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ABSTRACT

We analyze how a country's political institutions affect oil production within its borders. We find a pronounced negative relationship between political openness and volatility in oil production, with democratic regimes exhibiting less volatility than more autocratic regimes. This relationship holds across a number of robustness checks including using different measures of political conditions, instrumenting for political conditions and using several measures of production volatility. Political openness also affects other oil market outcomes, including total production as a share of reserves. Our findings have implications both for interpreting the role of institutions in explaining differences in macroeconomic development and for understanding world oil markets.

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I. Introduction

Development levels vary considerably across countries, and explaining why these differences exist is one of the central questions in economics. While scholars have long hypothesized that political institutions play an important role (see, *e.g.*, North 1981), a recent literature has made progress identifying a causal impact of institutions on cross-country differences in macroeconomic outcomes.[1] Still, the mechanisms by which specific institutions affect economic outcomes remain a "'black box'" (Acemoglu, Johnson and Robinson, 2001 – hereafter AJR – p.1395).[2]

This paper focuses on the influence of institutions on one particular industry: crude oil production. We document a pronounced negative effect of good political conditions on volatility in oil production, and this result is robust to using several different measures of political conditions. We also address the potential endogeneity of political structure, as suggested by the literature on the "resource curse." We estimate two-stage least-squares regressions where we instrument for recent political institutions with both institutions before oil was commercialized and, following AJR, settler mortality. We find that the negative relationship persists in these specifications.[3] We also evaluate whether other macroeconomic differences across countries affect oil market outcomes, including financial openness and legal formalism. None of these factors has a significant effect on volatility once we control for institutions.

It is important to acknowledge that a country's oil production may not necessarily be inefficient if it is volatile. To allow for this, we also construct volatility measures that control for market factors which *should* drive changes in a country's oil output, and our results are robust to using these alternative measures.[4]

Ideally, we would also like to measure oil output controlling for the natural resources available to the country, as this is analogous to studies that examine factors contributing to differences in economic development. With this goal in mind, we also examine the link between

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[1] See Barro (1997), Hall and Jones (1999), Rodrik (1999), Acemoglu et al. (2003), Persson and Tabellini (2003), and Mulligan, Gil and Sala-i-Martin (2004) for varying perspectives on the influence of political institutions on economic outcomes.

[2] Acemoglu and Johnson (2005) provides a peek inside the box, finding evidence that firms in countries with poor political institutions are more likely to report concerns about government corruption, including "additional payments" for government services, and concerns about unpredictable government regulation.

[3] Albouy (2008) critiques the settler mortality instruments developed by AJR. Our results are robust to excluding the potentially problematic observations.

[4] Existing work considers the effect of political institutions on macroeconomic volatility. See, for example, Acemoglu, Johnson, Robinson and Thaicharoen (2003).

political institutions and a country's average production as a share of its proven reserves. We find that countries with better political institutions produce a higher share, although we devote less attention to these results since the data on reserves are self-reported in some cases and could be systematically biased. Finally, we show that political institutions lead to volatility in the number of active wells, suggesting that the volatility is less likely to be driven by physical characteristics of a country's oil fields.

Oil production is a particularly convenient lens with which to view the possible microeconomic foundations for macroeconomic outcomes as it is a commodity sold on a world market. This means that production decisions within a country should be driven by world demand and not local macroeconomic conditions. Was this not the case, our results would be less interesting as they could simply reflect the effect of political institutions on overall macroeconomic activity. Since oil demand is worldwide, however, we can be confident that our results reflect supply-side factors and not demand-driven output volatility.

Another reason that oil is well-suited to this analysis is that the unit of output (a barrel of oil) is of essentially homogenous quality and is consistently measured across countries. Finally, rich data are available on oil production and its determinants, such as reserves and the number of wells.

By documenting that political institutions affect outcomes in a particular industry, our results provide insight on how institutions affect aggregate economic output. For example, they suggest that while political institutions may work by influencing structural factors, such as by promoting a well-developed commercial sector or less reliance on agriculture (see, *e.g.*, Duarte and Restuccia, 2010), these cannot be the only mechanisms at play as institutions have effects within an industry. Although our results cannot address this hypothesis directly, they are consistent with the idea that well-functioning political institutions support efficient investment in crude oil production.

Our results also provide insight on world oil markets. Like many energy markets, oil 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. While much has been written about how systematic shifts in oil demand or supply affect prices (see, for example, Hamilton (2009) and Kilian (2009)), less is understood about the underlying determinants of short-run changes in supply.

Our results imply that political institutions in the countries endowed with oil reserves affect the volatility, and perhaps the level, of its production. To the extent countries with poor political conditions will have less stable production of other natural resources, our results suggest a useful metric for comparing different energy sources. As U.S. policymakers attempt to drive shifts to new, alternative energy technologies, it is useful to be able to make these comparisons.

To explore the implications of our results for world oil markets, we construct annual, worldwide statistics that summarize the political institutions of oil-producing regimes. Generally, our indexes depict a reduction in the political conditions of oil producing countries 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 measures into "production share" and "internal conditions" indexes to show how changes in the aggregate measures are driven by changes across countries in their share of world oil production and changes within countries in political conditions. In the early part of our sample, changes in oil political conditions 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, however, appear to be driven by changes in internal conditions in addition to changes in the location of oil production.

We show that the higher the share of oil coming from countries with poor political conditions in any given year, as measured by the decomposed "production index," the higher is the volatility of oil prices in that year. Within-country changes in political conditions, as measured by the decomposed "internal conditions index," if anything have the opposite effect on oil price volatility, suggesting that it may take time before short-run changes in political conditions impact oil production.

While short-run production volatility within one country's borders may be quickly counteracted by adjustments in other countries so that any resulting price volatility will be short-lived, there are reasons to be concerned about the volatility. For one, 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.[5]

The next section of the paper presents a model that helps elucidate the mechanisms by which political conditions might affect oil markets. Section III presents our main empirical findings, documenting the negative relationship between political conditions and oil market volatility. Section IV interprets our findings and analyzes their implications for price volatility in world oil markets. We also discuss why our findings probably do not support an "energy-security" based argument for government intervention in energy markets. 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.

II. Background and Theory

In this paper we seek to identify the role that political conditions play 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), there has been little focus on the role governance plays in affecting supply. 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 resource wealth 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. See also the recent empirical analysis by

[5] 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).

Wacziarg (2009). For our purposes, these three papers (and others such as Smith (2004), Basedau and Lacher (2006), Tsui (2008), and 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 affect of institutions on 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 several important respects. First, while they interpret weak institutions as indicative of "ownership risk," in one specification, we include a variable that measures expropriation events in addition to the political conditions variable. The results of this specification suggest that political conditions affect oil production more through other channels (*e.g.*, government pressures to pursue nonmarket goals) than through expropriation risk, although this is based on only one, perhaps blunt, measure of ownership risk. Second, we treat governance institutions as endogenous and instrument for them in our empirical analysis.

A. Model Setup

We consider a simple model that illustrates the relationship between political structure and production volatility. We take as our point of departure the model of Acemoglu and Robinson (2008) which describes the relationship between political and economic institutions. There are two political groups, an elite (E) with M_E members and citizens (C) with $M_C > M_E$ members. Members of each group wish to maximize the present discounted value of consumption over an infinite horizon, $\sum_t \beta^t c_t$, where β is a discount factor common to all and c_t is consumption for an individual in period t.

Each period the groups struggle for control of the government. The group in power controls economic resources in a country and wishes to maximize economic rents for itself. In particular, the government controls a nationalized oil sector and receives the revenue from oil sales.[6]

We model political institutions as a state variable in a Markov model in which economic decisions along with citizen mobilization affect the probability of future political institutions. Thus there is an interplay between political institutions and economic outcomes.

A state variable s indicates whether the political regime is a democracy (state D) or autocracy (state A). Which state the regime is in depends on the outcome of a struggle between citizens and the elite as described below.

