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Cursed Resources? Political Conditions and Oil Market Volatility*

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Abstract

Politicians and the popular press have recently highlighted the concept of energy security, broadly suggesting that it has declined in recent years and that governments, particularly the U.S. government, should take steps to stabilize it. This paper proposes several statistics that systematically measure “security” in the world oil market. Specifically, we analyze several indicators of the political and social conditions of oil-producing countries and show how these have evolved since the 1960s. We then decompose our measures to analyze whether the trends are driven more by changes in the types of countries that are producing oil or by changes in the political conditions within the set of oil-producing countries.

The second half of the paper asks in what way the political conditions of the oil-producing countries affect the world oil market. We show that there is a pronounced negative relationship between the short-run volatility in oil production in a country and its political openness, with very democratic regimes exhibiting less volatility in their oil production than more autocratic regimes. This result holds across several robustness checks including using different measures of political conditions, instrumenting for political conditions and using different measures of oil production volatility.

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Safety and certainty in oil lie in variety and variety alone.

– Winston Churchill

Much of the world's oil supplies are in the hands of nations that either are not supportive of America's interests or are politically unstable.... We need to address a national security emergency.

– Sen. Richard Lugar

I. Introduction

Many energy markets are characterized by extremely inelastic short run supply and demand, meaning that even small fluctuations in either can lead to large swings in price. The supply of fossil fuels, which provide 85% of U.S. and 86% of world energy needs (IEA, 2008), are largely controlled by the governments under whose soil the natural resources rest. The popular concept of “energy security” appears to recognize the potential vulnerability of energy markets to short-run changes in fossil fuel supplies, which could be influenced by the political agendas of the controlling governments. From a U.S. perspective, this is no truer than for oil, which is supplied by both friendly and unfriendly countries into a world market.

While much has been written about how systematic shifts in oil demand or supply affect prices (see, for example, Hamilton (2009a) for a recent assessment) less is understood about the underlying determinants of short-run changes in supply. In this paper, we analyze how the political conditions in a country affect its oil production activities.

Our focus is on short-run supply volatility since this is generally the source of price volatility. Price volatility makes business planning difficult and raises the cost of hedging risk. It is particularly difficult for energy-dependent industries such as the airlines and automakers. It also raises concerns for many that speculation is contributing

to price volatility and spikes causing many to call for tighter regulation of energy markets.¹

Seemingly trivial events can cause significant price shifts. In June of 2009, for example, insurgents in Nigeria's Niger delta announced an attack against one of Royal Dutch Shell's two export terminals in that country. News of the raid help drive up oil prices by over three percent in one day according to a report in the Washington Post (Mufson (2009)). A Swiss oil analyst warned of "legitimate geopolitical concerns ... We will need to keep an Iranian risk premium for the weekend and to it we will add a Nigerian risk premium" (Mason (2009)). To put this in perspective, Nigeria's share of world production is less than three percent and the amount of oil that had been temporarily shut in by insurgents in that country accounted for just over one percent of world production (BP (2009)).

To a first approximation the short-run price change required to eliminate a supply shortfall is the inverse of the sum of the price elasticities of supply and demand (in absolute value).² For example, price elasticities of supply and demand equal to 0.10 and -0.10 respectively would require a five percent price increase to eliminate a shortfall in production of one percent. The response in world oil markets to a curtailment of Nigerian oil production is not inconsistent with equilibrium responses in the face of highly inelastic supply and demand.³

¹ The Commodity Futures Trading Commission announced plans to consider placing limits on the trading behavior of financial investors in futures markets for energy products. The CFTC opened hearings in July 2009 to consider how this might be best accomplished. See Andrews (2009).

² This abstracts from imperfectly competitive behavior in oil supply. See Hamilton (2009b) for a discussion of price and income elasticity estimates and supply behavior in oil markets.

³ The short-run price elasticity of demand is likely smaller (in magnitude) than -0.10. Supply responses are also likely to be highly inelastic as discussed in Hamilton (2009b).

The mechanisms by which oil price shocks affect the macroeconomy are not entirely understood. Davis and Haltiwanger (2001) document that oil shocks contributed twice as much to variability in employment growth in the manufacturing sector as monetary shocks between 1972 and 1988. Job destruction is especially sensitive to oil shocks. Hamilton (2009a) argues that high oil prices contributed to the crisis faced by domestic automakers in 2008 and may have hastened the onset of the latest recession.⁴

The idea that abrupt price changes lead to economic dislocation and macroeconomic adjustment costs is built into various oil premium estimates (see, for example, Greene and Leiby (2006), Leiby (2007), and Greene (2008)). Greene (2008) estimates the costs of economic dislocation due to oil shocks at \$150 billion in 2008. That works out to over \$20 per barrel of oil consumed in the U.S. in that year. Whether one accepts these particular estimates or not, the perception that oil shocks have large macroeconomic costs influence policymaking at the national and sub-national level.⁵ Understanding the source of price volatility in oil markets and the role that governance institutions in oil producing countries plays in affecting price volatility appears worthwhile.

Another element of oil security is physical supply. For example, the U.S. may prefer supply from China relative to Kuwait even if the two governments have similar institutions because oil from Kuwait passes through the Straits of Hormuz, a potential choke point bordered on one side by Iran. Physical security is beyond the scope of the current paper, although the metrics that we identify for political conditions in oil

⁴ "...the evidence to me is persuasive that, had there been no oil shock, we would have described the U.S. economy in 2007:Q4-2008:Q3 as growing slowly, but not in a recession." Hamilton (2009a), p. 40.

⁵ These estimates may overstate the case as they ignore important changes in the U.S. economy in the past twenty-five years. Blanchard and Riggi (2009) find that reduced wage indexation and more credible monetary policy in the United States has reduced the macroeconomic impacts of oil shocks.

producing countries could easily be applied to assess the security threats associated with different physical constraints. We note that the physical constraints do not appear to be binding over very long time periods, as there is usually convergence in world oil prices.

Finally, some concerns about oil imports to the U.S. stem not from unease about the security of production from the exporting countries, but from the fear that the oil revenues are funding activities counter to America's interests, such as terrorism (see the Lugar quote above, where he identifies both politically unstable countries and those that do not support America's interests). In the empirical analysis below we do not distinguish countries on the basis of their alliance with the U.S.

We begin our analysis by constructing aggregate measures of oil production security that summarize the political conditions of oil producing regimes using various measures of a country's political stability.⁶ This is the first attempt, of which we are aware, to systematically measure security in the world oil market. Armed with our measures, we document trends since the mid-1960s. Generally, our indexes depict a reduction in oil security between 1965 and 1978, followed by an increase that peaks sometime in the late 1990s or early 2000s, depending on which index is considered. In recent years most of the indexes show a modest decline starting around 2003.

