent wave of resource curse scholarship has suggested the negative effects of oil wealth are in fact conditional – on public versus private ownership (Jones-Luong), pre-existing levels of administrative capacity (Karl), inequality in the non-resource sector (Dunning). Others have suggested that while natural resource wealth does not directly induce authoritarian political development, natural resources instead stabilize whatever the incumbent regime type might be (Smith) – which tends to be authoritarian in much of the developing world. Finally, in a very contemporary and probably the most methodologically rigorous study of the linkages between oil wealth and political regime, Haber and Menaldo (2011) are unable to detect any clear association (either positive or negative).

Thus after twenty years of serious scholarship, we are probably further from a consensus as to the effects of resource wealth on politics today than we were a decade or more ago. This article makes a potentially controversial claim: not only is natural resource wealth in the form of oil *not* a political curse – seconding Haber and Menaldo on this point – but rather it is under particular circumstances a direct blessing from the perspective of democratic development. But how can such a contention be leveled against a conventional wisdom that asserts a strong claim for the existence of a resource curse – in a direct or at least a conditional form? And what is the causal mechanism connecting natural resource wealth to democratic political development?

In this paper we will seek to address both questions. To begin with, we contend that most analyses of the political resource curse suffer from measurement and design inadequacies that have rendered their empirical tests far from determinative. Some studies have substituted "resource exports" for "resource wealth" in their definition of petro-states, thus introducing pernicious sample selection problems by virtue of a poor translation from concept to measure. Others, however, have more accurately directly examined the income earned from oil production – regardless of whether the product was consumed domestically or exported. This is much better, but still quite inadequate to the task for the testing resource curse contentions. For all these arguments share one signal characteristic: the claim that easy-to-tax, above-normal profits available in the oil sector form the fiscal foundation for pernicious political outcomes.

But examining the total income of the oil sector in any particular country tells us little about the availability of "rents" for use by political elites. For assessing oil income on the basis of oil sales alone is akin to assessing the profitability of a corporation by looking only at gross revenues. For without a sense of *costs* it is impossible to know whether production was profitable, loss-making, or profitable at a level that might fund the enormous expenditures required to construct and maintain the sorts of clientelistic authoritarian political systems that are seen as the likely political outcomes in resource curse scholarship. This problem, of course, would not be a big problem if the cost of producing oil were largely the same for all producing countries. But exploration, drilling, and production costs for oil vary massively not only by country but also by individual oil field. And even though some oil production will produce just the sorts of rents that resource curse scholars expect, others will produce normal rates of profit comparable to other industries in the economy, and still others will be marginal-to-loss-making endeavors. A more definitive test of the resource curse must thus drill down into the assumption that all oil income is the same – and seek to sort out the degree to which it represents easy-to-tax and enormous "rents" versus much more marginal and hard to extract ordinary rates of profit.

The second principal problem with examinations of the natural resource curse has little directly to do with natural resources. Instead, it has to do with the more general determinants of political regime outcomes. While scholars have long been aware that patterns of democratic transition (and, for that matter, authoritarian reversal) tend to come in "waves," and that these waves very often operate at the regional level, there has been little concrete effort to understand what this means from a theoretical perspective. Very importantly, this sort of bundled timing of allegedly-independent regime-producing events strongly suggests that international diffusion processes are at work. Given, however, the regional clustering of both oil resources and political regime types, interdependencies like this could well generate spurious relationships that mask the true linkages between oil wealth and democracy. Our approach is to explicitly model this spatial dependence in order to improve our estimates of relationship between oil wealth (and its type) and politics.

There is one further threat to accurate assessment of oil wealth's effects on politics – in an argument made elsewhere (Brooks and Kurtz 2016) we have shown that oil wealth is itself potentially endogenous to the political regime. Building on the insights of Wright and Czelusta (2004), we understand oil endowments not as fixed gifts of nature, but rather as quantities that are very much amenable to policy-induced change. That is, investments in research and development, improved oilfield management, alternative drilling and discovery techniques, and new ways to operate formerly "depleted"[1] oilfields can very sharply improve both reserves and output. The ability of states to pursue more technologically sophisticated forms of oil discovery, drilling, and production is, however, related to human capital infrastructure and public and private investments in this and related sectors. But investment and human capital formation are also linked to the political regime, with democracy being particularly auspicious for the development of human capital. And as a consequence, there is a real possibility of an endogeneity between the political regime and the oil income of a country – an endogeneity that we must further correct if we are to have an accurate assessment of the relationship between oil wealth and political regime outcomes.

[1] Very importantly in this regard, oilfields are not "depleted" because there is no more appreciable subsoil oil within them. Rather, fields have been regarded as depleted because inaccessible oil pockets have formed, internal well pressures have fallen, or rock formations were of a type that impeded the flow of oil. But all these problems have recently been transformed through technological innovations such hydraulic fracturing, horizontal drilling, the injection of water and other fluids into older wells, etc.

As we shall see below, our ultimate claim begins with the rejection of the conventional wisdom. We do not find that oil is always curse. But beyond this observation, we move a step further: under a substantial set of circumstances, oil wealth is by contrast a blessing with respect to the political regime. Why are our findings so different from much of the conventional wisdom? It is our contention that the empirical claims made in resource curse (or conditional curse) formulations have been assessed in flawed ways – both by misconceptualizing and mismeasuring resource wealth at the outset, and by failing to address problems of diffusion-induced non-independence and endogeneity.

**What is Oil Wealth?**

The focus of this paper is on the consequences of national ownership of large amounts of natural resource wealth. This is in keeping with the general practice of substantial subsets of the literature on the natural resource curse. At the same time we are explicitly avoiding an alternative formulation, which emphasizes public sector *dependence* on the natural resource sector. This alternative operationalization occurs in different forms – Ross (2001), for example, focuses on the ratio of oil exports to gross domestic product; Jensen and Wantchekon (2004) use an ordinal measure that captures the captures the share of fuel, mineral, and metal exports in overall merchandise exports; and Haber and Menaldo (2011) include as one of their metrics – though with the proper qualification – the fiscal reliance of the state on oil taxes of one form or another.