As discussed below all decisions made in a given time period affect only that period with the exception of the value of the political state variable which sets the regime type for the following period. Thus, in the discussion below we ignore time subscripts as all decisions relate to the current period (except where specifically noted otherwise).

1. Oil Production and Revenue Distribution

The government controls oil production in a country and must decide investment levels for production infrastructure (broadly defined as described below) and accrue rents for itself. For simplicity assume that oil production is the only source of revenue for the government. Each period the group controlling the government invests K in the sector financed by a lump-sum tax paid by all residents of the country. This includes spending on new capital and maintenance of existing capital as well as training of workers and managers. It could also include spending to hire higher quality managers. Higher levels of K reduce the probability of oil production disruptions.[7] Capital is fully depreciated in one period of the model.

An autocratic regime may also have a greater ability to monitor and stifle political dissent that could take the form of activities that reduce oil supply (Ross's Repression Effect). This could include sabotage of capital infrastructure as well as labor slowdowns among the workforce.[8] Alternatively, democratic governments provide additional outlets for dissent that mean workers need not sabotage energy capital to be heard by political leaders.

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[6] The model could be extended to allow for a capitalist economic system with corporate ownership of natural resources. In that case, tax and royalty policy would be potential instruments to extract oil rents.

[7] We ignore the possibility of foreign investment in the domestic oil sector. This would provide another channel of potential oil production volatility. Weak property rights that may be more likely in a less open political environment will deter investment.

[8] Nigerian rebels have disrupted oil production as noted elsewhere in our paper. Venezuelan oil workers went on strike in protest of decisions taken by Hugo Chavez in 2002.

Finally production disruptions can occur unexpectedly and for reasons unrelated to fiscal decisions made by the government. Specifically we assume that the value of oil production (*R*) in a period is given by the following:

(1) $$R = \begin{cases} R_H & y^* \leq 0 \\ R_L & y^* > 0 \end{cases}$$

with $R_H > R_L \geq 0$ and y^* is a latent variable defined as

(2) $$y^* = -\alpha K - \delta \cdot I_A + \varepsilon .$$

In equation (2) δ is a measure of an autocratic government's ability to monitor and deter activities that could disrupt production when $s = A$ (I_A is an indicator variable equal to 1 when $s = A$ and zero otherwise). We allow δ to be negative given the possibility that disruptive activities under autocracy more than offset the government's ability to monitor and deter those activities. As we shall see below, the sign and magnitude of δ have no bearing on the degree of production volatility. Finally ε is a random variable drawn from a density function $f(\varepsilon)$ and cumulative distribution function $F(\varepsilon)$. We assume that $P(R=R_H) = P(y^* \leq 0)$ is high so that increased volatility is associated with higher values of y^*. Higher values of *K* then are associated with lower production volatility.

Oil revenues are received by members of the class that controls government. Thus in political state *A*, members of the elite share oil revenues each receiving R/M_E. In democracy (D), citizens each receive R/M_C.

2. Political Struggle

The two groups engage in a political struggle for control of the government. We assume that a more democratic political structure can make it more possible to engage in public organizing to preserve democratic institutions.[9] In addition, the ability to mobilize and coalesce opposition to a regime and force an opening of political institutions has a random component (see Acemoglu and Robinson (2006) for a full discussion of the forces driving regime transition).

[9] Persistence of democracy is discussed by Acemoglu and Robinson (2008) and the subject of analysis by Perrson and Tabellini (2009) who provide a theoretical justification for persistence as well as empirical support for the proposition.

Activities that lead to potential change in political institutions occur at the end of the current period and determine political institutions for the following period.[10]

The following equations define the political transition process:

(3) $$s_1 = \begin{cases} A & P(s) \le 0 \\ D & P(s) > 0 \end{cases}$$

where s_1 is the political state in the following period and

(4) $$P(s) = \pi \cdot I_D + \eta$$

The parameter π measures the greater ability of citizens to mobilize for more democratic institutions if the current regime is democratic (I_D equals one when the political state is D and zero otherwise). The random variable η captures the stochastic nature of the public's ability to coalesce its opposition to the elite and is drawn from the density function $g(\eta)$ with cumulative distribution function $G(\eta)$. We assume that ε and η are independent random variables (though this could be relaxed).[11]

As in Acemoglu and Robinson (2008) the winners of the political struggle choose the political regime for the following period. The elite will choose an autocracy since this increases the likelihood of their obtaining oil production revenues while citizens will choose democracy.

3. Timing of Events

Events occur in the following sequence.

- The political state $s \in \{A, D\}$ is given exogenously based on actions taken last period.
- Knowing *s*, the current government chooses *K*, the investment in the oil sector for the current period (first stage decision).
- A draw is taken from the density function *f* and oil revenues are realized.
- A draw is taken from the density function *g*. Based on the draw, either the elite or citizens take control of the government. They choose the political regime for the following period. Oil revenues accrue to the political class now in control of government.

[10] We have also considered a model in which citizens and members of the elite can invest in de facto power that affects the probability of regime change. The model is considerably more complicated but does not provide additional insight.

[11] We have also constructed a model in which economic agents may invest in de facto power to increase the probability that their group will win the political struggle. As in Acemoglu and Robinson (2008), it is never optimal for citizens to invest in de facto power. The resulting solution is more complicated and does not provide clear results on conditions for higher or lower production volatility under either regime.

B. Solving the Model

Recall that the decision over the investment level is made by the group in power at the beginning of the period. Define $V^E(s)$ as the value function for a representative member of the elite when the political state equals $s \in \{A, D\}$. Similarly $V^C(s)$ is the value function for a representative citizen given state *s*. Thus a representative member of the elite chooses *K* in a non-democracy to maximize:

$$(5) \qquad V^E(A) = -\frac{K}{M_E + M_C} + F(\alpha K + \delta)\psi(A, R_H) + (1 - F(\alpha K + \delta))\psi(A, R_L)$$

where $\psi(A, R_v) = G(0)\left(\frac{R_v}{M_E} + \beta \Delta V^E\right) + \beta V^E(D)$, $v = H, L$ and $\Delta V^E = V^E(A) - V^E(D)$ is the difference in the value function for a representative member of the elite when the political state shifts from democracy to autocracy . The function ψ measures the expected net benefit to a member of the elite of oil revenue conditional on oil production. Ex post benefits will depend on the outcome after the political struggle and oil investment is undertaken. First order conditions for *K(A)* (*i.e.*, *K* in the autocratic state) are given by

$$(6) \qquad -\frac{1}{M_C + M_E} + \alpha f\left(\alpha K(A) + \delta\right)\left(\frac{G(0)}{M_E}\Delta R\right) \le 0$$

where $\Delta R = R_H - R_L$. Equation (6) holds as an equality if $K(A) > 0$. We will assume positive values for K in the analysis below. Second order conditions require

$$(7) \qquad f'(\alpha K(A) + \delta) \le 0 .$$

Assuming an interior solution

$$(8) \qquad f\left(\alpha K(A) + \delta\right) = \left(\left(M_E + M_C\right)\alpha G(0)\frac{\Delta R}{M_E}\right)^{-1} .$$

Investment in oil capital rises with the expected net gain from oil production rising from R_L to R_H.

In democracy a representative citizen chooses the level of oil investment to maximize:

$$(9) \qquad V^C(D) = -\frac{K}{M_E + M_C} + F(\alpha K)\psi(D, R_H) + (1 - F(\alpha K))\psi(D, R_L)$$

where $\psi(D,R_v) = -G(-\pi)\beta\Delta V^C + (1-G(-\pi))\frac{R_v}{M_C} + \beta V^C(D)$ is the expected net benefit to a representative citizen of oil production conditional on R_v production levels and $\Delta V^C = V^C(D) - V^C(N)$, the expected net gain in utility to a representative citizen from shifting from a non-democracy to democracy.