We next decompose the measure into "production" and "internal conditions" indexes to show how changes in the aggregate measure are driven by changes across countries in their share of world oil production and changes within countries in political

⁶ Measures of political conditions have been shown to affect macroeconomic development and volatility. See, for instance, Hall and Jones (1999), Acemoglu, Johnson and Robinson (2001) (hereafter, AJR) and Acemoglu et al. (2003). Albouy (2008), however, critiques the instrumental variables techniques developed by AJR.

conditions. In the early part of our sample, changes in world oil security were mainly driven by changes in the production share, as Middle Eastern countries accounted for a larger and larger share of total production. Recent trends in security, however, appear to be driven by changes in internal conditions in addition to changes in the location of oil production.

Having documented the trends in our oil security measures, we step back to consider whether our indexes have any bearing on world oil market outcomes. To motivate our empirical analysis, section III provides background and summarizes the theory on the relationship between oil production and governance. We relate our work, which looks at the relationship between political conditions and oil market outcomes, to the “resource curse” literature, which looks at how resource endowments affect political and economic outcomes.

The main empirical analysis focuses on identifying the impact of political conditions on the stability of oil production. We first construct various measures of oil volatility, which take different approaches to controlling for market factors which *should* drive changes in a country’s oil output. We document a pronounced negative relationship between our measures of political conditions and oil volatility, and this result is robust to including a dummy for OPEC membership.

We next address the endogeneity of political structure. We run two-stage least-squares regressions where we instrument for recent political conditions with political conditions before oil was commercialized. The negative relationship is even more pronounced in these specifications, consistent with the idea that our political conditions

variable measures the true set of institutions that can affect oil production decisions with error.

We also analyze whether within-country changes in political conditions over the time period we consider are associated with changes in production volatility. The evidence here is much weaker than in the cross-sectional specifications, although this is most likely because we see very little movement in political conditions within countries over our time period.

We conclude in section V with some thoughts on the lessons to be drawn from this analysis as well as possible future extensions of this research agenda. Taken together, our results suggest that political conditions in oil-producing countries affect production decisions. Counter to the recent increase in political attention to energy security, the weighted average of oil-producing countries' political conditions has only fallen slightly recently, and is roughly at the same level as in the mid-1990s. One could imagine using our measures to project future oil security by analyzing the political conditions in the countries holding the most economically viable reserves. Further, our measures could be used to analyze the potential risks associated with different renewable energy technologies, many of which (for instance, solar electricity and electric vehicles) rely on natural resources that are available in a limited set of countries.

II. An Index of Oil Security

We begin the analysis by presenting several indexes of oil security based on different measures of the political system in oil producing countries over the past several decades. We consider the following measures of political conditions in a country.⁷

Polity (P_{it}) : This is the Composite Democracy Index from the 2007 Polity IV Project.⁸

The composite score is defined as the difference between the Institutionalized Democracy index ($DEMOC_{it}$) and the Institutionalized Autocracy index ($AUTO_{it}$). The former index is based on the competitiveness and openness of executive recruitment, constraints on the chief executive, and competitiveness of political participation. The index ranges from zero to ten. The autocracy index is based on other measures of competitiveness and openness of executive recruitment, constraints on the chief executive, and competitiveness and regulation of political participation. It also ranges from zero to ten. The resulting combined polity score ranges from -10 (strongly autocratic) to +10 strongly democratic. We rescale the index to range from 1 to 21 with higher values indicating stronger democratic tendencies.

Freedom House Civil Liberties (CL_{it}): Freedom House ranks countries on a variety of scales including civil liberties and political rights (next index). We use data from the 2008 Freedom House Survey.⁹ Based on the answers to fifteen questions, a score between 1 (greatest range of civil liberties) and 7 (least amount of civil liberties) is

⁷ For this part of our analysis, we focus on measures that are available over a long time period, which excludes some of the variables macroeconomists have used (see the articles cited in footnote 5). We discuss the correlations between various measures of political conditions in section IV.

⁸ The Polity IV data are described in detail in Marshall and Jaggers (2009) and are available on-line at <http://www.systemicpeace.org/inscr/inscr.htm> .

⁹ This database is available on-line along with a description of the methodology at <http://www.freedomhouse.org/template.cfm?page=15&year=2008> .

awarded. We rescale the index to range from 1 (smallest degree of civil liberties) to 7 (greatest degree of civil liberties).

Freedom House Political Rights (PR_{it}): The political rights index is based on a checklist of ten questions that is converted to a seven point scale. As with the civil liberties index, we rescale the index to range from 1 (least amount of political rights) to 7 (most amount of political rights).

Major ($C1_{it}$) and Minor ($C2_{it}$) Conflicts: Counts of major and minor conflicts as recorded in the 2008 UCDP/PRIO Armed Conflict database, which heavily weights fatalities in armed conflicts.¹⁰ We use a five-year rolling average of this count, to smooth volatility, and because the effects of armed conflicts are likely to be felt in years following the conflict-related fatalities. Higher values of this index indicate greater amounts of conflict.

In all cases we construct oil security measures according to the following formula (where I_{it} represents one of the above indexes for country i in year t and Π_t is a global oil security index based on the underlying index.

$$(1) \quad \Pi_t = \sum_i \omega_{it} I_{it}$$

where ω_{it} is the share of country i 's oil production in world production for year t .¹¹ We normalize all of the indexes by dividing the index by its value in the first year that the index is available.

The oil security index, Π_t , is a convenient measure of the average political conditions in oil producing countries weighted by production. In the first three cases, a

¹⁰ This database is described in Gleditsch et al. (2002) and is available on-line at <http://www.prio.no/CSCW/Datasets/Armed-Conflict/UCDP-PRIO/>.

¹¹ BP (2009) provides oil production by country beginning in 1965

higher index indicates “better” political conditions, reflecting more democratic governance, more civil liberties and higher protection of political rights. For the conflict indexes, higher values correspond to more conflicts.

Figure 1 plots the various indexes over time. The polity and conflict indexes begin in 1965, when the oil data are first available, while the Freedom House data begin in 1972. Consider first the polity measure in the upper left corner of the figure. The security index is initially deteriorating falling from its 1965 value by 30 percent before bottoming out in the late 1970s. It then rises peaking in the early 2000s about 10 percent higher than its 1965 level before beginning to deteriorate again. A similar picture emerges from the Freedom House indexes (note that these indexes starts seven years later). The number of minor conflicts has grown in recent years, although the number of major conflicts has fallen.