*Why not resource dependence?* At its core, we do not focus on resource dependence as a primary explanatory factor precisely because its various constructions in different ways would artificially stack an empirical test in favor of a finding of a resource curse. Consider fiscal reliance – the revenue sources that are relied upon by states are political choices conditioned in part by institutional capacities. That is, states make choices to tax one sector versus another, or to impose comprehensive indirect and direct taxation or not. Similarly, they choose whether or not to invest in the construction of better, more effective institutions (especially revenue-collecting ones). But unless these are *not* choices, but rather the inevitable consequences of natural resource endowments, using fiscal dependence as the key measure of resource wealth produces a profound selection effect: states that build strong taxation institutions and choose to impose broad based taxation will be seen as not oil reliant even if (1) they have quite a lot of oil wealth, and (2) they use those rents to build stronger institutions, which are in turn used in part to collect more and different taxes. In this way the causal mechanism underlying resource curse scholarship – that the access to allegedly easy oil "rents" will induce institutional atrophy, corruption, and authoritarian politics – becomes tested in a sample that recodes those with strong institutions as not resource reliant regardless of the scope of their resource wealth. A focus on exports is similarly but more indirectly problematic – for here, we must consider that a dependence on primary products in exports is only partially a problem of resource dependence. It is also implicitly a failure of broader efforts at industrialization (that would enable the successful export of non-fuel or mineral manufactured goods). But the states that fail at industrialization are likely to be characterized by myriad other maladies (inequality, weak institutions, corruption, inter alia) that are associated with authoritarianism. And in so doing, the reliance on measures of fuel exports as a share of merchandise exports (or of GDP) will select the better governed, more democratic, and more industrial countries out of the "resource rich" category even when they are manifestly resource rich.[2] And thus a spurious correlation would obtain.

We are left then with looking at resource wealth directly – that is, the revenues generated by the oil sector. But here we face a secondary problem of substantial importance. Haber and Menaldo (2011, 5) in their seminal piece on the resource curse have constructed a measure of total oil income (the per capita proceeds from the sale of crude oil). This captures the annual flows generated off the stock of oil reserves. The problem, however, is in moving from this measure of the proceeds of oil sale (and to their credit, domestic and international sales are treated equivalently) to the theoretically operative category of "resource rents," heroic assumptions are required. While this approach marks a sharp improvement over

[2] Consider briefly that any of these approaches would suggest that the United States, Norway, and Canada are not particularly resource rich. Norway, despite massive oil wealth relative to its population manages to tax other activities at *very* high levels. Similarly, the U.S. and Canada used their natural resources to produce long-run processes of industrialization which in the former case rendered the country a net importer of oil despite being the world's largest oil producer, and in the latter sharply reduced oil's share in exports and GDP relative to what it would have been without industrialization.

earlier work, more refinement is needed. For what we do not know – and cannot know with oilfield-level specificity – is what the profitability of oil production is. But this is crucial for resource curse theory departs from the central point that oil production produces rents – returns in excess of the normal rate of profit. But simply having data on the proceeds of sale, without a sense for discovery, drilling, and production costs and their related amortization, we have no idea whether rents are being produced at all, never mind whether they are successfully taxed by the state. One might make the simplifying assumption that costs of production are universally low – *and equally so* – across countries, rendering total income a direct correlate of resource rents, but both parts of that assumption are demonstrably wrong. Indeed, the littering of the globe with bankrupt oil companies suggests that oil production and exploration is anything but a sure thing or always a source of 'easy money.'

What we do know, however, is that some types of oil are more difficult and expensive to find and extract than others. Others may be easy to find, but technologically difficult to recover, and costly to refine (such as 'heavy oil') and therefore yield a considerably lower profit per barrel compared to conventional (Brent) oil. The heavy oil of the Western Canadian 'tar sands' and Venezuela's Orinoco basin are prime example of this less-profitable and more technologically-intensive resource. For even where heavy oils are located near the surface, and thus 'easy to get' the high viscosity and density of the oil means that recovery rates (the amount of oil extracted from a reservoir) can be quite low unless more expensive methods such as heat and chemical upgrading are employed in the extraction process. Even then, the cost of transporting and refining heavy oils cuts dramatically into the per-barrel profitability compared to Brent oil.

Even conventional oil, however, may be 'hard to get' in terms of the cost and difficulty of exploration and drilling. One of the most important factors differentiating easy and hard-to-get oil is whether the oil is located onshore or offshore, particularly if the latter is in deep water. In such contexts the challenges of exploration, drilling, and extraction are technologically demanding and exceedingly costly. Given that deep-water exploration has now commonly reached more than two miles below the surface of the ocean, where the extremes of temperature, pressure and distance from the platform mean that the costs of discovery and extraction are high, the risks of catastrophe more severe, and overall operation and maintenance are slower and more costly than on-shore exploration. For example, whereas an oil well on land may take as few as ten days to drill, completion of offshore wells may take more than a month and cost $100 million or more to prepare for extraction (including casing and cementing the well, displacing fluids, stimulating the reservoir, etc.) Even though new deep and ultra-deep water reservoirs have been detected in an increasing number of locations off the shore of Africa, the Middle East, and Gulf of Mexico, there remain only a few dozen companies that possess the technical and physical capacity to explore and produce within them. The consequence is that for governments that lease these exploration rights to those firms, the ultimate revenue that flows to the government will be much lower after the operating costs are accounted for in the exploration contract. And, as fields age, their natural pressures decline, and lack of porosity in the geological formation can become more challenging to manage – continued production requires substantial ongoing investments and the use of new, and expensive, horizontal drilling and/or hydraulic fracturing processes. Indeed, as conventional wells age, drilling into unconventional sources like shale and 'tight' rock formations has prompted the development of ever more sophisticated, and more expensive, technologies. Today's newest oil wells, therefore, are achieving depths, temperatures and distances from the operating facilities in geological formations that were considered beyond reach even a decade ago (Osman, 2017). In the case of the deep-water Gulf of Mexico discoveries, development of the Paleogene resources (Lower Tertiary) has involved fracturing tight rock reservoirs at high pressures, extreme temperatures and depths below the salt layers and involving tremendous upfront capital investments on the part of the operators that are likely to reduce considerably any 'windfall' of oil revenue to the Mexican Government.