First order conditions are

(10) $$-\frac{1}{M_C + M_E} + \alpha f(\alpha K(D))\left((1-G(-\pi))\frac{\Delta R}{M_C}\right) \le 0 .$$

Second order conditions are

(11) $$f'(\alpha K(D)) \le 0 .$$

Assuming an interior solution,

(12) $$f(\alpha K(D)) = \left((M_E + M_C)\alpha(1-G(-\pi))\frac{\Delta R}{M_C}\right)^{-1}$$

The relation between production volatility and political structure is a complex one. We first note that an improvement in the ability to monitor and deter oil production disruption in a non-democratic regime $(\Delta\delta > 0)$ has no effect on the equilibrium level of production volatility. To see this note that the right hand side of equation (8) is unaffected by a change in δ. Thus $\alpha K(A) + \delta$ is unaffected by a change in δ. Increases in δ are offset by reductions in *K(A)* leaving production volatility unchanged.

Oil production is more volatile as the probability of disruption rises which in turn is related to the amount of capital investment. The model suggests several channels through which the political state can affect investment (and possibly production volatility). They include 1) regime specific ability to monitor and deter production disruption activities (δ) as discussed above; 2) the extent of oil revenue losses due to disruption (ΔR); and 3) citizen organizing gains when political state equals *D* that affect optimal oil revenue sharing (π).

Volatility is higher in an autocratic political regime (*s* = *A*) if the following is true:

(13) $$K(D) > K(A) + \frac{\delta}{\alpha} .$$

Assuming the second order conditions for investment hold as a strict inequality, this will occur when

(14) $$\frac{1-G(-\pi)}{M_C} > \frac{G(0)}{M_E}.$$

Equation (14) can be re-written as

(15) $$P(s_1 = D \mid D) > \frac{M_C}{M_E} P(s_1 = A \mid A).$$

In other words production volatility under autocratic governments is more volatile if democracy is sufficiently more persistent than non-democracies. This condition is consistent with the empirical findings of Persson and Tabellini (2009) that democratic institutions contribute to a consolidation of democratic institutions across countries.

Our model provides some insight into the forces affecting oil production volatility and provides a theoretical link between political structure and economic outcomes in this industry. We turn next to an analysis of oil production data and political structure as an initial step to developing a deeper understanding of this relationship. In the analysis below, we test empirically whether in fact oil production volatility is higher in non-democracies than democracies.

III. Empirical Analysis

We analyze the empirical relationship between a country's political conditions and its oil production in several steps, first presenting our basic results on political conditions and volatility, then describing our approach to dealing with the possible endogeneity of political conditions, next testing the empirical relationship using several additional political conditions measures, and finally presenting several alternative specifications that evaluate whether other macro factors influence volatility in addition to political institutions. We also show results suggesting that political conditions influence the share of a country's reserves that are extracted, although we place less emphasis on these results since reserve estimates could be misleading. Table 1 provides summary statistics on all of the variables used in the analysis.

Our basic regression is of the form:

(16) $$V_i = \alpha_1 + \beta_1 PC_i + \mathbf{X_i}\gamma_1 + \eta_i$$

where V_i is a measure of oil volatility in country i, PC_i is a measure of political conditions, $\mathbf{X_i}$ is a vector of control variables included in some specifications and η_i is a random error. We estimate equation (16) across the 48 major oil-producing countries. All of our specifications are weighted by a country's average production within the appropriate time period, although the basic results are not sensitive to this weighting.

Our base measure of political conditions is the Composite Democracy Index from the 2007 Polity IV Project.[12] The composite score is defined as the difference between the Institutionalized Democracy index ($DEMOC_{it}$) and the Institutionalized Autocracy index ($AUTOC_{it}$). 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. For use in our index decompositions in Section IV, we rescale the index to range from 1 to 21 with higher values still indicating stronger democratic tendencies. Country-level oil production data is from BP (2009).

A. Basic Results

Table 2 presents versions of equation (16) estimated over two different time periods and without covariates. We use data from both 1965-2007, where the start date is constrained by the availability of the oil production data, and 1980-2007, where the start date is constrained by the availability of data on oil reserves, used in later rows of the table. Other work on political institutions has begun with the 1970s to ensure that the countries are independent nation states throughout the entire period of analysis (Acemoglu, Johnson, Robinson and Thaicharoen, 2003).

The results in the first row suggest that countries with higher polity scores have lower volatility, and the coefficient estimate is similar across the two different time periods. Considering the specification in the left-hand column, 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 .084, which represents approximately half a standard-deviation change in volatility. Also, the R^2 in that specification suggests that political conditions explain nearly one fifth of the volatility differences across countries. Figure 1 plots the data used to generate

[12] 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.

this set of results, where the size of each circle is proportional to the country's average production over the sample period.

We also 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 appropriate, economically-motivated 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 consider the following formula:

$$\ln(Q_{it}) = f(S_{it},D_{it}) + g(PC_{it}) \quad (17)$$

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

We estimate $\ln(\hat{Q}_{it}) = \hat{f}(S_{it}, D_{it})$ and then calculate the residual production: $\hat{g}(PC_{it}) = \ln(Q_{it}) - \ln(\hat{Q}_{it})$. Our country-level measure of volatility is then:

$$V_i^1 = \text{std.dev.}\left(\hat{g}(PC_{it}) - \hat{g}(PC_{it-1})\right) \quad (18)$$

The second row of Table 2 reflects a specification where f() is a country-specific quadratic time trend. At the country level, scientists have suggested that production will increase slowly at first, then more quickly and eventually decline (Hubbert (1956)). Because some countries began extracting oil long before the beginning of our dataset while others began during our dataset, we are concerned that the volatility measure might reflect changes in output driven by petroleum engineering factors, as countries with recent oil discoveries would go through both the slow and rapid increase in our data set. The results in the second row suggest that controlling for this possibility, the relationship between polity and volatility is even stronger, and, in the 1981-2007 time period accounts for almost half of the variation in volatility.[13]

The third and fourth rows of Table 2 estimate f() using information on world GDP, which affects world oil demand, and a country's reserves, which, as an abstraction, we take to be

[13] These results do not appear to reflect over-differencing as they are very similar to results using the standard deviation of the residuals from the quadratic trend as opposed to the difference in the residuals.

exogenous determinants of the country's ability to produce oil.[14] The reported specifications reflect a coefficient of one on both ln(World GDP) and ln(Reserves), although the results are quantitatively very similar if we impose different coefficients on either variable.[15] In both rows, the absolute value of the coefficient on polity declines, but remains statistically significant at the five-percent level.

Finally, the last row of Table 2 reports coefficient estimates that use a dependent variable measuring the largest single percent decline in annual production. The results similarly suggest that countries with poor political conditions are more prone to large output drops. In the regressions that follow, we will report results based on the volatility measure used in the first row of Table 2, although our results are not sensitive to this decision.

B. Reverse Causality

We argued in section II that our polity measure is likely endogenous and possibly correlated with the error term in regression equation (16). In Table 3 we report results using several different instruments, all of which are based on the assumption that activities which took place before oil was commercialized in a country will reflect institutions independent of oil. 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 narrower definition, dating commercialization based only on outside sources. The results in column four use the settler mortality measure developed by AJR.[16]

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. AJR argue that settler mortality correlates with settlement patterns in European

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[14] We have also estimated specifications using Kilian (2009)'s real demand variable, as he argues that it is a much better predictor of commodity demands than world GDP. The coefficient on polity was slightly smaller in absolute value, although still precisely estimated to be different from zero.

[15] The equation we estimate is a reduced form of the supply and demand equations under certain assumptions about the relationship between income, supply and demand elasticities.

[16] Specifically, our instruments are the log of the settler mortality rate from Acemoglu, Johnson and Robinson (2001) and a dummy variable for European countries (for whom we assume that the log of settler mortality is zero). Based on Albouy (2009), we have estimated specifications omitting the nine countries in our data for which mortality estimates were based on soldiers on campaign, and our results are very similar. The 2SLS coefficient on polity is -.0124 (standard error = .0057).

colonies and the subsequent political institutions that developed.[17] In all cases, the first-stage coefficients take the expected sign (positive for pre-commercialization polity and negative for settler mortality) and the F-statistics suggests that the instruments have good explanatory power.