Figure 1. Oil Security Indexes

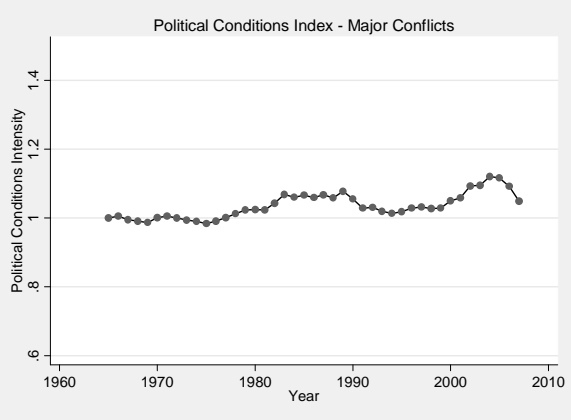
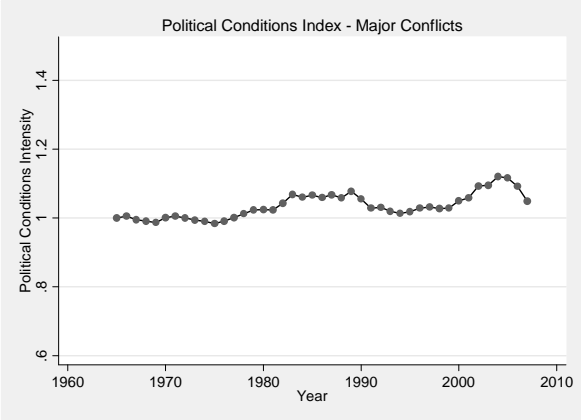
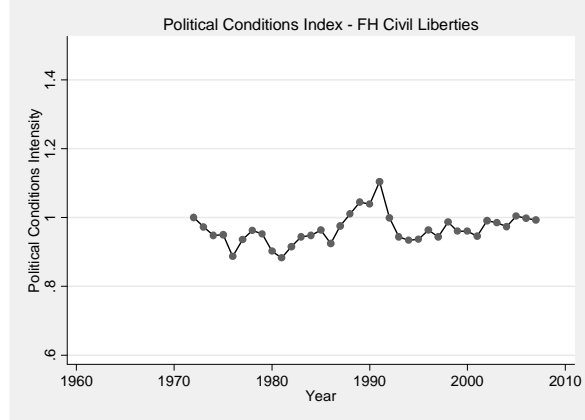
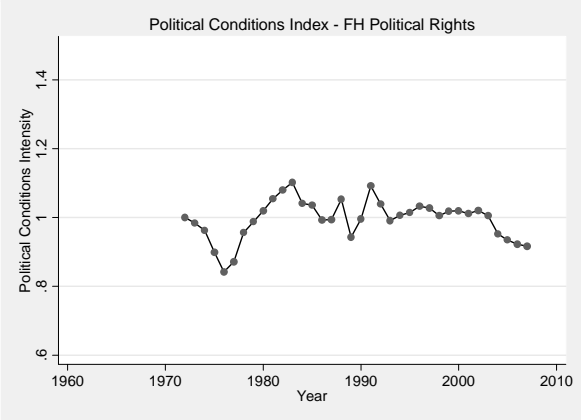
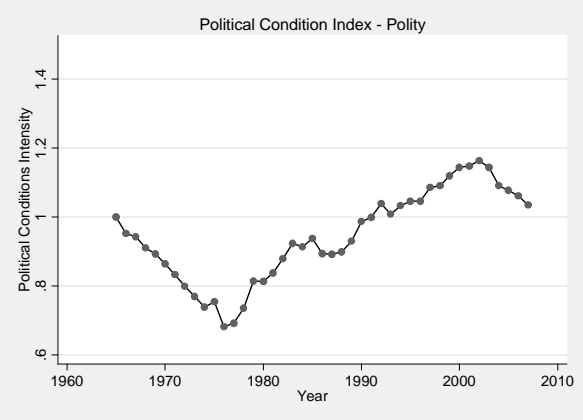
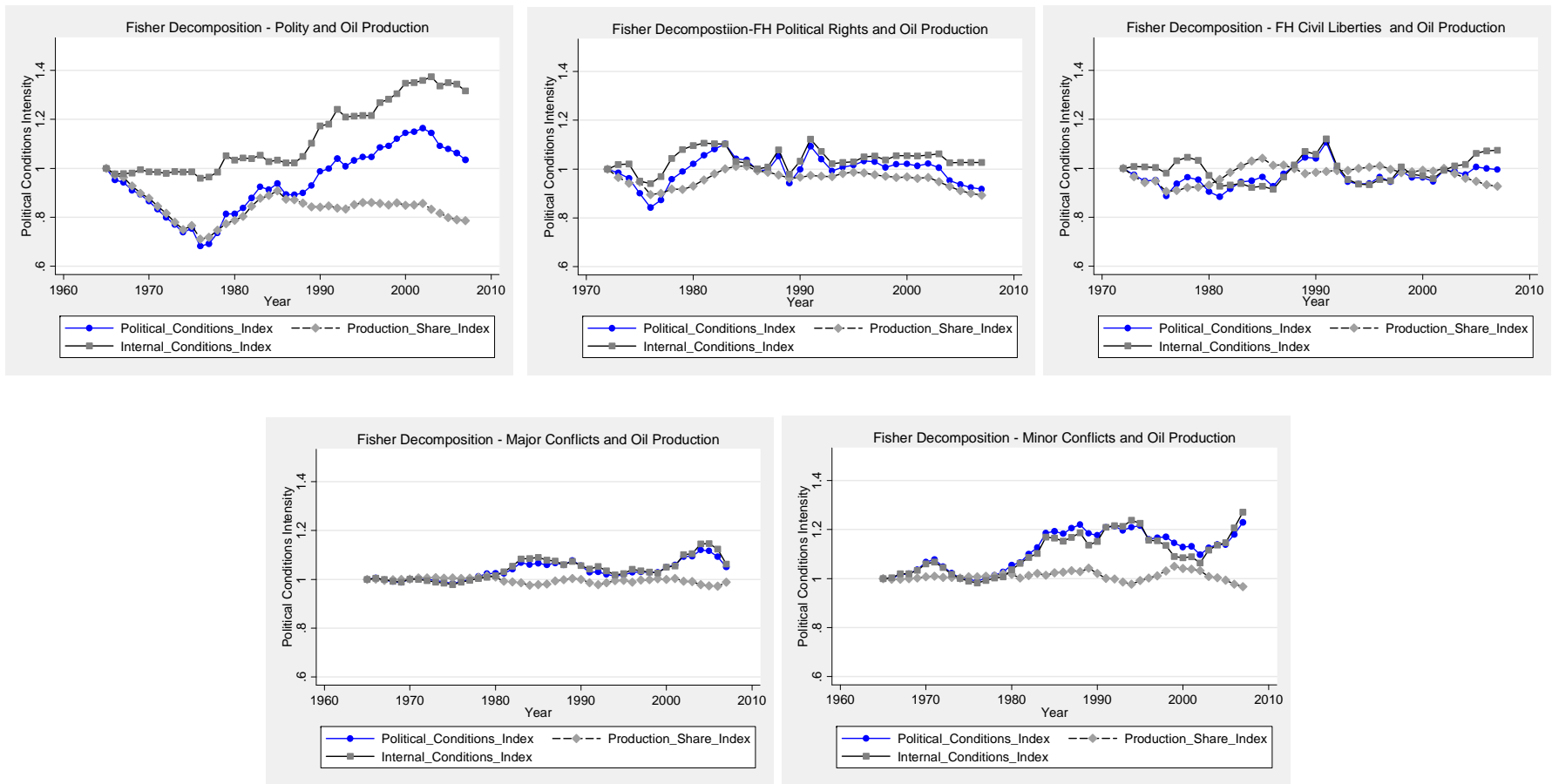