In light of these varying costs of production – both over time and across location – a critical effort we make in this paper is to consider not simply *how much* oil and country produces (at whatever the global mean price is at that time), but also *what kind* of oil it produces. Here we introduce oilfield level measures designed to discriminate costly, technologically demanding oil production from less-expensive, rent generating forms. For if the arguments of the resource curse scholars are correct, the latter should produce pernicious effects or perhaps more pernicious effects relative to the former. In the section that follows, we will describe our strategy for characterizing the reserve holdings if each individual oil-producing country. The key challenge, however, is that a single country can be home to a wide variety of different types of oilfields, and these can vary massively in terms of the cost to discover, extract, and manage the production operations. Our strategy thus begins with a comprehensive global mapping of oilfields, which we then match to the geographic boundaries of individual states. We have created a composite measure of difficulty of oil extraction, identified at a field-specific level, from which we create a weighted average (weighted by field-specific production as a share of total national production), that should capture the average difficulty involved in producing the oil extracted in a particular national territory. This measure is then used in a country-level based analysis of the resource curse.

**Getting an Accurate Estimate: Diffusion Processes and the Importance of Neighborhood**

It has become customary of late in research on the relationship between natural resource wealth and regime outcomes to at least tip one's hat at the possibility that diffusion effects help to shape processes of political development. This is an important step forward, and one that has the potential to upend findings with respect not only to the resource, curse but other major literatures that focus on the cross-national determinants of political regime outcomes (see, for example, Lipset 1959, Przeworski et al. 2000, Boix and Stokes 2003, Acemoglu et al. 2006). For implications of cross-national diffusion are in some ways potentially worse than garden variety omitted variable bias. Diffusion processes, by their nature, imply that the outcomes of particular cases (national level political regimes, here) are decidedly *not* independent of other cases in the data. And this implies that the inferences we seek to draw are potentially highly misleading unless these interdependencies are properly modeled.

With respect to the resource curse, the possibility of cross-national diffusion processes is particularly troubling. To begin with, with respect to regime outcomes, there is a strong theoretical case to be made that such processes will operate primarily at a regional or subregional level. That is, it is difficulty to make the case that regime outcomes in one country will be affected equally by regime outcomes everywhere else in the world. And in many cases, it is likely that no meaningful case for diffusion can be made – there is no reason to believe, for example, that the presence of democracy in Austria has any particular impact on political development in Vietnam (or vice versa). Unfortunately, the most common treatment for the possibility of diffusion is the inclusion of a control in cross-national, time-series models for the proportion of democracies in the world – positing precisely this sort of equally-weighted, universal diffusion.[3]

At the same time, however, there is strong case to be made that meaningful processes of diffusion *can* and do operate at a much more local (regional and subregional) level. To begin with, there is very likely a regional effect inducing a certain amount of isomorphism in particular localities. The most obvious situation in which this would occur is when a regional organization induces a certain amount of coordination around a particular regime form. So, for example, the European Union places member states (and would-be member states) under very considerable pressure to conform to democratic norms.[4] The same, of course, can happen with respect to the stabilization of authoritarian political systems. At an earlier period in time in the Latin American region, myriad authoritarian governments cooperated to support each other's hold on power, both diplomatically, and through the internationalization of intelligence and repressive resources through Operation Condor. In the Middle East, wealth authoritarian petro-states have often been financially very supportive of similarly authoritarian political allies throughout the region – a fact that while not necessarily intended to *promote* authoritarianism, can likely have that effect, regardless.

[3] Actually, such a control is slightly more inadequate, for of course the reference country of interest is always a component of the "proportion" of democracies in the world, implying at least a small amount of diffusion from a country to itself.

[4] There is little doubt that this has helped to stabilize nascent democracy in some cases (as in Iberia or Eastern Europe), or to prevent even minimal backsliding (as in the case of Austria when Jörg Haider's Freedom Party entered government). Similarly, at a time when nearly the entirety of the Latin American region was characterized by political democracy, a coup attempt in Venezuela was met with fierce resistance organized under the auspices of the Organization of American states, which was married by the direct pressures of other important countries within the region to reverse the ouster of President Hugo Chávez. Notably, these pressures were exerted even as Chávez was far from universally respected, and even from countries led by governments of far different partisan color.

It should be noted as well that these pressures that conduce toward institutional isomorphism in the political regime are consistent with the dynamics of stability and change of political regime. For transitions (both to authoritarianism in an earlier era and to democracy in the more contemporary period) quite frequently are observed in a wave pattern – precisely what one would expect were mimetic diffusion processes at work. Notably, particularly with respect to democratization, not all of these diffusion processes are mediated by government action or elite behavior. Citizen pressure, and reaction to regional demonstration effects can induce similar outcomes – precisely what one observes in the wake of the collapse of authoritarianism in Tunisia and the subsequent "Arab Spring," or the wave of democratization that swept the Latin American region in the 1980s (in, for example, Peru, Argentina, Uruguay, Brazil, and Chile). Accordingly, and in light of previous findings on the interdependence of regime types (Starr 1991; Brown and Gleditsch 1998; Gleditsch and Ward 2006; Brooks and Kurtz 2016) we must control regional peer effects in our analysis of political regime outcomes.

**Getting an Accurate Estimate 2: Endogenous Oil Wealth**

A final piece of the conventional wisdom in studies of the political resource curse must be directly addressed. Most treatments have taken a country's endowments of oil to be essentially a fixed, exogenous quantity that is unalterable in anything other than geologic time. But recent scholarship has begun to suggest that oil resources are far from fixed, and that for practical purposes reserves are more frequently a function of the technology available to particular states or producers to discover, extract, and manage them (e.g., David and Wright 1997; Stijns 2006).[5] But these technologies and the deployment of them are amenable to change through public action. In particular – in earlier work – we have made a

[5] Very notable in this regard is the return of production to oilfields once thought of as at the end of their lifespans in the United States. While much ink has recently been spilled about new production coming out of oil reservoirs made accessible by hydraulic fracturing, similar innovations have returned previously played out fields in the oil belt to production. And as a consequence the United States is on track to return to the top of the hierarchy of global oil production – despite a hundred year history of intensive extraction – even as proven reserves in countries with in principle more-accessible oil are declining.

connection between the scope of oil endowments and human capital investments, which are in turn, of course, connected in the literature to the presence of democratic political systems.