All three instruments are only available for a subset of our countries. With the settler mortality instruments, we are mainly missing information from the Middle Eastern countries, which account for ten of the fourteen that are missing. The broad polity variable is missing for Indonesia and Qatar, while the strict polity information is missing primarily for African and Asian countries. OLS results based on the same subset of the data are reported in the panel below the 2SLS results.

When we use the broad pre-commercialization polity instruments, the two-stage least squares result suggests a smaller impact of polity on volatility compared to the equivalent OLS specification. This could reflect a resource curse phenomenon if higher exogenous volatility in oil production facilitates more autocratic governments, perhaps because an autocrat is better able to smooth oil revenues over boom and bust periods. By contrast, when we use the settler mortality instrument, the coefficient estimate more than doubles compared to the OLS specification. This could reflect persistent measurement error in the polity measure.[18] In all three cases, the 2SLS coefficient estimate is negative, and it is statistically significant at the ten percent level or better for the two more precisely estimated instruments.

C. Alternative Political Conditions Measures

A similar story emerges when the polity variable is replaced by other measures of a country's internal political conditions. We consider four additional measures:

Freedom House Political Rights (PR_{it}): Freedom House ranks countries on a variety of scales including political rights and civil liberties (next index). We use data from the 2008 Freedom House Survey.[19] The political rights index is based on a checklist of ten questions that is converted to a seven point scale ranging from 1 (most political rights) to 7 (fewest political rights). For consistency with our other measures, we rescale the index to range from 1 (fewest political rights) to 7 (most political rights).

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[17] Du (2010) provides empirical support for this instrument in an analysis of currency and real economic crises.

[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 measurement error (see, e.g., Acemoglu, Johnson and Robinson (2001)).

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

Freedom House Civil Liberties (CL_{it}): Based on the answers to fifteen questions, a score between 1 (most civil liberties) and 7 (fewest civil liberties) is awarded. As with the civil liberties index, we rescale the index to range from 1 (fewer civil liberties) to 7 (most civil liberties).

ICRG Expropriation Risks: 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).

Results are reported in Table 4. Each panel of the table reports univariate OLS and 2SLS specifications, equivalent to both the upper and lower panels of the second column of Table 3. The results for both of the Freedom House variables are very similar to those in Table 3, suggesting a negative relationship between production volatility and internal conditions in both the OLS and 2SLS specifications, and all results are statistically significant at the ten percent level except for the 2SLS specification for the Freedom House Political Rights variable, which is significant at the 11% level.[20] In fact, even though the Freedom House and polity variables are constructed using different methodologies, they are highly correlated ($\sigma_{\text{FH Civil Liberties – Polity}} = 0.95$ $\sigma_{\text{FH Civil Liberties – Polity}} = 0.92$).

Both ICRG measures are negatively and statistically significant predictors of oil production volatility, and this holds for both the OLS and 2SLS specifications.

For three of the four measures, the estimated coefficients in the 2SLS regression are smaller in absolute value than the OLS coefficients. The ICRG risk of expropriation is the one exception to this pattern. The first-stage coefficients are positive and significant in all four cases, although the F-statistic suggests weak explanatory power using the ICRG risk of expropriation.

D. Additional Covariates

Table 5 reports results that include variables that capture cross-country differences in additional, nonpolitical, determinants of development. Our objective is to discern whether the strong relationship between political conditions and oil market volatility is mainly capturing an intermediate relationship between political conditions and another factor, such as financial

[20] We also estimated 2SLS specifications using the settler mortality variable as an instrument. The second stage coefficient estimates, equivalent to the four reported in Table 4, were all statistically significantly negative, although the instrument is weak, with first-stage F-statistics below 7 in all specifications.

openness. We do this by estimating versions of equation (16) that include several additional covariates described more fully below (represented by Add. Cov.$_i$ below).

(19) $$V_i = \alpha_2 + \beta_2 PC_i + \delta_2 Add.Cov._i + \mathbf{X_i}\boldsymbol{\gamma}_2 + \nu_i \, .$$

If there is an intermediate relationship between political conditions and the additional covariate, then β_1 from equation (16) will reflect both the direct effect of political conditions on volatility and the indirect effect, working through the covariate. Equation (19) will separately identify the direct effect, so if β_2 approximately equals β_1 from equation (16), this suggests that the relationship we have picked up so far is not due to an intermediate effect of political conditions on the additional covariate.

Panels A through D use Polity, Freedom House Political Rights, Freedom House Civil Liberties and the ICRG Composite Index, respectively. Each column in a panel reports results from a separate specification. All specifications include a control for the land area in a country (square miles) on the hypothesis that larger countries may be able to diversify production across sites and so control volatility. This hypothesis bears out as countries with larger land area appear to experience less production volatility. To save space, we do not report the coefficient on the land area variable, but in all specifications, it is negative and statistically significant at the five percent level or higher.[21] The economic impact is small, though, as the coefficient suggests that volatility falls by one-fifth of a standard deviation in countries with four million square miles more land area, which is more than a one standard deviation change in land area among our countries. The first columns in Panels A-D, based on the same time period as the specification in the first row of the left-hand column of Table 2, only include the land area variable, and are included for purposes of comparison to the rest of the table.

In the second column, we report results that include a measure of the country's financial openness: its gross stock of foreign assets and liabilities as a share of GDP.[22] We include this variable to test the hypothesis that political institutions affect firms' ability to produce efficiently at least in part by altering their access to foreign capital.[23] Also, previous work has pointed to the importance of financial openness at the industry level. For example, Rajan and Zingales

[21] The reported coefficients in Table 5 are not sensitive to the inclusion of land area.

[22] The data are described in Lane and Milesi-Ferretti (2006), and Kose et al. (2006) summarize the pros and cons of different financial openness measures. We have tried other variables, such as the Chinn-Ito Index (see Chinn and Ito (2006), and they are similarly insignificant.

[23] The literature on the relationship between financial openness and growth has recognized the potential relationship between political conditions and financial institutions (see, *e.g.*, Eichengreen, Gullapalli and Panizza (2009)).

(1998) show that manufacturing industries that are more dependent on external finance grow disproportionately faster in countries that are financially open. While that paper's focus on manufacturing startups may appear irrelevant to the oil extraction industry, startups may provide many valuable support services to established oil extraction firms.

If political institutions affect oil market outcomes by influencing the degree of financial openness, we would expect the coefficient on financial openness to be negative and the coefficient on polity to fall in absolute value. In fact, in all four panels, the coefficient on the financial openness measure is *positive*, suggesting that countries with more financial openness are more volatile. It is not significant at conventional levels, and the coefficient on the polity variable is attenuated, but not appreciably so. The raw correlation between polity and financial openness for our countries is -.076. This result could reflect the fact that even in countries with considerable capital flows, foreign investment in the oil industry is limited. It may also simply reflect the fact that countries with considerable oil wealth are diversifying by investing abroad (*e.g.*, Saudi Arabia and other major Arab oil and gas producing states), which makes them appear more financially open.

The next set of specifications includes a dummy variable for countries that are in OPEC over the entire time period. Political conditions could drive OPEC membership, as, for instance, countries with institutions that support strong antitrust laws will not be in the cartel. Including the dummy also helps 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.[24]

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 price or profit goals in ways that could contribute to increased production volatility. In general, OPEC membership seems to be associated with high volatility, although the coefficient on the dummy is only significant in one specification. The coefficients on the political conditions variables are generally attenuated, suggesting that our results reflect, in part, the fact that countries with poor political conditions

[24] We have also estimated specifications that allow for a quadratic relationship between polity and volatility and found little evidence of important nonlinearities.

are in OPEC, but the coefficients on the political conditions variables are still negative, and significantly so in the case of polity, even with the OPEC dummy.