Figure 2. Political Conditions Index Decompositions



What explains the changes in the various indexes? Log differentiation of equation

(1) yields:

$$(2) \quad \hat{\Pi}_t = \sum_i \frac{\omega_{it} I_{it}}{\sum_k \omega_{kt} I_{kt}} (\hat{\omega}_{it} + \hat{I}_{it}) \equiv \sum_i \phi_{it} (\hat{\omega}_{it} + \hat{I}_{it})$$

where a hat indicates a percentage change (e.g. $\hat{S}_{it} = \frac{dS_{it}}{S_{it}}$). Changes in the oil security

index can be decomposed into changes in underlying country conditions and changes in countries' share of world oil production. This forms the basis for a decomposition of the oil security index following the work of Boyd and Roop (2004) and Metcalf (2008).

Using a Fisher perfect decomposition, we decompose the oil security index (Π_t) into an

internal conditions index ($\tilde{\Pi}_t^{Pol}$) and production share index ($\tilde{\Pi}_t^{Prod}$). The internal

conditions index, $\tilde{\Pi}_t^{Pol}$, measures the change in the oil security index holding the world

oil production shares constant.¹² It thus isolates the importance of political changes in oil

producing countries. The oil production share index, $\tilde{\Pi}_t^{Prod}$, on the other hand, measures

the change in the oil security index holding country-specific political conditions constant.

This index isolates the changes in world production and their contribution to the overall

index. These indexes (known as Fisher Ideal Indexes) have the desirable property of

perfect decomposition. This means that the oil security index can be decomposed into

these two indexes with no unexplained residual:

$$(3) \quad \Pi_t = \tilde{\Pi}_t^{Pol} \tilde{\Pi}_t^{Prod}$$

Figure 2 reproduces each index (in blue) and plots it against its two components.

Consider the upper left graph on Figure 2 where oil security is measured using the polity

¹² We describe the construction of the Fisher indexes in the appendix.

index. The upper gray line with squares is the internal conditions index, $\tilde{\Pi}_t^{Pol}$, while the other gray line, which is below the oil security index in the later years, is the production share index, $\tilde{\Pi}_t^{Prod}$. Between 1965 and 1987 changes in the production share index drive changes in the oil security index. In the first decade oil is increasingly produced by countries with poor political stability measures. This partly reflects the growing share of OPEC and the USSR (share of world oil production rising from 61 percent in 1965 to 69 percent in 1976) and the declining share of the United States (26 percent to 14 percent over the same period). Over the next decade OPEC's share of world oil production dropped from 51 percent in 1976 to 28 percent in 1985. This followed the expansion in non-OPEC oil production following the two oil shocks of the 1970s, in particular the development of North Sea oil (rising to a world share of 6 percent by 1985) and a rebound in the US share of world oil production.

For the next twenty years changes in the production shares of world oil played little role in the steady rise in the oil security index. Rather a transformation of the world political order occurred. Beginning in the mid-1980s, Gorbachev introduced democratization efforts leading up to the dissolution of the Soviet Union in 1991. Also, Mexico's polity score increased in 1988, when it held its first election with a serious opposition candidate in many years.

The decline in the oil security index that began in 2003 can be explained roughly equally by declines in the internal conditions index and the oil production index. In sum, the oil security index constructed from the polity measure first declines and then rises to a peak in the early 2000's before starting to decline again. Changes in the index are driven

over the first half of the data by changes in the oil production share index. The internal conditions index drives changes for most of the second half of the sample.

A similar story holds for the Freedom House political rights index. Changes in both the internal conditions and the production share indexes appear to contribute to changes in the security index prior to the mid-1980s. After that year the influence of the internal conditions index dominates until the early 2000's. Similarly the Freedom House civil liberties index shows a mixture of influences. The internal conditions index appears to dominate from roughly 1985 to the early 2000's and the production share index dominates in the last several years. The conflicts index tells a somewhat different story. It appears to be driven throughout by the internal conditions index.

In sum, the data suggest that there has been considerable variation over the past forty years in the political structure of oil producing countries. That change has been driven at times by changes in the political structure within oil producing countries and at other times by changes in production shares across countries. We next consider the question of why this might matter. The next section reviews the literature on the relationship between oil production and governance to provide the theoretical framework for our subsequent empirical analysis.

III. Background and Theory

In this paper we seek to identify the role that political conditions plays in driving the volatility of oil production. While a considerable literature exists on the causal relationship between a country's oil wealth, or wealth from other natural resources, and political governance (the "resource curse" literature), we have not identified any other papers that focus on the role governance plays in affecting supply.¹³ We discuss the resource curse literature in this section both to distinguish our paper from that line of research and to motivate the econometric strategy we use in the next section.

A number of papers have analyzed the relationship between a country's oil wealth – or resource wealth more generally – and various economic and political outcomes, including slower economic growth and development, conflict, and corruption. We focus on the subset of papers that argue that "oil and mineral wealth tends to make states less democratic" (Ross (2001), p. 328). Ross (2001) identifies three causal mechanisms: governments keep tax rates low and spending high to dampen support for democracy (a rentier effect); they spend money on police to repress dissent (a repression effect); and they fail to develop a modern economy with industrial and service jobs thereby preventing the rise of a middle class that might demand greater voice in government (a modernization effect). Haber and Menaldo (2008) find support for a resource curse of the sort articulated by Ross in simple pooled time series cross section regressions but they find the results are sensitive to the inclusion of fixed effects. For our purposes, these two papers (and others such as Smith (2004), Basedau and Lacher (2006), Tsui (2008), and

¹³ A large literature exists focusing on how changes in political institutions affect economic outcomes. See, for example, Barro (1997), Rodrik (1999), Acemoglu, Johnson and Robinson (2001), Acemoglu, et al. (2003), Perrson and Tabellini (2003), and Mulligan, Gil and Sala-i-Martin (2004) for varying perspectives on the influence of political institutions on economic outcomes.

Alexeev and Conrad (2009)) highlight the point that we cannot treat political institutions as exogenous in any analysis of the role political conditions play in affecting oil supply, and they motivate our choice of instruments for a country's political conditions.