This of course raises a final concern: that the relationship between oil wealth and democracy might be characterized by a potential endogeneity. Democratic politics may produce greater public investments in human capital – and this in turn can affect the endowment of oil that is available in a particular state. The critical point is that where human capital stocks are high and public investments are made in developing them, particularly as they relate to the oil- or related industrial sectors, this can lead to the discovery of substantial new sources of oil (in more difficult-to-access locations) or the improved management and utilization of existing fields. In both cases, human capital investments result in the discovery of greater petroleum endowments and accessory industrialization in oil-technology or downstream petroleum-related activities. One would also observe this endogeneity if the finding in the literature that property rights are more strongly and credibly protected in democratic political systems is true. For, these would have substantial advantages in developing oilfields given their huge up-front costs, and the fact that the amortization of these investments occurs over long periods of time. And indeed where time horizons are longer – a consequence of secure property rights – incentives to operate fields in ways that maximize production over time will obtain.

If this endogeneity initially seems implausible, it tracks closely the empirical history of the development of Norwegian oil. High levels of human capital and public investments in petroleum-related fields helped make it possible to turn a country that was *not* particularly industrial (for its location and wealth) into one capable of not only successfully managing production and extraction of difficult-to-reach oil in the North Sea via the publicly owned producer, Statoil. Moreover, these investments have been so successful that Statoil is now one of the leading global exporters of key oil-related products (from deep-water offshore drilling platforms to transport).

The key link back to democracy here is that where resources help fuel industrialization – as they arguably did in Canada, the United States, Australia, and via coal in German and the United Kingdom – they also help to build a foundation for the sorts of bourgeois coalitions that have been seen as important ingredients in the initial construction of democratic political systems (see, for example, Moore 1966; Karl 1989). Industrialization also changes the social structure in ways that increase equality, raise educational and living standards, and promote urbanization, all of which have been associated with democratic development or survival (Lipset 1959; Przeworksi et al, 2000; Boix and Stokes 2003; Bollen and Jackman 1985; Acemoğlu et al. 2001, 2006). Finally, such industrialization, as it occurred in developmental states throughout the less advanced nations, is also linked to the creation of new and powerful working class actors, also widely seen as a foundational component of long-lasting democratic politics (Rueschemeyer et al. 1992; Collier 1999). Thus we follow Brooks and Kurtz (2016) by controlling for levels of industrialization and human capital, as these should be key predictors not only of oil finding, but also of democratization.

The point is that we cannot assess the relationship between natural resource wealth and democracy without understanding two critical issues. First, in addition to the oft-claimed 'political resource curse' argument about easy access to rents providing the revenues through which authoritarian governments stay in power, corruption blossoms, and clientelism supplants public goods provision as a foundation for political support, there is an alternative hypothesis that links oil wealth to the promotion of industrialization and thus of democracy. Indeed, in earlier work we have shown that under some conditions – typically of higher levels of human capital investment – natural resource wealth can be developmentally nutritious rather than detrimental (Kurtz and Brooks 2011). The second point, of course, is the potential for an endogenous relationship back from industrial development and the sorts of human investments it supports back to the actual natural resource endowments themselves, as well as democracy. Unless we take this into consideration, our estimation of the effect of oil wealth on regime outcomes will surely go awry.

The next step in theorizing this potentially complex conjuncture is to consider the ways in which natural resource endowments might launch states onto a favorable or unfavorable regime trajectory. The direct way to assess the opening question of this paper is to examine whether oil production is associated with the sorts of negative regime outcomes posited in traditional political resource curse accounts, net of the differential *rent-producing capacity* of oil sectors in different countries, the effects of the critical international interdependencies, and the potential endogeneity between democracy oil endowments themselves.

To do this we cannot consider all oil income equally rent-producing. Difficulty and hence cost of production vary widely, implying that the same quantity of income earned by final sale can produce very different levels of politically allocable rents depending on the characteristics of the oil sector in a particular country itself. This is a critical distinction, and thus in assessing the effect of oil income on regime dynamics, we must evaluate this *net* of the part of oil wealth that comes from less profitable fields. This is of course a very difficult distinction to make, for there are quite a few factors known to affect the cost of oil production. Notably, very crucially, the distinction between onshore and offshore production is important. For the latter usually implies not only sharply higher costs, but also places vastly greater technological demands on would-be producers. And of course within this category, deep-water offshore fields are the most difficult of all. In addition, of course, rock types, depth of wells, and the age of a field affect the level of rent (if any) produced by oil production. Our preliminary analysis will begin to differentiate among oil producing countries based on the endowments that are resident in onshore versus offshore oilfields, the depths of the various sources, and the age of the field.

In addition to considering whether the *type* of endowment matters with respect to the political resource curse, we therefore consider whether the effect of oil production varies depending on the types of oil endowments from which it was extracted. While in an ideal world we would instead have a measure of oil *profits* by oilfield, which could be aggregated up to the total oil rent 'base' available for the state to tax, such data are impossible to estimate. Not only is the profitability of particular fields information that closely guarded by the oil firms themselves (particularly private ones which are not keen to maximize taxation), but what information is available is also likely to be distorted through transfer pricing and other sorts of misrepresentation as firms seek to minimize their tax burdens. We instead consider an interaction between total oil production and a composite measure of the difficulty of its extraction (the construction of this measure is described below). The idea would be that as the proportion that comes from costly production sites increases, the relative amount of "profit" embodied in a particular quantity of production would tend to decline. This would then provide at least a crude proxy for actual oil rents (or the actual oil tax base), rather than simply the total income of the sector. And this is a much closer conceptual match to the theoretical claims made by resource curse scholars. Obviously, however, this is an exceedingly preliminary effort to address this problem, and much more work is required before we can have great confidence in the findings.

**Data, Measures, and Modeling Strategy**

Our goal in the empirical analysis began with the task of generating a dataset that gave an accurate picture of the value of oil produced in each country in each year. Work on the resource curse has historically been bedeviled by problems in attempting to accurately estimate these values. Early work, for example, relied on the dollar value of exports. But this was a gross mis-measure of the concept of interest, which is the value of oil production, not of exports. Indeed, the US is typically the first or second greatest producer of oil, but exports almost none of it. A second approach was to utilize national-level production data, and multiply this by something like a global price for oil. While surely an improvement over the use of data on exports, reliance on this sort of data is still a severe mismeasurement of the concept that is crucial for evaluating resource curse hypotheses: the rents produced in the oil sector. For, as we have argued above, the profitability of oil production depends massively on two factors: the cost of actually extracting the oil, and the price that the oil commands. But this is precisely the issue – the cost of extraction varies not by country but by oilfield. And the price of oil is far from a single world price, but rather quite variable based on the type of oil (notably, by specific gravity).