We also included an indicator variable for countries in which there were overt nationalization acts in the oil sector. Specifically, Guriev, Kolotilin and Solin (2009) compiled a list of countries where there were, “forced divestments of foreign property,” [p. 12]. Their paper investigates determinants of these nationalization acts, including political institutions. Our results suggest that countries that have had overt nationalizations have more volatile oil production, although the coefficients on the nationalization variable are never statistically significant. The coefficient estimates on the political conditions variables are all smaller in absolute value, but, at least in the case of polity, still statistically significant. This suggests that nationalizations do impact volatility, but that political conditions appear to work through additional channels as well.[25]

The fourth column includes a country’s average GDP per capita between 1965 and 2007. As we have discussed, previous work has found a strong, causal relationship between political conditions and economic development levels, as measured by GDP per capita, among other things. This appears true for the oil-producing countries in our data. For instance, the raw correlation between the political conditions variables and GDP per capita is strongly positive: 0.47 for polity, 0.59 for Freedom House Civil Liberties, 0.65 for Freedom House Political Rights and 0.76 for ICRG Composite Index. In the specifications in Panels B-D (which measure political conditions using Freedom House Political Rights, Freedom House Civil Liberties and the ICRG Composite Index), the coefficients on the political conditions variable are slightly larger in absolute value and remain statistically significantly negative. Contrary to expectations, the coefficient on GDP per capita is positive, though quite imprecisely estimated.

The results for the polity variable, on the other hand, accord with expectations. The coefficient on GDP is negative, though imprecisely estimated, and the coefficient on polity falls slightly in absolute value. This result suggests that, at least for polity, some of the same factors that hinder economic development contribute to higher oil market volatility. Taken together, the

[25] In unreported specifications, we also included a variable to measure the presence of a national oil company (NOC). An NOC may produce oil with more year-to-year volatility because it is constrained to pursue nonmarket objectives (Jaffee 2007). The coefficient on this variable was very imprecisely estimated in all specifications, although this is not altogether surprising since over our time period, all but four of the countries in our sample (Australia, Denmark, United Kingdom, and United States) had NOCs. This result is consistent with the idea that NOCs behave very differently depending on the political institutions within which they are operating.

result in Panels A-D indicate that political conditions affect production volatility after controlling for the country's development level (as measured by per capita GDP). This buttresses the conclusion that political conditions can have real effects on production decisions in a particular market.

Finally, we include a variable to measure countries' legal environments. These specifications are not directly analogous to the others in Table 5, as political conditions and legal environments are generally believed to arise independently. Previous work has evaluated "property rights institutions", which protect citizens from governments (and are generally measured by our political conditions variables), and contracting institutions, which facilitate commercial transactions between citizens, as competing explanations for different economic development levels. Measures of contracting institutions include variables such as the number of legal procedures required to settle the collection on an overdue payment.[26] La Porta et al. (1998) show that countries in which the legal system derives from the French (civil-law) tradition have weaker contracting institutions (*e.g.*, higher number of procedures) than countries with legal systems derived from the English (common law) tradition. Acemoglu and Johnson (2005) show that contracting institutions matter little for macroeconomic growth once differences in political institutions are accounted for. We find a similar result for oil production volatility.[27]

E. Alternative Specifications

The regressions reported above use average political conditions measures over the sample, so the coefficients 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 a 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 several specifications similar to those reported in Tables 2 through 5 using the variance in polity over our time period as the explanatory variable of interest. The

[26] Our variable "World Bank Procedure Count" is from World Bank (2004).
[27] We have also estimated 2SLS specifications, using pre-oil commercialization political conditions and legal origins as instruments, and the results are very similar to those reported.

coefficients, except for the univariate OLS specification, are all positive. All coefficients are 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 the polity measure with the change in polity defined as the difference between the average value across 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 the volatility for the last third of a country's observations and the first third of observations. The results are small and 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.

F. Political Conditions and Other Oil Production Outcomes

Overall, our cross-sectional results suggest a robust causal relationship between political conditions and oil production volatility. To further explore the role of political institutions, Table 6 reports results from a specification where we examined the volatility in the number of wells in a country. The coefficients on polity suggest that the number of wells is also more volatile in countries with poor political conditions, consistent with the hypothesis that poor political conditions impact infrastructure investment and supply decisions. Put differently, this helps confirm that the results in Tables 2 through 5 do not reflect a spurious correlation between physical or other determinants of oil production and political institutions, but instead can be interpreted causally. The 2SLS results are nearly twice the magnitude of the OLS estimates, consistent with the presence of measurement error in the polity measure, and the results are statistically significant at the one percent level.[28]

The results in Table 7 speak to whether political conditions affect not just the volatility of oil production but also the absolute level. We consider the mean of production as a share of total reserves by country, under the theory that reserves are exogenous to political conditions and mainly reflect a country's natural oil endowment. The coefficient on polity is positive, suggesting that countries with good political conditions are extracting a greater share of their total reserves over the time period we examine. This could reflect a number of factors. For instance, it could reflect profit-maximizing withholding by monopoly state-owned oil companies

[28] Specifications including the OPEC dummy are very similar to those reported in Table 6.

in low polity countries, although the result is robust to the inclusion of the OPEC dummy variable. The results are also robust to instrumenting for political conditions. While in no way dispositive, the result is consistent with the hypothesis that poor political conditions impede production.

IV. Implications

Having documented the importance of a country's political conditions to its oil production, we explore how changes in average political conditions of oil producing countries affect price volatility in world oil markets. This allows us to explore whether the results we find at the micro level aggregate up to the macro level. It also allows us to analyze the impacts on volatility of changes in political conditions within countries versus changes across countries in world production shares.

To conduct this analysis we construct several indexes of the political conditions of oil-producing countries over the past several decades. In all cases we construct a political conditions measure according to the following formula (where I_{it} represents one of the political conditions measures described in the previous section for country *i* in year *t* and Π_t is a global index based on the underlying measure):

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

ω_{it} is the share of country *i*'s oil production in world production for year *t*. We normalize all of the indexes by dividing by the value in the first year that the index is available. The oil conditions index, Π_t, is a convenient measure of the average political conditions in oil-producing countries weighted by production.

Figure 2 plots the various indexes over time. The polity index begins in 1965, when the oil data are first available, while the Freedom House and ICRG indexes are constrained by data on the political conditions. Consider first the polity measure in the upper left corner of the figure. The 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). Both ICRG indexes rise through the 1980s and 1990s and then show signs of leveling off or even declining in early 2000.

A. Changes in Production Shares versus Changes in Internal Conditions

What explains the changes in the various indexes? Log differentiation of equation (20) yields:

$$\hat{\Pi}_t = \sum_i \frac{\omega_{it} I_{it}}{\sum_k \omega_{kt} I_{kt}} \left(\hat{\omega}_{it} + \hat{I}_{it}\right) \equiv \sum_i \phi_{it}\left(\hat{\omega}_{it} + \hat{I}_{it}\right) \quad (21)$$

where a hat indicates a percentage change (*e.g.*, $\hat{S}_{it} = \frac{dS_{it}}{S_{it}}$). Changes in the oil index can be decomposed into changes in underlying country conditions and changes in countries' shares of world oil production following the work of Boyd and Roop (2004) and Metcalf (2008). Using a Fisher perfect decomposition, we decompose the oil 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 index holding the world oil production shares constant.[29] 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 political conditions 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 index can be decomposed into these two indexes with no unexplained residual:

$$\Pi_t = \tilde{\Pi}_t^{Pol} \tilde{\Pi}_t^{Prod} \quad (22)$$

Figure 3 reproduces the three indexes available over the longest time periods (in blue) and plots each against its two components. Consider the upper left graph on Figure 3 where oil conditions are measured using the polity 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 overall 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 overall index. In the first decade oil is increasingly produced by countries with poor political conditions 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

[29] We describe the construction of the Fisher indexes in the appendix.