Turning to the role of institutions in affecting energy markets, Bohn and Deacon (2000) consider how ownership risk affects the exploitation of natural resources in countries. They find that higher ownership risk decreases oil drilling and oil production whereas higher risk increases deforestation. Ownership risk affects oil and forestry differently due to differential capital intensity. While ownership risk encourages more rapid exploitation to extract resources before assets are (potentially) expropriated by the government, capital investment required to extract resources is also discouraged. Since oil production is relatively capital intensive (compared to forestry) this investment effect offsets the production effect. Our paper differs from Bohn and Deacon in two important respects. First, we focus on volatility in production rather than level and speed of resource depletion. Second, we treat governance institutions as endogenous and instrument for them in our empirical analysis.

Our paper is closest in spirit to the papers by Acemoglu, et al. (2003) and Acemoglu, Johnson and Robinson (2004). These papers consider the role governance institutions play in affecting macroeconomic volatility. They regress measures of volatility (standard deviation of GDP per capita growth, severity of crises and average per capita growth) on a measure of governance and other control variables. Their governance measure is the Polity IV measure of constraints on the executive. Recognizing that governance is endogenous (and also likely measured with error) the authors identify instruments based on the historical development of the country. Specifically their

instrument is the mortality rate of settlers between the 17th and 19th centuries in former European colonies. Their logic is as follows. In countries that were hospitable to colonial settlers (low mortality rates), European governments would establish institutions similar to those in the countries from which they came and which protected private property and placed constraints on local elites and politicians. In contrast, if the climate of the colony was inhospitable to settlers, European colonialists were more likely to establish extractive industries and ignore abusive local governance institutions so long as these political institutions did not impede resource extraction.¹⁴

These papers find that current fiscal and monetary policy choices are less important than institutions once one instruments with mortality data. Current macroeconomic choices are not the primary sources of macroeconomic instability once governance variables are included. Put differently, current macroeconomic policy choices are "symptoms of deeper institutional causes" (p. 108). The authors do not argue that current policy choices are irrelevant but rather that those choices are themselves driven by institutional forces that are more root causes of instability.

Governance structure can affect oil supply volatility in a number of ways. Weak regimes may not provide sufficiently strong property rights to encourage infrastructure investment or spending on maintenance of the existing capital stock. Thus equipment malfunctions may occur more regularly leading to unscheduled supply outages.¹⁵ Weak or autocratic regimes also may face domestic unrest that threatens normal business activity. Nigeria provides a good example of this as does Venezuela in late 2002 when

¹⁴ We do not use the colonization instrument for our primary 2SLS results as they are not applicable to the Middle Eastern countries, which are major oil suppliers. Also, as noted above, the validity of the instruments has been called into question.

¹⁵ Weak property rights may also deter investment in new capacity leading to lower overall production of oil.

workers at PDVSA, the national oil company, went on strike. In the latter instance production abruptly fell by roughly 3 million barrels of oil per day.

An offsetting force for autocratic regimes to the destabilizing impacts on oil production is the ability of a repressive regime to suppress opposition and curtail disruptions to economic activity. Saudi Arabia's internal security services have kept close tabs on extremist groups and have engaged in mass arrests including the arrest of 701 militants in the first half of 2008 (Al-Saadi (2008)). In our empirical analysis below we consider the possibility of a non-linear relationship between governance structure and production volatility. We conjecture that an inverted-U shape relationship may hold between governance and volatility.

In summary, we expect a relationship between governance and oil supply volatility. That relationship may be non-linear with low volatility associated with particularly repressive and democratic regimes. We also treat governance as an endogenous variable and run instrumental variable regressions to address this issue.

IV. Empirical Analysis

This section examines the empirical relationship between a country's political conditions and the volatility of its oil production. We approach the analysis in several steps, first describing our approach to constructing a measure of volatility, next describing the empirical relationship between several political conditions measures, then describing our approach to dealing with the possible endogeneity of political conditions and finally presenting several alternative specifications.

A. Constructing a Volatility Measure

We would like to be able to measure volatility in oil production after controlling for changes in underlying market conditions. For example, if a country’s oil production increases dramatically over the span of several years because of the discovery of new oil reserves, this would be considered “good” volatility. Similarly, profit-maximizing firms within a democratic country may cut back on production if world demand declines.

To separate the “excess” volatility from the market-driven changes in oil production, we begin with the following formula:

$$(4) \quad Q_{it} = f(S_{it}, D_{it}) + g(PC_{it}) + \varepsilon_{it}$$

where Q_{it} represents country i ’s production in year t , $f(S_{it}, D_{it})$ reflects output driven by both supply (S) and demand (D) factors, $g(PC_{it})$ captures the influence of political conditions (PC) on output and ε_{it} captures other determinants of oil production and could reflect measurement error. ¹⁶

We will estimate $\hat{Q}_i = \hat{f}(S_{it}, D_{it})$ and then construct $\hat{g}(PC_{it}) = Q_{it} - \hat{Q}_i$. Our country-level measure of volatility is then:

$$V_i = \frac{std. dev.(\hat{g}(.))}{mean(Q_{it})}$$

Our principle hypothesis is that poor political conditions will cause higher levels of V_i .

We take several approaches to estimating f , and each row in Table 1 summarizes the results from different country-level specifications of the function (or related functions where Q is measured in logs). For example, in the first row, we simply regress each country’s annual production on a time trend, which could capture exogenous technological changes or changes in the productive capability of the country’s existing oil

¹⁶ We are assuming that measurement error in the production variable is not systematically correlated with the political conditions in a country.

fields. The time trend is linear, except that it does not begin until a country's annual production is above five percent of its average annual production. This is important for countries such as the United Kingdom, which were not producing any oil, and then began ramping up quickly after North Sea oil was discovered. The first column of Table 1 indicates that the average R^2 across the oil-producing countries was 0.63 with a range from .0002 (for Egypt) to .966 (for China). The next column indicates that the average coefficient on the time trend was 3,995, and the right-most column documents the range from -53,144 (for the U.S.) to 64,256 (for Saudi Arabia).

The second row adds information on reserves, which, as an abstraction, we take to be exogenous determinants of the country's ability to produce oil. We do not want to use reserves as a right-hand-side variable in each country-level regression as we suspect that the relationship between reserves and output may be driven by political factors. Instead, we assume that the fraction of output from reserves will follow a linear trend, specific to each country.

The final four rows of Table 1 use log specifications of output. Row 3 simply regresses log quantity on a time trend; row 4 controls for changes in demand for oil driven by changes in world GDP. We impose the same coefficient on the log of world GDP across all countries. We chose a coefficient of one based on previous literature that suggests the income elasticity of oil demand is near unity (see Hamilton (2009b)). Given this assumption, the equation we estimate is a reduced form of the supply and demand equations assuming that the elasticity of demand is equal to the elasticity of supply. Row 5 drops the world GDP variable and imposes a coefficient of one on reserves in the reduced form log specification and row 6 includes both world GDP and reserves.