In this paper we seek to make progress on both fronts. We begin with a dataset not of country-level production, but rather by oilfield-level production. Our data rely on the annual survey of oilfield production conducted by Penn Energy Research (2014). This survey provides production, well age, onshore/offshore status, API specific gravity, and well depth information for over 8000 major oilfields, from 1980 to the present.

One issue we faced in our dataset that many of the oil fields we examined suffered from some level of missing data. This was a function of reliance on a survey approach to measure production – which did not generate a response in each year. To solve this problem, we turned to machine learning techniques for missing data imputation. Our imputation strategy started by removing from the dataset those oilfields for which there were zero reported observations (and thus nothing to impute from), and to avoid over-imputing, we also removed those with only a single positive value. This reduced the initial dataset from 333270 observations (at the field-year level), to 213840 observations, when all oil fields with no observations were removed. Removing all oil-fields with only one observation reduced the dataset to 180708 observations.

Missing oil yield data were imputed using the "missForest" package in R, an implementation of Random forests specifically for imputation (Breiman 2001). Random forests use regression trees to recursively partition data, fitting models which minimize the mean squared error in a subsample of the data. Random forests bootstrap the data repeatedly and then fit regression trees, using subset of both the data and predictors to minimize the risk of overfitting (Murphy 2012, ch. 16). The random forest approach is powerful because it is non-parametric, robust to outliers, and capable of handling non-linearities in data and mixed data types. In our case, we fit random forests to each set of country-years, on the assumption that oil fields within countries were more similar than those across countries. The risks involved in leveraging information from other countries (e.g., using data on production in Norway to fill in gaps in places like Brazil) far outweighed any potential gains in imputation. As a further corrective we removed obviously erroneous observations (this resulted in the removal of the data for Nigeria, as reported oilfield production in that country was repeatedly reported to exceed the aggregate of Saudi Arabia by one or two orders of magnitude). As a further cross check we made sure that the sum of oilfield level production approximated the separately-reported country-level production numbers provided by Penn Energy. In all cases the sum of the oilfield-level production data matched the separate country-level output data (within a 20% tolerance range). Diagnostics revealed no systematic pattern to over- or under-imputation.

From this large dataset of oilfield level production, we then sought to construct a metric of the difficulty of oil production. Direct measures of cost of production are proprietary and closely-held by the myriad transnational, local, and state-owned firms that dominate production. Our approach is to estimate the relative cost of oil extraction based on the available data on features that are primary contributors to cost. For this we constructed a composite measure of the difficulty of oil extraction by assuming that there was a latent underlying factor which we could measure with a variety of indicators in our data (age of the well, which correlates with pressures; depth of the well; API gravity; onshore/offshore status). Factor analysis revealed that these indicators loaded strongly onto a single dimension and the factor loadings were used to construct a composite measure of difficulty, weighting a normalized version of each indicator by its factor loading and summing. To bring these data back to the country-level, we then constructed a weighted average of difficulty based on the volume of oil produced in each oilfield.

The next step was to link this information on production to differentiated data on the price of oil in each year based on its type (API gravity). For this we used prices in the US market for oil based on six API gravity bands, as provided by the US Energy Information Administration (2018). Oilfield level production (of each type of oil in each year) was multiplied by its relevant price, and then aggregated by country to produce the country total oil receipts information.

This effort, however, naturally informs our modelling strategy. We aim to stay as close as practicable to contemporary analyses in the resource curse debate (as in Haber and Menaldo 2011 and Anderson and Ross' rejoinder (2014), but at points will necessary depart from specific aspects of their set ups. The first departure we make is to consider the appropriate universe of countries. We are exceedingly interested in the different political consequences of oil-based development as they vary by the difficulty of extracting and producing petroleum. But for such an analysis, it makes little sense to include all countries of the world – for the effects of oil are only felt in places that in principle could extract and produce oil. Instead, we limit our analysis to any country that produced any oil in the 1980-2006 period of our dataset.[6] While

[6] Countries without reserves (or without knowledge of reserves) would be odd comparators – after all, they would, for example, necessarily score zero on variables of importance like "proportion offshore

the assignment of oil to geographic locations is by no means random, it is surely exogenous to regime characteristics given that it develops over geologic time. We have also excluded from the analysis countries in the Communist world (but not their post-Communist successor states), as their regime outcomes prior to independence cannot be understood as independent observations. Obviously, the determinants of political regime type for Communist states are surely very different from those conditioning outcomes in the broader international arena. Nor could they meaningfully be considered independent observations.

We constrain our period of analysis to start in 1980 (in contrast to some other analyses that cover a much longer period of time), as a critical contribution to the resource curse debate has made the point that this year represents a structural break after which the pernicious political effects of oil wealth come to the fore (Anderson and Ross 2014). And, from the perspective of an expectation that oil may not be the curse that many thought it was, this is a hard test, for we restrict the analysis to an era in which others have argued it is most politically unsalutary. As we have noted above, we complement this basic modeling strategy with a theoretically more-defensible conceptualization of oil rents, allow for possible endogeneity between resource endowments and regime outcomes, and finally attempt to capture the likely diffusion-induced interdependencies among the states in our analysis that might contaminate core findings.

***Measures***. Our measure of the dependent variable in this study – political regime – is the Polity measure almost universally employed in scholarship on the resource curse. Our innovation comes in the way in which we measure natural resource rents. We begin with a measure of oil production – taken from the PennEnergy Worldwide Oil Field Production Survey (Historical Version, 2013). We then normalize production based on population – to avoid biases induced by counting only exports or normalizing by GDP, which would artificially underestimate the absolute oil rents produced in comparatively wealthy countries. This is not in itself novel, but is different from some of the earlier resource curse scholarship.

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production" but without being conceptually similar to other countries scoring zero but producing large quantities of oil.

We then use oilfield-specific data on field age, depth, oil weight, and location on or offshore to construct a composite measure of production difficulty.[7] A principal components analysis of this oilfield-level data was used to score these components into a single metric representing the latent concept of "field difficulty." From these field specific measures, annual country-level weighted averages of difficulty (weighted by production) were created, for use in the cross-national dataset of regime outcomes.