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 overall 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 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 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 overall 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.

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.

B. Political Conditions and Macroeconomic Indicators

A natural question to ask is whether the changes over time in the weighted-average political condition have impacted world oil markets. For instance, we might suspect that as production moves away from countries with poor political conditions, which we demonstrated in the previous section had more volatile production, volatility in prices would decline. Table 8 reports results from simple time series regressions which use two of the three indexes depicted in the upper left panel of Figure 3, decomposing the polity measure, to predict oil price volatility.[30] We measure oil price volatility in two ways. In the first and third columns, we measure the within-year variance in the spot price (using data from the Global Financial Database, Commodity Price series). As spot prices are only really meaningful beginning in the early 1980s, we use data from the last 25 years of our sample (1983-2007). In the second and fourth columns, we measure price volatility using the absolute value of the difference between the oil forward contract closing price traded three-months prior to delivery minus the delivery date's closing spot price. (The last daily trade in a month is used as the monthly observation of spot price and as the contract delivery date.) This measure will capture unexpected changes in the market over the short run, which could be driven by supply-side disruptions caused by the political conditions in the oil-producing countries.

The top panel of Table 8 uses the overall political conditions index as the independent variable, and the bottom panel uses the production share index as the independent variable. The results at the top of the table suggest that there is little, or if anything positive, correlation between the overall polity index and price volatility, which is inconsistent with our hypothesis. The results at the bottom without a trend suggest a distinct negative effect of increasing the production share index on price volatility. The coefficient estimates fall and become statistically insignificant when we add a linear trend, although with only 25 observations over time, it may be too difficult to detect a relationship based on deviations around a trend. Overall, the results may suggest that it takes time before short-run changes in political conditions impact oil production in a country, but that shifts in production to countries with long histories of good governance will lead to lower price volatility.

C. Interpreting Our Results

We have presented a theoretical model that suggests a link between political conditions in a country and the stability of the country's oil production. Empirical evidence suggests that more democratic countries have more stable production over time. Moreover our preferred political conditions index of oil supply suggests a recent downturn in polity among oil producing nations.

One should not, however, interpret our results as suggesting a new rationale for government intervention in energy markets to promote energy security. For example, it would

[30] Although the indexes are not additive, the results for the third index were similar to the linear combination of the other two indexes, so we report results using only two of the three indexes.

be incorrect to interpret our results as supporting a policy of more domestic supply to reduce oil imports. We say this first because supply shocks of the sort that we investigate in this paper – country-specific and largely idiosyncratic shocks – can in general be quickly replaced in world markets by other suppliers. Thus price shocks are for the most part short-lived.[31] Second, oil is a fungible commodity and price shocks arising from a supply shortfall anywhere in the world affects all oil consumers regardless of the source of their particular oil. As noted by Deutch and Schlesinger (2006) and the National Research Council (2009), among others, a country's vulnerability to oil shocks depends on its consumption of oil relative to the size of its economy rather than its imports.

The results do enhance our understanding of the relationship between political governance and energy supply and more generally of the connections between political institutions and economic performance. In that vein, our paper can be viewed as a contribution towards opening up Acemoglu, Johnson and Robinson's "black box" to see an example where governance affects the workings of a particular market, one that happens to be of particular importance to the world economy.

V. Conclusion

We have analyzed how political conditions in oil producing countries affect the volatility of oil production as well as other oil market outcomes. 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.

We next 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 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

[31] This is not to suggest that idiosyncratic supply shocks are entirely unimportant. They can contribute to an atmosphere of concern about supply that feeds into a precautionary demand shock as described by Kilian (2008).

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.

One should be cautious in drawing 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. Also, our index 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.

Appendix (Not for Publication). Construction of the Fisher Political Conditions 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 conditions 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 conditions 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

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

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

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 conditions index due to changes in each country's share of world oil production holding their political conditions constant. The Paasche indexes are

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

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

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) $$\widetilde{\Pi}_t^{Pol} = \sqrt{L_t^{Pol} A_t^{Pol}}$$

(A6) $$\widetilde{\Pi}_t^{\Pr od} = \sqrt{L_t^{\Pr od} A_t^{\Pr od}} \ .$$

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 conditions index into political and production share indexes with no residual:

(A7) $$\Pi_t = \widetilde{\Pi}_t^{Pol} \widetilde{\Pi}_t^{\Pr od} \ .$$

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. Summary Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum	Years Covered
Oil Production Volatility Measures					
Stdev[$\ln Q_t - \ln Q_{t-1}$]	0.191	0.163	0.029	1.001	1965-2007
Stdev[$(\ln Q_t - \ln GDP_t) - (\ln Q_{t-1} - \ln GDP_{t-1})$]	0.198	0.160	0.062	0.986	1965-2007
Stdev[$\ln Q_t - \ln Q_{t-1}$]	0.158	0.180	0.020	1.001	1980-2007
Stdev[$(\ln Q_t - \ln GDP_t) - (\ln Q_{t-1} - \ln GDP_{t-1})$]	0.169	0.175	0.051	0.986	1980-2007
Stdev[$(\ln Q_t - \ln GDP_t - \ln Reserves_t) - (\ln Q_{t-1} - \ln GDP_{t-1} - \ln Reserves_{t-1})$]	0.230	0.192	0.059	0.987	1980-2007
Largest one-year percentage decline	0.212	0.179	0.000	0.867	1965-2007
Largest one-year percentage decline	0.168	0.169	0.000	0.867	1980-2007
Volatility in Wells	0.221	0.209	0.000	0.896	1980-2006
Production/Reserves	0.061	0.035	0.007	0.175	1980-2007
Explanatory Variables					
Polity	10.0	7.0	1.0	21.0	1965-2007
1900 Polity Broad	8.9	7.2	1	21	See text
1900 Polity Strict	7.4	6.7	1	21	“
Settler Mortality	3.1	2.3	0	7.6	“
Freedom House Political Rights	3.4	2.1	1.0	7.0	1972-2007
Freedom House Civil Liberties	3.6	1.8	1.0	7.0	1972-2007
ICRG Risk of Expropriation	7.5	1.5	2.5	9.9	1982-1997
ICRG composite index (aggregate of 5 ICRG measures)	31.0	8.1	14.6	49.4	1982-1997
Financial Openness	1.3	1.0	0.3	5.8	1970-2007
OPEC Membership	0.2	0.4	0.0	1.0	1965-2007
Act of Nationalization	0.5	0.5	0.0	1.0	1960-2006
National Oil Company	0.9	0.3	0.0	1.0	1965-2007
Average GDP per Capita	5724	7683	328	30013	1965-2007
World Bank Procedure Count	27.2	11.9	11.0	54.0	2004
Common Law Origins	0.3	0.4	0.0	1.0	NA
Land Area (millions of square miles)	2.1	3.5	0.0	17.1	1965-2007
Source: Various (see text).					

Table 2. Volatility and Polity

	Data range: 1980-2007		*Data range: 1965-2007*	
Volatility Measure	***Coefficient on mean(Polity)***	***R^2***	***Coefficient on mean(Polity)***	***R^2***
Stdev[$\ln Q_t - \ln Q_{t-1}$]	-0.0068*** (0.0023)	0.185	-0.0060** (0.0024)	0.175
Stdev[$(\ln Q_t - \beta_1 t - \beta_2 t^2) - (\ln Q_{t-1} \beta_1 (t-1) - \beta_2 (t-1)^2)$]	-0.0068*** (0.0022)	0.207	-0.0062*** (0.0023)	0.212
Stdev[$(\ln Q_t - \ln GDP_t) - (\ln Q_{t-1} - \ln GDP_{t-1})$]	-0.0052** (0.0023)	0.120	-0.0048** (0.0023)	0.122
Stdev[$(\ln Q_t - \ln GDP_t - \ln Reserves_t) - \ln Q_{t-1} - \ln GDP_{t-1} - \ln Reserves_{t-1})$]	-0.0053** (0.0026)	0.113		
Largest one-year percentage decline	-0.0118*** (0.0036)	0.249	-0.0138*** (0.0038)	0.266

Robust standard errors in parentheses. All specifications are weighted by a country's average production within the appropriate time period. The first two columns present results where the dependent variable is estimated over the range 1981-2007, where the first year is one year after the data begins since the dependent variables are in first differences. The two right-most columns present results where the dependent variable is estimated over the data range 1966-2007. N = 48, rows 1-3, 5; N=47, row 4 (data on reserves in Cameroon are not available).