Considering all of the specifications in Table 1, the average R^2 is highest in the last specification, which controls for both shifts in supply driven by reserves and shifts in demand driven by world GDP, although adjusting for reserves in other specifications seems to lower the predictive power of the time trend. Going forward, we will focus our attention on the volatility measure derived from the specifications in the first row, although we will present sensitivities using the specifications from other rows. We focus on row 1 for several reasons. First, data on reserves are only available from 1980-2007, while data on output are available from 1965-2007. Also, both real and reported reserves may be subject to manipulation for political reasons. Finally, the results in other rows rely on assumptions about the functional form of the relationship between output, reserves and world GDP. Rather than defend one particular set of assumptions, we chose to focus on a more basic specification.

For each country we then divide the standard deviation in the residuals from the trend fitting regressions by either the mean value of oil production in each country or the mean of the log of oil production to calculate V_i , which reflects non-economic changes in oil production as a share of total production. Table 2 presents summary statistics on our volatility and political conditions variables. The mean value of V_i for our base case is 23.2%, suggesting that the average country's standard deviation in output is nearly one quarter of its mean production

B. Basic Results

Our basic regression is of the form

$$(5) \quad V_i = \alpha + \beta PC_i + \mathbf{X}_i \boldsymbol{\gamma} + \varepsilon_i$$

where V_i is our oil volatility measure, PC_i is a measure of political conditions and \mathbf{X}_i is a vector of other covariates. In addition to our measure of political conditions, we include in various regressions the physical size of the country and a dummy variable if the country is a member of OPEC in all years. Summary statistics on the covariates are in the lower portion of Table 2.

Table 3 presents a first set of regressions where we use the polity variable as our measure of political conditions. Each row reports results from a specification using a different value of V_i , and the rows use the corresponding volatility measures from Table 1. The left-most columns of results use the volatility measures described in Table 1, which were estimated on data from 1980-2007. Since this is the data range for reserves, we wanted all specifications to use the same time period. The right-most columns report results for the volatility measures that did not use reserves and use data from 1965-2007. In all but one specification, the coefficient on polity is negative and statistically significant.

Considering the specification in the right-most columns of the first row of Table 3, the magnitude of the coefficient on polity suggests that moving a country from the 25th percentile polity score of 4.1 (e.g., Libya or Vietnam) to the 75th percentile polity of 16.4 (e.g. Thailand or Ecuador), should reduce production volatility by 8.7 percent. This represents approximately a one standard-deviation change in volatility. Also, the R^2 in that specification suggests that political conditions explain nearly a third of the volatility differences across countries. Figure 3 plots the data used to generate this set of results.

Table 4 focuses on the measure from the first row of Table 2. The first column reproduces the simple OLS regression of the oil stability measure on average polity for

each country. The regression in column 2 adds additional controls. Larger countries may be able to diversify production across sites and so control volatility, so we control for land area. Countries with larger land area appear to experience less production volatility though the coefficient is not strongly statistically significant.

We also add a dummy variable for countries that are in OPEC over the entire time period. We do not necessarily believe that OPEC membership is independent of political conditions, as, for instance, countries with institutions that support strong antitrust laws will not be represented. Including the dummy does help us assess whether the results in the first column are simply identifying differences between the large OPEC countries and the rest of the world or, alternatively, whether polity scores have an effect on production volatility even within OPEC and non-OPEC countries.

Controlling for OPEC membership reduces the coefficient estimate on polity (in absolute value) and drives up the p-value, though it is still statistically distinguishable from zero. In principle, it is not clear what the sign of the OPEC dummy would be, as OPEC membership could provide production discipline that reduces volatility. On the other hand, OPEC countries may adjust production to achieve certain price or profit goals in ways that could contribute to increased production volatility. In fact, OPEC membership is strongly associated with increased volatility, 6.5 percentage points higher than occurs in non-OPEC countries.

As discussed in the previous section, it is possible that highly autocratic countries and highly democratic countries exhibit stable production – though for very different reasons. We test this by adding a quadratic in our polity measure in the next regression. We do see some evidence of a nonlinear effect, although the result is not robust to some

of the checks we describe later in the section. Production volatility increases until the polity measure is above 9 and then begins to decline with increased values of polity. This includes key producing countries such as Saudi Arabia, Russia, Iran and China. It is also possible that the relationship between polity and volatility is different in OPEC countries, if, for instance, volatility is more tied to cartel membership and less to internal political conditions. We have estimated specifications that allow the coefficient on polity and polity squared to vary by OPEC membership. While this specification relies on a small number of observations for identification (the 12 member countries identify the OPEC-specific coefficients), we do not see evidence of differences in the coefficient on polity by OPEC membership.

C. Instrumenting for Political Conditions

We argued in the last section that our polity measures are likely endogenous and possibly correlated with the error term in regression equation (5). In Table 5 we report results using several different instruments, though they are all based on the assumption that activities which took place before oil was commercialized in a country will reflect institutions independent of oil. For instance, the results in the second column use the polity measure before known commercialization, where we use a broad definition of known commercialization, dating it as the first year we see oil production in our data base unless we were able to find evidence of earlier commercialization online and in Alexeev and Conrad (2009). The results in column three use a more narrow definition, dating commercialization based only on outside sources. The results in column four use the settler mortality measure developed by AJR.

The pre-commercialization instruments are valid if the polity measures are persistent over time. In that case the instruments will be correlated with the time-persistent components of the polity measures while post-commercialization impacts of oil on polity are uncorrelated with the instruments.¹⁷ AJR argue that settler mortality correlates with settlement patterns in European colonies and the subsequent political institutions that developed.

The simple two-stage least squares regression of volatility on polity yields a slightly stronger impact of polity on production volatility compared to the equivalent OLS specification. This could reflect a resource curse phenomenon if lower exogenous volatility in oil production facilitates more autocratic governments, and it also could indicate that the polity measures do not fully reflect the important differences in political conditions.¹⁸ The first-stage F-statistic suggests that the instrument have very good explanatory power.

D. Alternative Political Conditions Measures

A similar story emerges when the polity variable is replaced by other measures of a country's internal political conditions. Results are reported in Table 6. The first two blocks of the table report simple univariate OLS and 2SLS specifications, equivalent to columns (1) and (2) in Table 5, using the Freedom House Political Rights or Civil Liberties measures. The results are very similar to those in Table 5, suggesting a negative and statistically significant relationship between production volatility and

¹⁷ This assumes that early twentieth century oil exploration activities were not skewed towards countries with specific polity characteristics. Our reading of the literature supports the view that oil companies searched widely for oil with little regard to the political institutions of the countries in which they suspected oil might be found. See Yergin (1991) for a general description of oil exploration and Bronson (2006) for a more detailed discussion of oil exploration and development in Saudi Arabia and the Middle East.