The approach in state of the art analyses of the resource curse has tended to include controls for two very crude indicators of cross-national diffusion. These models generally include the proportion of democracies in the world in the antecedent period and the proportion of democracies in arbitrarily defined geographic regions in the antecedent period. As we pointed out above, neither of these is an appropriate measure of diffusion processes, as they are both inevitably calculated by including the reference country itself in the score (a minor consideration at the global level, and a more severe one as the number of countries in a specific region becomes smaller). We make a modest improvement on this necessary control by defining regional peer countries for the construction of a spatial weight matrix.

In the diffusion variable, we thus create a spatial lag (the weight matrix multiplied by the dependent variable) that weighs all countries within this spatially-defined region equally. This *regional diffusion* should capture mimetic isomorphism and the cross-national pressures to emerging in specific regions that promote democracy or authoritarianism. The diffusion effects are row-standardized, and scored in units of the dependent variable. Row standardization is employed based on the belief that it is the proportion of one's peers that matters most in mimetic isomorphism, not the aggregate number of peers with one or the other set of characteristics. For the latter approach would imply that diffusion effects are larger in regions containing more peers.

In addition to these variables of primary theoretical interest, we further utilize a series of controls. We begin with classic modernization variables such as the level of *wealth* (natural log of GDP per capita in constant dollars), *industrialization* (industrial value-added to GDP), and *human capital* (gross

[7] The PennEnergy data include over 7000 individual oil-fields, covering the vast majority of global production. .

secondary school enrollment ratios). These are taken from the World Development Indicators (2015) We also control for the degree of international integration (*trade*) as captured by imports plus exports as a share of GDP (WDI 2015), and for a linear *time trend* – as it is known that the number of democratic regimes has been increasing since the "third wave" began in the 1970s.

***Modeling Strategy***. Our approach to estimation begins with the analysis of a basic model:

$$y_t = \alpha + \Theta y_{t-1} + \gamma_1 W_1 y_{t-1} + \boldsymbol{X\beta} + e_t$$

Where $W_1$ represents the spatial weight matrix defined above, $\Theta y_{t-1}$ represents a lagged dependent variable, and $\boldsymbol{X\beta}$ is a matrix of independent variables. Similarly, as the proportion of democratic regimes in the world has trended up over time, we include a linear time trend on the right hand side to avoid potential spurious correlation with similarly-trended independent variables. For robustness, given the potential for non-stationarity (or near non-stationarity) in the dependent variable, we also specify alternative models examining the changes in political regime as they respond to oil production (and type), as well as diffusion processes. Direct examination of the model above in the presence of a lagged dependent variable is of course rendered problematic by the high inter-temporal correlation in political regime in our data. To address this we examine the robustness of our findings to the utilization of a differenced dependent variable.

In addition to a focus on examining the effects of oil production on regime outcomes while properly controlling for diffusion-induced interdependencies in the data, we also take special concern to deal with the potential endogeneity between oil income and the political regime. We use as an instrument for oil production the ratio of reserves to geographic area (following Haber and Menaldo 2011). This displays a modest correlation with total oil production in the dataset, but is essentially uncorrelated with the outcome, democracy as measured by the Polity 2 measure. This variable – essentially geographic reserve density – has other important features. First, there is little theoretical reason to expect it to be correlated with (and thus express its relationship to the outcome) through any of the other included independent variables. While reserve density should theoretically be associated with total oil income (for which it instruments), as ceteris paribus, reserves that are more tightly geographically arrayed are more cheaply and easily extracted (necessitating inter alia, fewer accessory resources like costly pipelines). But that said, this density has no obvious connection to diffusion processes, development, human capital endowments, or the like. For this reason, we use it as an instrument to correct for the potential endogeneity between oil income and regime outcomes.

**Results and Analysis**

The results of our analysis can begin in Table 1. In Table 1, Model I, we see the results of simple baseline analysis. Using our measure of per capita oil production, we find a negligible effect on the political regime. The coefficient is positive but small in substantive terms. This is, however, just a starting point, for as we have argued above, if there are regional interdependencies in the formation of national political regimes, it is possible that the relationship between oil wealth and authoritarianism found in Model I is simply a spurious result of a self-reinforcing tendency to have a large number of major oil producing countries in a region of the world characterized by high levels of authoritarianism. In Model II, we control for diffusion processes shown in other work to be relevant – mimetic isomorphism based on geographic neighbors. In this specification we still observe a positive relationship between oil income and authoritarianism. In Model III we begin to get at the core of our analysis. The actual causal mechanisms implied by resource curse proponents suggest that the level of *rents* is what matters – not the level of output or gross proceeds. In this model, we begin an effort to evaluation this causal perspective more directly, by examining the effect of oil wealth as it interacts with the difficulty of extracting that oil. Hard-to-get oil, that is far belowground, from aging sources, and/or is more technologically complex and costly to extract, is likely to be very different in its effects on the political regime from "easier" oil. The interaction variable (*oil receipts X difficulty*) is positively signed, while the direct effect of oil production is negative.

None of this, so far, suggests a resource blessing. But it does suggest that a finding of an oil curse is at least contingent on how much of the oil is "easy." In the easiest of locations, oil production appears to be associated with authoritarian outcomes, but as these become more challenging – and rents become less present – the effect of oil production actually turns positive for the political regime (see Figure 1).

[Insert Figure 1 Here]

That said, there is still one major worry that we must address. In various other work, we have found that actual oil production is in fact endogenous to the national political regime (as it affects crucial variables like human capital formation, etc.). The consequence is that we must address this endogeneity in order to obtain a more appropriate effect estimate for oil wealth on national political development. In Table 2, Model 4, we test this, instrumenting for *oil production*. The results of Model 4, which do not find a significant interaction between oil revenue and difficulty, should be qualified by the short time series, the Fixed Effects model, and the differencing of the dependent variable, which remove both the length of the time series and variance on the dependent variable. There are several non-exclusive mechanisms that might account for such a finding. First, since what is at theoretical issue (as opposed to what is generally analyzed empirically) is the level of rents or super-profits generated by the oil sector, as production comes to be dominated by offshore sources, profitability (and thus funds available to the state via taxation) can decline sharply. One would, from a conventional resource curse perspective, expect that this would mitigate the negative effects of oil production. As it becomes in profit terms much like any other industry, its effect on regime outcomes should disappear. But this explanation is at best partial, for our results suggest that as 'difficulty' oil becomes important as a share of total production, the effect of oil wealth on regime outcomes favors democracy, not authoritarianism.