* - p-value less than 10 percent

** - p-value less than 5 percent

*** - p-value less than 1 percent

Table 3. Volatility and Polity: Two-Stage Least Squares

	2SLS	2SLS	2SLS
	1900 Polity (Broad)	1900 Polity (Strict)	Settler Mortality
Polity	-0.0031 (0.0035)	-0.0039* (0.0022)	-0.0120** (0.0054)
First-stage F-statistic	48.66	61.26	11.05
	OLS	OLS	OLS
Polity	-0.0063** (0.0025)	-0.0038* (0.0018)	-0.0034 (0.0030)
R^2	0.186	.248	.075
Obs	46	26	34

Robust standard errors in parentheses. All specifications are weighted by a country's average production between 1965-2007.
* - p-value less than 10 percent
** - p-value less than 5 percent
*** - p-value less than 1 percent

Table 4. Oil Production Volatility Regressions: Alternative Political Measures

	OLS	2SLS
Freedom House Political Rights	-0.0169** (0.0081)	-0.0150 (0.0091)
R^2	0.114	
First-stage F-statistic		63.06
Freedom House Civil Liberties	-0.0188** (0.0082)	-0.0154* (0.0092)
R^2	0.124	
First-stage F-statistic		68.14
Risk of Expropriation	-0.0349* (0.0175)	-0.0407** (0.0186)
R^2	0.175	
First-stage F-statistic		4.89
ICRG composite index	-0.0050** (0.0024)	-0.0046** (0.0022)
R^2	0.120	
First-stage F-statistic		19.81

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. The specifications for the first two alternative measures are weighted by a country's average production between 1972 and 2007. The specifications for the last two alternative measures are weighted by a country's average production between 1982 and 1997. 2SLS results use 1900 Polity (Broad) as the instrument.

Table 5. Volatility and Political Conditions with Additional Covariates

PANEL A	**Bench-mark**	**Financial Openness**	**OPEC**	**Act of National-ization**	**GDP per capita**	**WB Procedure Count**
Polity	-0.0047** (0.0020)	-0.0040*** (0.0015)	-0.0048** (0.0019)	-0.0038* (0.0022)	-0.0041 (0.0028)	-0.0041* (0.0021)
Covariate		0.0308 (0.0187)	-0.0047 (0.0413)	0.0215 (0.0270)	-0.0010 (0.0022)	-0.0021 (0.0015)

PANEL B	**Bench-mark**	**Financial Openness**	**OPEC**	**Act of National-ization**	**GDP per capita**	**WB Procedure Count**
FH Political Rights	-0.0149** (0.0062)	-0.0125*** (0.0037)	-0.0109 (0.0069)	-0.0102 (0.0072)	-0.0157* (0.0082)	-0.0119** (0.0057)
Covariate		0.0370 (0.0225)	0.0512 (0.0448)	0.0337 (0.0318)	0.0004 (0.0022)	-0.0025 (0.0015)

PANEL C	**Bench-mark**	**Financial Openness**	**OPEC**	**Act of National-ization**	**GDP per capita**	**WB Procedure Count**
FH Civil Liberties	-0.0165** (0.0063)	-0.0144*** (0.0035)	-0.0120 (0.0075)	-0.0120 (0.0082)	-0.0191** (0.0092)	-0.0136** (0.0058)
Covariate		0.0383* (0.0222)	0.0465 (0.0473)	0.0292 (0.0356)	0.0010 (0.0023)	-0.0026* (0.0015)

PANEL D	**Bench-mark**	**Financial Openness**	**OPEC**	**Act of National-ization**	**GDP per capita**	**WB Procedure Count**
ICGR composite index	-0.0040* (0.0022)	-0.0022** (0.0011)	-0.0021 (0.0020)	-0.0015 (0.0040)	-0.0103* (0.0061)	-0.0039** (0.0016)
Covariate		0.0411 (0.0322)	0.1069* (0.0548)	0.0586 (0.0580)	0.0079 (0.0060)	-0.0046** (0.0021)

Land area is included in all specifications, but coefficient estimates are not shown. Standard errors are in parentheses. All regressions are cross-sectional OLS with one observation per country. Each column in each panel reports results from a separate regression. N = 48 for all cells in Panels A-C (except 47 for the Financial Openness specifications). N = 45 for Panel D (except 44 for the Financial Openness specification).

Table 6. Volatility in Oil Producing Wells and Polity

	OLS		2SLS	
Polity	-0.0116* (0.0064)	-0.0116* (0.0066)	-0.0204*** (0.0074)	-0.0206*** (0.0076)
Land Area		-0.0010 (0.0102)		-0.0018 (0.0075)
R^2	0.251	0.252		
First Stage F-Statistic			21.09	16.40

Robust standard errors in parentheses. All specifications are weighted by a country's average wells between 1980 and 2006. Producing wells data from the Oil & Gas Journal Energy Database. Wells totals do not include shut in, injection, or service wells. There are 48 observations in the OLS regressions and 46 in the 2SLS regressions. 2SLS results use 1900 Polity (Broad) as the instrument.

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

Table 7. Oil Production as a Fraction of Reserves and Polity

	OLS		2SLS	
Polity	0.0035*** (0.0008)	0.0020** (0.0007)	0.0042*** (0.0008)	0.0030*** (0.0009)
Land Area		-0.0004 (0.0010)		-0.0003 (0.0009)
OPEC		-0.0424*** (0.0125)		-0.0378*** (0.0146)
R^2	0.457	0.622	0.463	0.653
First Stage F-Statistic			28.38	14.01

Robust standard errors in parentheses. All specifications are weighted by a country's average production between 1980 and 2007. OLS regressions have 47 observations and the 2SLS 46. 2SLS results use 1900 Polity (Broad) as the instrument.