¹⁸ The analyses of the effects of institutions on macroeconomic conditions generally find that instrumenting for institutions increases their importance, which they interpret as evidence of market power (see, e.g., Acemoglu, Johnson and Robinson (2001)).

internal conditions. In fact, even though the Freedom House and polity variables are constructed using different methodologies, they are highly correlated ($\sigma_{\text{FH Civil Liberties} - \text{Polity}} = 0.95$ $\sigma_{\text{FH Civil Liberties} - \text{Polity}} = 0.92$). We have also estimated specifications that included the land area and OPEC dummy controls, and that allowed for an inverted U relationship. The controls (particularly the OPEC dummy) reduce the coefficient on the Freedom House variables by about forty percent, although they are both still statistically significant in the OLS specifications. With a quadratic term, the coefficient estimates suggest an inverted U relationship, but it is not statistically significant.

We also considered the relationship between our two measures of conflict – counts of the number of major and minor conflicts – and production volatility. The coefficients are both positive, although only the coefficient on major conflicts, which is nearly four times larger than the coefficient on minor conflicts, is statistically different from zero (to save space, we have only reported the coefficient on major conflicts). A positive sign, suggesting that countries that have been involved in more conflicts have more volatile oil production, is consistent with the story emerging from the other measures of political conditions. The polity-based instrument does not predict cross-country differences in either major or minor conflicts, so the 2SLS results are extremely noisy.

Finally, we use the two expropriation measures used in previous macroeconomic work on institutions. The first, capturing the risk of expropriation in a country between 1982 and 1995, was used by Acemoglu, Johnson and Robinson (2001), while the second composite index was used by Hall and Jones (1999). Both are negatively and statistically significant predictors of oil production volatility, and, based on the R-squared values,

explain more of the differences in production volatility than the polity variable. As with the other measures, 2SLS estimates are larger in absolute value.

E. Alternative Specifications

The regressions reported above use average political stability measures over the sample, so the specifications are identified by cross-country differences in political conditions. Our instruments pick up only those components of political conditions which were pre-determined before oil was a major factor in any country's economy, but our exclusion restriction will be violated if there is an omitted variable correlated both with poor political conditions and volatile production. For instance, if there is something about dominant religious institutions in a country that leads both to strong, unchecked executives and to volatility in production, our results cannot be interpreted causally. In this section, we focus on variation in the political measure as the source of instability in oil production.

We estimated one specification with the same dependent variable V_i , but using the variance in polity over our time period as the explanatory variable. The coefficients are all positive though statistically indistinguishable from zero. Positive coefficients, suggesting countries with more volatile political conditions have more volatile production, are generally consistent with the conclusions suggested by our previous results.

An alternative specification replaces polity measure with the change in polity defined as the difference between the average value of the last third of a country's observations and the average of the first third of observations. The production volatility measures are also re-defined as the difference between V_i for the last third of a country's

observations and V_i for the first third of observations. Table 7 presents results from that regression. The results are again indistinguishable from zero. In sum, there appears to be too little variation in polity scores within countries over time to identify the role of changes in political conditions on oil production volatility.

Overall, our cross-sectional results suggest a robust causal relationship between political conditions and oil production volatility.

V. Conclusion

The very inelastic nature of short run supply and demand in oil markets means that small fluctuations in either can have quite large price effects. In this paper we have considered how political conditions in oil producing countries affects the volatility of oil production and by extension the volatility of global oil prices. We first document that the average political conditions of oil producing countries has changed markedly over the past thirty-five to forty years. Using the polity composite democracy index, for example, we find that our oil security index falls by 30 percent between 1965 and 1976 and then nearly doubles over the next twenty-eight years. Over the past five years it has fallen by roughly five percent. We then decompose that index into a political index that controls for the distribution of oil production across countries and a production share index that controls for the political structure of producing countries. Again using the polity measure, early changes in our oil security index are driven by the distribution of countries producing oil while latter changes are driven more by changes in political conditions within producing countries.

We next show that political conditions affect the volatility of oil production. We show that there is a pronounced negative relationship between the short-run volatility in

oil production in a country and its political openness, with very democratic regimes exhibiting less volatility in their oil production than more autocratic regimes. This result holds across several robustness checks including using different measures of political conditions, instrumenting for political conditions and using different measures of oil production volatility.

One should be cautious in drawing any policy recommendations from this finding. It does suggest that a research agenda focusing on the role of political institutions in affecting global energy markets is a fruitful one. This paper takes a reduced form approach. Subsequent research will be important to begin to understand the mechanisms that affect supply volatility and what the implications are for policy.

Appendix. Construction of the Fisher Oil Stability Indexes

We begin by constructing an index of oil security as a weighted average of country level security as measured by one of our political stability measures weighted by oil production in that year. The index is normalized to equal one in the first year. We describe the process in detail for our polity variable.

$$\Pi_t = \frac{\sum_i \omega_{it} P_{it}}{\sum_i \omega_{i1965} P_{i1965}}$$

The political stability index based on the polity measure (P_{it}) is denoted by Π_t . The numerator is the average in year t of the polity measure across countries in year t weighted by the share of country i 's oil production in that year (ω_{it}). To construct the Fisher Ideal index, we first construct Laspeyres and Paasche political and production indexes. The Laspeyres indexes are

$$(A1) \quad L_t^{Pol} = \frac{\sum_i \omega_{i1965} P_{it}}{\sum_i \omega_{i1965} P_{i1965}}$$

$$(A2) \quad L_t^{Prod} = \frac{\sum_i \omega_{it} P_{i1965}}{\sum_i \omega_{i1965} P_{i1965}}$$

The Laspeyres political index fixes the oil production shares at their 1965 levels and allows the political conditions measure to change over time. It thus measures changes in the political conditions index solely due to changes within countries. The Laspeyres production index, on the contrary, measures changes in the political stability index due to changes in each country's share of world oil production holding their political stability constant. The Paasche indexes are

$$(A3) \quad A_t^{Pol} = \frac{\sum_i \omega_{it} P_{it}}{\sum_i \omega_{it} P_{i1965}}$$

$$(A4) \quad A_t^{Prod} = \frac{\sum_i \omega_{it} P_{it}}{\sum_i \omega_{i1965} P_{it}} .$$

The Laspeyres indexes use a base period fixed weight while the Paasche indexes uses a period t weight. The Fisher Ideal indexes are then given by

$$(A5) \quad \tilde{\Pi}_t^{Pol} = \sqrt{L_t^{Pol} A_t^{Pol}}$$

$$(A6) \quad \tilde{\Pi}_t^{Prod} = \sqrt{L_t^{Prod} A_t^{Prod}} .$$

Fisher (1921) showed that his ideal index satisfied perfect decomposition of an expenditure index into a price and quantity index under conditions satisfied by our data.

In our context, a Fisher ideal index provides a perfect decomposition of an aggregate political stability index into political and production share indexes with no residual:

$$(A7) \quad \Pi_t = \tilde{\Pi}_t^{Pol} \tilde{\Pi}_t^{Prod} .$$

The other political conditions indexes are decomposed in a similar fashion where we simply substitute other country level political conditions measures for the polity measure used here.