Instead, as we have argued here, we think there is the potential for a virtuous cycle linking oil wealth and democratic regime development. We specifically contend that this is the case where oil wealth is used in order to develop further industrial and human capital investments, which on the one hand themselves lead to the discovery and production of more oil, but also to the deepening of the linkages between the oil economy and other higher-technology industrial efforts (in exploration, processing, construction, imaging, shipping, or industrial inputs for oil production such as specialty steel, seamless pipes, drills, and the like). But at the same time, such expansions – where they occur (see Brooks and

Kurtz 2016) – also induce societal transformations. They expand the middle classes, the (often organized) working classes, they reduce income inequality, and they undermine the influence of rural sectors on national political outcomes. All of these phenomena have long been thought to induce pressure for the creation and consolidation of more democratic political regimes. These sorts of efforts are also, necessarily, more common in settings in which it is technologically more challenging to discover and extract oil – something capture, albeit loosely, by our measure of difficult production.

***Conclusion***

The concept of "peak oil" was popularized in the 1950s by M. King Hubbert, a geologist for Royal Dutch Shell, who predicted that U.S. oil production would reach its limits and the world's oil reserves would be depleted. With changes in technology, new discoveries of hitherto unknown resources, and new capabilities to explore and produce plays that seemed to have been depleted have all but erased discussion of oil supplies running dry. Instead, discussion of "peak oil" has turned to questions of consumer demand – at least in the advanced industrial nations – as citizens turn to renewable sources of energy and more energy-efficient technologies. But with growth and demand remaining stable in large countries such as China and India, oil exploration and production has continued into deeper, more extreme reservoirs, employing ever more sophisticated, and costly technology. In light of these changes in the economics of oil production, we have sought to bring attention to the possibility that as 'easy oil' gives way to more hard-to-get resources, we must re-think the concept of an oil 'rent.'

We have examined the hypothesis that not all oil may be regarded as a 'curse' to political development. Instead, we have argued that it may be only the 'easy to get' oil that is tied with such pernicious consequences, while hard-to-get oil, by virtue of the technological hurdles and higher costs of production, would either yield a smaller revenue stream to the state when produced by private contractors, or emerge from a national oil company where the level of industrial development and human capital stocks would be highly favorable to democracy. Our analysis of data from over 7,000 oilfields around the world, aggregated to the country level and assessed for the relative difficulty of production, offers a promising confirmation of our expectation. We find that only at the lowest levels of 'difficulty' is there a negative effect of oil income on democracy, while at moderate and high levels of difficulty, the regime impact turns positive.  While these results are promising, many questions remain. Our agenda going forward will include an effort to gather data on the extent to which states tax oil production, and a closer analysis of important cases of democracy and development in the context of easy and hard-to-get oil production.

Table 1. What Sort of Oil Has What Sort of Effects?

**DV: Democracy (Polity)**

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| Oil Receipts per capita | 0.00000383** | 0.00000333* | -0.00535** |
| | (0.00000161) | (0.00000173) | (0.00247) |
| Wealth | 0.251 | 0.418 | 2.018** |
| | (1.423) | (1.383) | (0.943) |
| Human Capital | 0.0450* | 0.0475* | 0.0541* |
| | (0.0246) | (0.0248) | (0.0273) |
| Trade | -0.0115 | -0.0104 | -0.00588 |
| | (0.0144) | (0.0129) | (0.0119) |
| Industrialization | -0.00113 | -0.00194 | -0.00355 |
| | (0.0396) | (0.0390) | (0.0379) |
| Time Trend | 0.0664 | 0.0694 | |
| | (0.0454) | (0.0476) | |
| Regional Peer Diffusion | | -0.153 | -0.114 |
| | | (0.183) | (0.179) |
| Difficulty | | | -5.008* |
| | | | (2.677) |
| Oil Receipts X Difficulty | | | 0.0165** |
| | | | (0.00763) |
| Constant | -133.1 | -140.4 | -14.04* |
| | (82.13) | (87.29) | (7.419) |
| *N* | 839 | 839 | 839 |

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

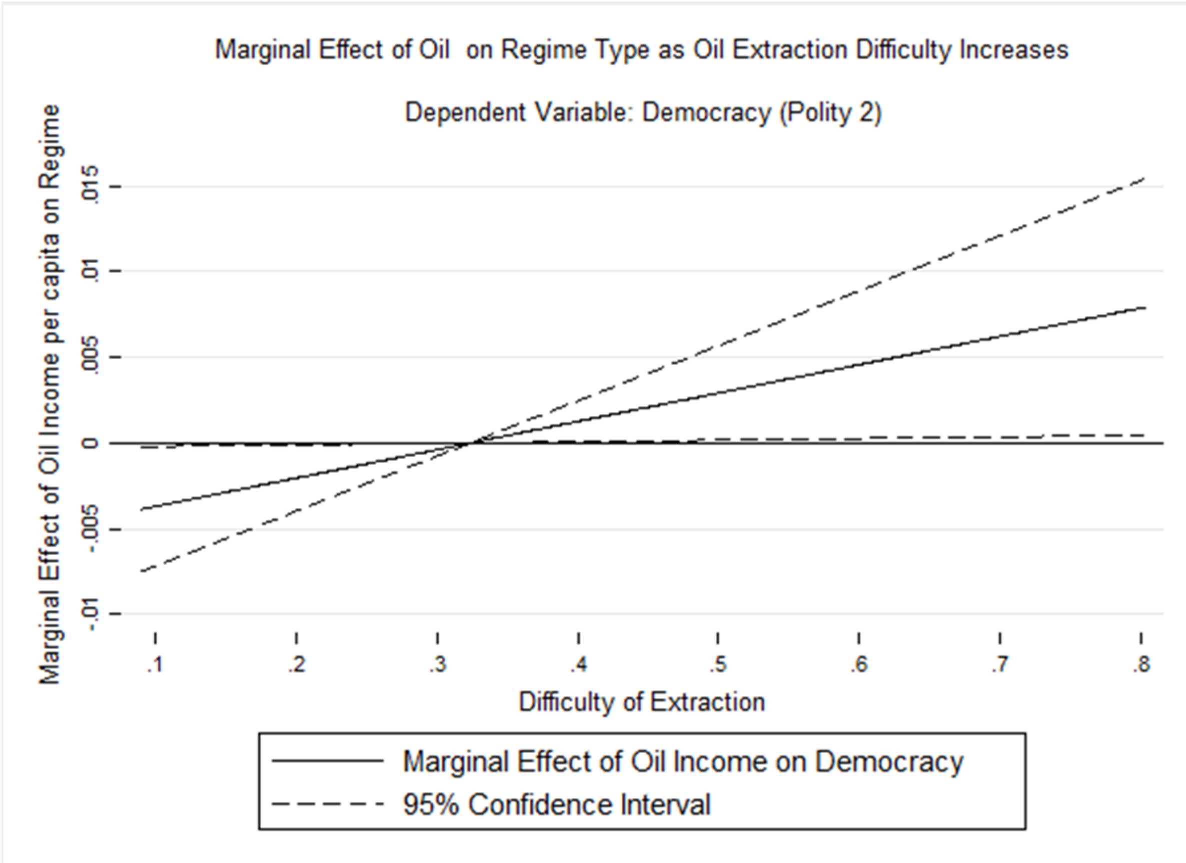
Table 2. Endogenous and Offshore Oil, Non-stationarity, and Regime Outcomes