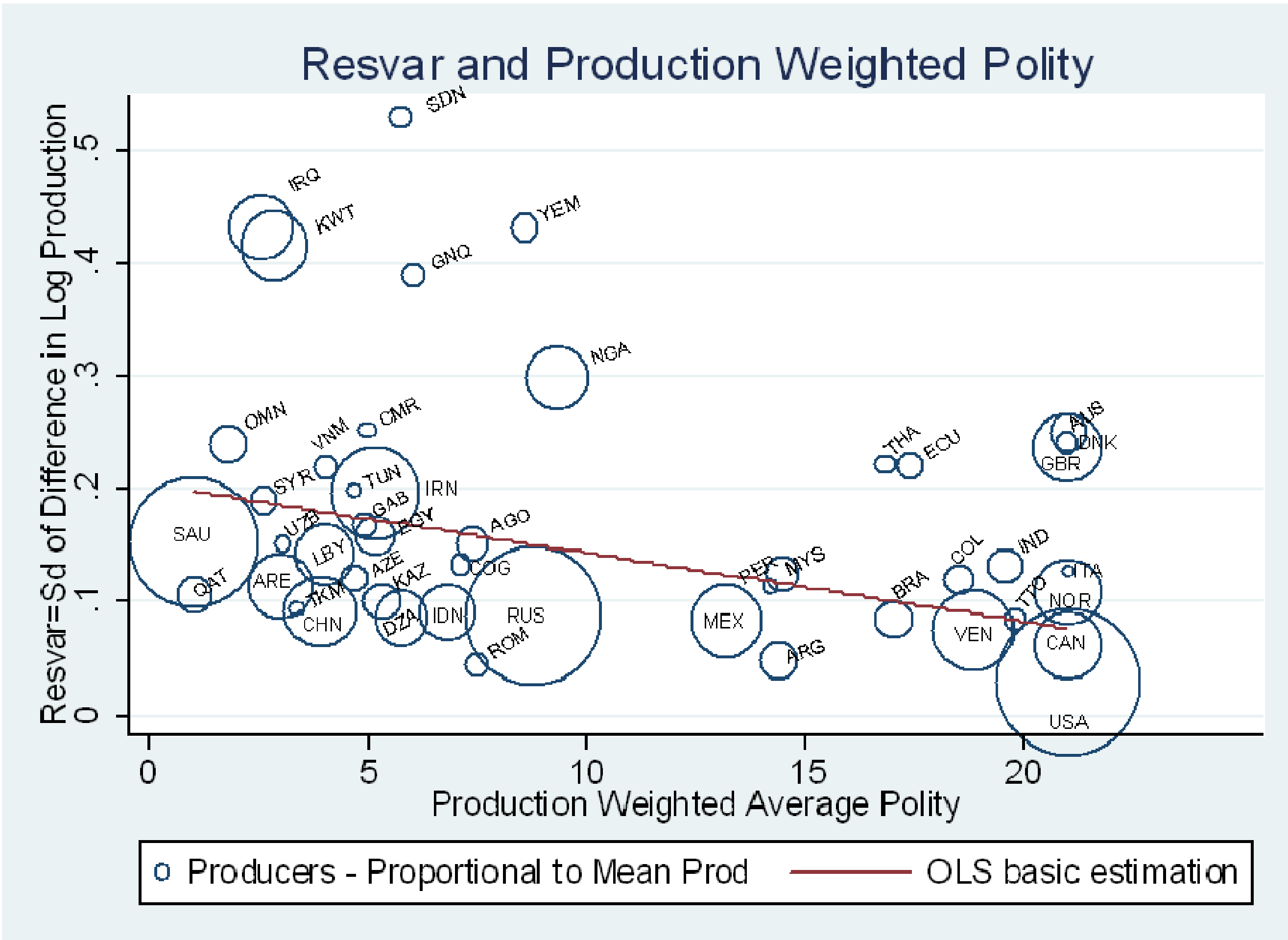
* - p-value less than 10 percent
** - p-value less than 5 percent
*** - p-value less than 1 percent

Table 8. Oil Price Volatility and Political Conditions

	Spot Price Volatility	Forward minus Spot Price	Spot Price Volatility	Forward minus Spot Price
Polity Index	0.1526 (0.0921)	9.147*** (2.505)	0.0027 (0.1456)	-11.33 (7.67)
Trend			0.0021 (0.0019)	0.2929** (0.1083)
R^2	0.129	0.153	0.155	0.653
Polity Production Share Index	-0.5395* (0.2728)	-45.65** (17.91)	-0.2347 (0.6391)	-14.77 (16.99)
Trend			0.0015 (0.0025)	0.1332 (0.0343)
R^2	0.056	0.405	0.161	0.600

Regressions are run using data from 1983 through 2007 (25 observations). Estimated using a Prais-Winsten transformation to adjust for the presence of serial correlation.
* - p-value less than 10 percent
** - p-value less than 5 percent
*** - p-value less than 1 percent

Figure 1



Resvar and Production Weighted Polity
Resvar=Sd of Difference in Log Production
0
.1
.2
.3
.4
.5
0
5
10
15
20
Production Weighted Average Polity
SDN
IRQ
KWT
YEM
GNQ
NGA
OMN
VNM
CMR
SYR
TUN
IRN
GAB
EGY
AGO
SAU
UZB
LBY
QAT
ARE
AZE
KAZ
COG
TKM
CHN
DZA
IDN
RUS
ROM
MEX
PER
MYS
ARG
THA
ECU
AUS
DNK
GBR
BRA
COL
IND
ITA
TTO
NOR
VEN
CAN
USA
Producers - Proportional to Mean Prod
OLS basic estimation

Figure 2. Political Conditions Indexes

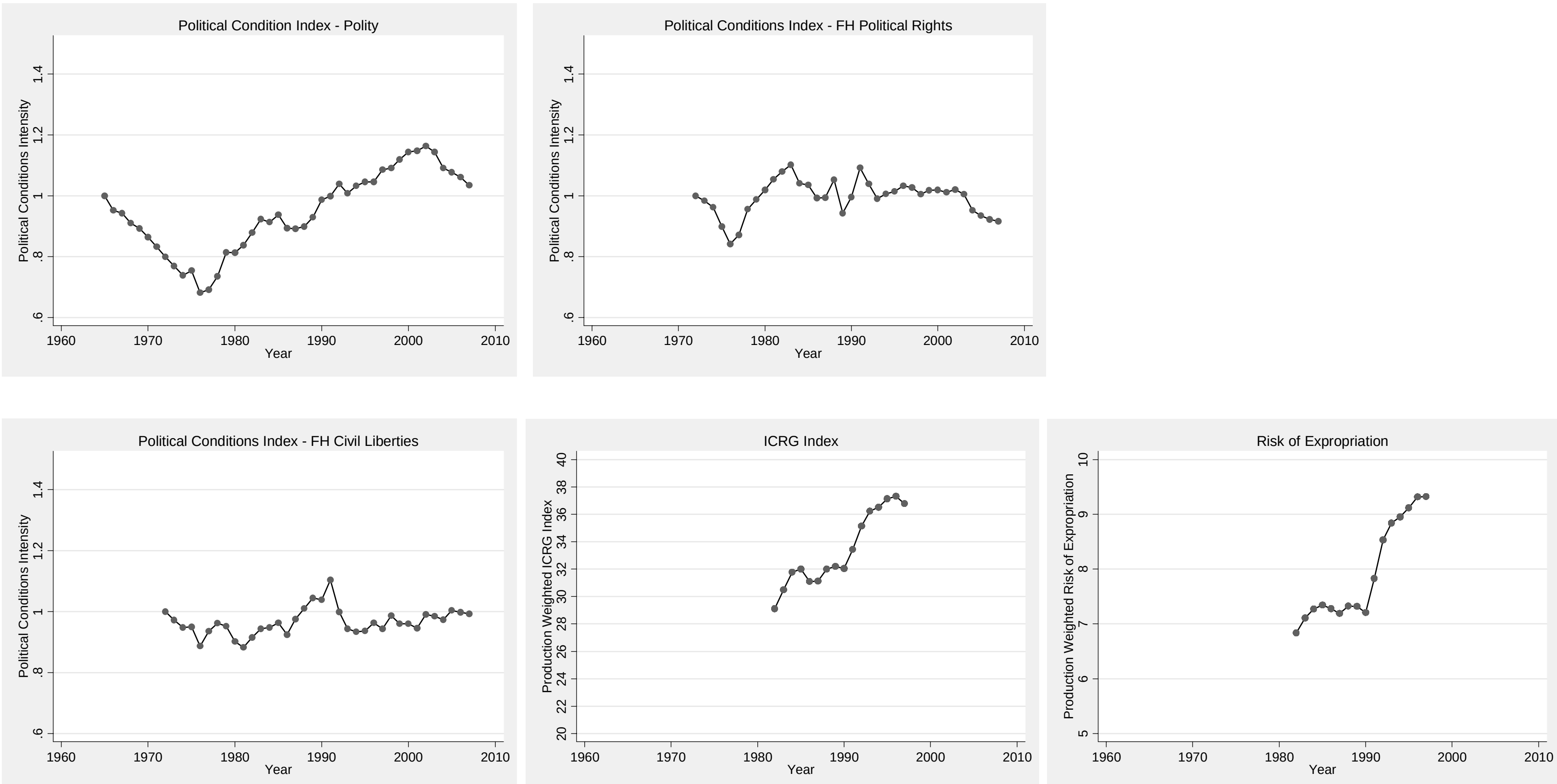


Figure 3. Political Conditions Index Decompositions