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Table 1. Country-level Oil Economic Specifications

	Average R ² in Prediction Equations	Average Coefficient on Annual Trends	Range of Coefficients on Annual Trends
Q on annual trend	0.63	3995 (38398)	[-53144, 64256]
Q/Reserves on annual trend	0.40	~0 (.002)	[-0.004, 0.009]
ln(Q) on annual trend	0.60	.018 (.038)	[-0.035, 0.354]
ln(Q) – ln(GDP) on annual trend	0.72	-0.040 (0.038)	[-0.093, 0.293]
ln(Q) – ln(Reserves) on annual trend	0.41	.0006 (.032)	[-0.050, 0.348]
ln(Q) – ln(Reserves) – ln(GDP) on annual trend	0.78	-0.057 (0.031)	[-0.106, 0.256]

Note: The first column summarizes 47 regressions per cell. In both columns (1) and (2), results are weighted by country's average output.

Table 2. Summary Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum	Years Covered
Oil Production Volatility Measures					
Production	0.232	0.088	0.068	0.439	1965-2007
Production/Reserves	0.261	0.193	0.038	1.17	1980-2007
Production (from Reserves database)	0.165	0.093	0.029	0.495	1980-2007
ln(Production) (from Reserves database)	0.017	0.012	0.002	0.063	1980-2007
ln(Production) - ln(GDP) (from reserves database)	0.018	0.012	0.006	0.069	1980-2007
ln(Production) - ln(Reserves) (from reserves database)	0.021	0.014	0.003	0.087	1980-2007
ln(Production) - ln(Reserves) - ln(GDP) (from reserves database)	0.022	0.014	0.006	0.092	1980-2007
Explanatory Variables					
Polity	9.8	6.9	1.0	21.0	1965-2007
Minor Conflicts	1.2	0.5	1.0	4.0	1965-2007
Major Conflicts	1.1	0.2	1.0	1.9	1965-2007
FH Political Rights	3.4	2.1	1.0	7.0	1972-2007
FH Civil Liberties	3.5	1.8	1.0	7.0	1972-2007
Risk of Expropriation	7.3	2.2	0.5	10.0	1982-1997
ICGR composite index (aggregate of 5 ICGR measures above)	24.0	7.4	3.4	38.0	1982-1997
Area (millions of square miles)	2.074	3.473	0.005	17.1	1965-2007
OPEC Membership	0.17	0.38	0	1	1965-2007
Source: Authors' calculations. There are 48 observations for all variables except the production to reserves ratio for which there are 47. Data on reserves for Cameroon were not available.					

Table 3. Volatility and Polity

<i>Prediction for Economic Production</i>	<i>Data range: 1980-2007</i>		<i>Data range: 1965-2007</i>	
	<i>Coefficient on mean(Polity)</i>	<i>R²</i>	<i>Coefficient on mean(Polity)</i>	<i>R²</i>
Q on annual trend	-0.005** (0.002)	0.19	-0.007** (0.003)	0.33
Q/Reserves on annual trend	-0.008** (0.003)	0.18		
ln(Q) on annual trend	-0.0006** (0.0002)	0.17	-0.0013* (0.0006)	0.19
ln(Q) – ln(GDP) on annual trend	-0.0004* (0.0002)	0.08	-0.0009 (0.0006)	0.10
ln(Q) – ln(Reserves) on annual trend	-0.0006** (0.0003)	0.16		
ln(Q) – ln(Reserves) – ln(GDP) on annual trend	-0.0005** (0.0003)	0.12		

N = 48. Robust standard errors in parentheses. All specifications are weighted by a country's average production between 1965 and 2007. The first two columns present results where the dependent variable is estimated over the data range 1980-2007, while the two right-most columns present results where the dependent variable is estimated over the data range 1965-2007.

* - p-value less than 10 percent

** - p-value less than 5 percent

*** - p-value less than 1 percent

Table 4. Volatility Regressions with Controls			
	OLS	OLS	OLS
Polity	-0.0071**	-0.0049*	0.0187**
	(0.0026)	(0.0027)	(0.0076)
Land Area		-0.0010	-0.0024
		(0.0038)	(0.0028)
OPEC		0.0646**	0.0914***
		(0.0312)	(0.0298)
Polity ²			-0.0010***
			(0.0003)
R ²	0.329	0.426	0.541
Inflection point			9.4

N = 48. Robust standard errors in parentheses. All specifications are weighted by a country's average production between 1965 and 2007.

* - p-value less than 10 percent

** - p-value less than 5 percent

*** - p-value less than 1 percent

Table 5. Oil Production Volatility Regressions: Alternative Instruments				
	OLS	2SLS	2SLS	2SLS
		1900polity_broad	1900polity_strict	Settler Mortality
Polity	-0.0071**	-0.0087***	-0.0089***	-0.0097***
	(0.0026)	(0.0028)	(0.0028)	(0.0031)
obs		46	26	32
First-stage F-statistic		46.06	62.13	5.89

Robust standard errors in parentheses. All specifications are weighted by a country's average production between 1965 and 2007. N varies depending on availability of instrument.

- * - p-value less than 10 percent
- ** - p-value less than 5 percent
- *** - p-value less than 1 percent

Table 6. Oil Production Volatility Regressions: Alternative Political Measures		
	OLS	2SLS
Freedom House Political Rights	-0.0243***	-0.0290***
	(0.0090)	(0.0088)
R ²	0.335	
First-stage F- statistic		69.64
Freedom House Civil Liberties	-0.0270***	-0.0293***
	(0.0089)	(0.0087)
R ²	0.375	
First-stage F-statistic		72.85
Major Conflicts	0.2946**	2.4474
	(0.1164)	(2.1217)
R ²	0.176	
First-stage F-statistic		1.19
Risk of Expropriation	-0.0370***	-0.0635***
	(0.0092)	(0.0192)
R ²	0.484	
First-stage F- statistic		5.44
ICGR composite index	-0.0097***	-0.0114***
	(0.0023)	(0.0026)
R ²	0.517	
First-stage F-statistic		18.03

N = 48 for OLS specifications (46 for last two measures). N = 46 for 2SLS specifications (44 for last two measures). Robust standard errors in parentheses. All specifications are weighted by a country's average production between 1965 and 2007.

* - p-value less than 10 percent

** - p-value less than 5 percent

*** - p-value less than 1 percent

Table 7. Change in Volatility and Change in Polity

	Change in Production Volatility	Change in Production/Reserves Volatility
Change in Polity	0.0007	0.0038
	(0.0044)	(0.0029)
R ²	0.001	0.033

N = 46. Robust standard errors in parentheses. All specifications are weighted by a country's average production between 1965 and 2007.

Figure 3

Resvar and Production Weighted Polity