**DV: Δdemocracy (ΔPolity)**

| | Model 4 | Model 5 |
|---|---|---|
| Democracy | -0.242*** | -0.243*** |
| | (0.0462) | (0.0466) |
| Oil Receipts per capita | 0.000000773 | -0.000572 |
| | (0.000000606) | (0.000513) |
| Wealth | 0.156 | 0.162 |
| | (0.409) | (0.413) |
| Difficulty | 0.00111 | -0.101 |
| | (0.781) | (0.834) |
| Human Capital | 0.0105* | 0.0105* |
| | (0.00539) | (0.00539) |
| Trade | 0.00317 | 0.00312 |
| | (0.00726) | (0.00730) |
| Industrialization | -0.000919 | -0.00119 |
| | (0.00882) | (0.00882) |
| Oil Receipts X Difficulty | | 0.00177 |
| | | (0.00158) |
| Constant | -1.138 | -1.134 |
| | (2.820) | (2.810) |
| *N* | 839 | 839 |

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Figure 1. Interaction Effects: Oil and its Difficulty



## References


Acemoglu, Daron and James A. Robinson. 2006. *Economic origins of dictatorship and democracy*. Cambridge University Press.

Acemoglu, Daron and James A. Robinson. 2001. "A Theory of Political Transitions." *The American Economic Review,* 91(4): 938-963.

Anderson, Jørgen Juel and Michael Ross. 2014. "The Big Oil Change: a closer look at the Haber-Menaldo analysis" *Comparative Political Studies* (November).

Barro, Robert and Jong-Wha Lee. 2010. "A New Data Set of Educational Attainment in the World, 1950-2010." NBER Working Paper No. 15902, April.

Boix, Carles, and Susan C. Stokes. 2003. Endogenous democratization. *World Politics* 55 (July):517-49.

Bollen, Kenneth A. and Robert W. Jackman. 1985. "Political Democracy and the Size Distribution of Income." *American Sociological Review,* 50(4): 438-457 .

Breiman, Leo. 2001. "Random Forests." *Machine Learning* 45 (1). Springer: 5–32.

Brooks, Sarah and Marcus Kurtz. 2016. "Oil and Democracy: Endogenous Natural Resources and the Political 'Resource Curse'" *International Organization*, 70 (2): 279-311.

Collier, Ruth. 1999. *Paths toward democracy: the working class and elites in Western Europe and South America*. Cambridge University Press.

David, Paul and Gavin Wright. 1997. "Increasing Returns and the Genesis of American Resource Abundance." *Industrial & Corporate Change*, 6 (2): 203-45.

Dunning, Thad. 2008. *Crude democracy: Natural resource wealth and political regimes*. New York: Cambridge University Press.

Haber, Stephen and Victor Menaldo. 2011. "Do Natural Resources Fuel Authoritarianism? A Reappraisal of the Resource Curse." *American Political Science Review*, 105 (1): 1-26.

Jensen, Nathan and Wantchekon, Leonard. 2004. “Resource Wealth and Political Regimes in Africa.” *Comparative Political Studies*, 37 (7): 816-841

Jones Luong, Pauline, and Erika Weinthal. 2010. *Oil Is Not a Curse: Ownership Structure and Institutions in Soviet Successor States.* Cambridge.

Karl, Terry. 1997. *Paradox of plenty: Oil booms and petro-states*. Berkeley: University of California Press.

Kurtz, Marcus and Sarah Brooks. 2011. “Conditioning the “Resource Curse”: Globalization, Human Capital, and Growth in Oil-Rich Nations” *Comparative Political Studies* 44(6): 747-770.

Lipset, Seymour Martin. 1959. Some social requisites of democracy. *American Political Science Review* 53 (March):69-105.

Murphy, Kevin P. 2012. *Machine Learning: A Probabilistic Perspective*. MIT press.

Osman, Ahmed. 2018. “High-temperature Drilling Pushes the Limits” *E&P Online*. (January): 46-48.

Ozer-Balli, Hatice and Bent Sørensen. 2013. “Interaction effects in econometrics” *Empirical Economics*. Vol. 45:1 (August).

PennEnergy. 2013. Worldwide Oil Field Production Survey 2013. Historical Version.

Przeworski, Adam, Michael Alvarez, José Antonio Cheibub. 2000. *Democracy and development: political institutions and well-being in the world, 1950-1990*. Cambridge University Press.

Ross, Michael L., 1999. The Political Economy of the Resource Curse. *World Politics* 51: 297–322.

Rueschemeyer, Dietrich, Evelyne Huber Stephens, and John D. Stephens. 1992. *Capitalist Development and Democracy*. Chicago: University of Chicago Press.

Sachs, Jeffery D., Warner, Andrew, 1995. Natural resource abundance and economic growth. Harvard Institute for International Development, Development Discussion Paper No. 517.

Sachs, Jeffery D., Warner, Andrew, 1999. The big push, natural resource booms and growth. *Journal of Development Economics* 59: 43– 76.

Smith, Ben. 2007. *Hard Times in the Land of Plenty*. Ithaca, NY: Cornell University Press.

Stijns, Jean-Philippe. 2006. “Natural Resource Abundance and Human Capital Accumulation.” *World Development*, 34 (6): 1060–1083.

US Energy Information Administration. 2018. https://www.eia.gov/opendata/qb.php?category=293653.

Woolridge, Jeffrey. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: Massachusetts Institute of Technology Press.