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Impact of Political Stability and Property Rights Protection on Oil and Gas Investments:

A Cross-Country Analysis

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Problem Description

This paper investigates how political risk influence the decision to invest in petroleum projects. We use the time lag from the discovery of an oil and gas reservoir until it is approved for development, as a proxy for the time spent deciding whether to invest. We apply time-varying hazard regression on this time lag to estimate the impact of risks related to political stability and property rights in a host country. Furthermore, we examine variation in the impact of political risk across different types of companies and also analyse how firm characteristics affect the investment behaviour of oil and gas companies.

Preface

We submit this thesis in fulfillment of the requirements for our Master of Science degrees in Industrial Economics and Technology Management at The Norwegian University of Science and Technology (NTNU).

First and foremost, we would like to thank our supervisor Peter Molnar at the Department of Industrial Economics and Technology Management at NTNU, for his invaluable guidance and support. Special thanks are also due to Štěpán Mikula who has provided highly appreciated data on and insight into political risk measures.

In addition, we would like to express our gratitude to Rystad Energy represented by consultant Andreas Eraker, for providing data on and valuable insight into the global oil and gas industry. Gratitude is also owed to the following people: Assistant Professor Brandon Julio at The University of Oregon, for providing useful data, Professor Bo Henry Lindquist at the Department of Mathematical Sciences at NTNU, for his steady mathematical guidance, and Einar Cathrinus Kjenstad for helpful comments and for sharing his wide knowledge of statistical software.

Trondheim, June 9, 2016

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Abstract

This paper documents a strong negative relationship between political risk and investments in the petroleum industry. Our unique data set, released for the purpose of this study only, allows us to study the timing of investments in individual oil and gas fields around the world. We find that oil and gas firms invest faster in countries that are politically stable and have solid protection of property rights. In the investigation, we employ risk measures of a host country's legal system, expropriation risk and government stability as well as risks of internal and external conflicts. We find that they consistently indicate negative causality from political risk to investment decisions. We also examine variation across company types and document significant differences in sensitivity to political risks between major multinational companies and national oil companies. We find majors to be more concerned with all risks investigated. In addition, we provide evidence that companies with higher relative valuation (Tobin's Q) and companies with lower debt invest faster.

Sammendrag

Denne artikkelen dokumenterer en sterk negativ sammenheng mellom politisk risiko og investeringer i petroleumsindustrien. Vårt unike datasett, frigitt kun for denne studien, tillater oss å studere timing av investeringer i individuelle olje- og gassfelter verden rundt. Vi finner at olje- og gasselskaper investerer raskere i land som er politisk stabile og har solide eiendomsrettigheter. I undersøkelsen benytter vi risikomål knyttet til rettssystemet i et vertsland, stabilitet i landets regjering og ekspropriasjon, samt mål på risiko for interne og eksterne konflikter. Vi finner at alle disse målene konsistent indikerer negativ kausalitet fra politisk risiko til investeringsbeslutninger. Vi undersøker også variasjon mellom ulike typer selskaper, og dokumenterer signifikante forskjeller i sensitivitet til politisk risiko mellom store multinasjonale selskaper og nasjonale oljeselskaper. Vi finner at store multinasjonale selskaper er mer sensitiv til alle risikotypene vi undersøker. I tillegg fremlegger vi bevis for at selskaper med høyere relativ verdivurdering (Tobin's Q) og selskaper med lavere gjeld, investerer raskere.

Contents

1 Introduction

Crude oil and gas have been the dominant sources to cover our energy needs for the better part of the last 60 years, and has held more influence over the politics and economic strategies of nations than any other commodity (Deutsche Bank, 2013). Petroleum exploration and field development have been subject to economic research for decades, with most studies focusing on the influence of the oil price and oil price volatility as well as geological variables. Another interesting relation is the one to politics. There is a long history of research on how polity and political factors affect wealth and investments, but very few researchers conduct cross-country analyses based on micro-level data. The close link between politics and crude oil and gas suggests that political factors may be important in oil and gas investment decisions. This paper investigates the relation between investments in oil and gas fields, and property rights protection and political stability in the countries in which oil and gas fields are located.

North (1990) defines institutions as "the rules of the game in a society", and economic institutions are widely considered a fundamental cause of economic growth. They determine the incentives of and the constraints on economic actors, and shape economic outcomes. In particular, they influence investments in physical and human capital and technology (Acemoglu et al., 2005). Rodrik et al. (2004) estimate the contribution of institutions in determining income levels around the world, comparing it to the contributions of geography and trade. He concludes that the quality of institutions is the most important factor.

In analysing and empirically testing how investments are affected by institutions, different indicators of institutional quality have been used throughout the literature. Protection of property rights has been awarded much attention and is considered to be a key determinant of growth and investment. Without property rights, individuals will not have the incentive to invest in physical or human capital, or adopt more efficient technologies (Acemoglu et al., 2005). In earlier research, it has been common to use measures of property rights protection related to political risks, such as coups and revolutions, and political freedom and civil liberties (e.g. Kormendi and Meguire (1985), Grier and Tullock (1989), Scully (1988) and McMillan et al. (1991)). In later years, scholars have argued that these measures should not be employed as they do not directly bear on the security of property rights. Knack and Keefer (1995) utilize improved indicators of institutional quality: the political risk ratings by the International Country Risk Guide (ICRG) and the Business Environment Risk Intelligence (BERI). They conclude that institutions with solid property rights are crucial to economic growth and to investment. Svensson (1998) investigates why investment rates vary across countries, and finds in his study a link from political instability to the quality of property rights and further from property rights to investment. As Knack and Keefer (1995), he employs institutional indicators from the ICRG and BERI databases as proxies for property rights protection. He finds evidence that high quality property rights induces more investments. Johnson et al. (1999) investigate whether investment is constrained more by limited external finance or by insecure property rights, and provide evidence of the latter.

Several scholars have investigated the effects of political risk on investments and economic growth. Schneider and Frey (1985), Feng (2001), Campos and Nugent (2003) and Asiedu (2006) investigate the impact of political stability on investments in less developed countries by looking at measures such as number of assassinations, coups and riots. Feng (2001) employs data on private investment in the form of fixed capital as a percentage of GDP, while the other scholars investigate the impact on foreign direct investment (FDI). While Campos and Nugent (2003) find a positive short-term causal relation from instability to investment, particularly in low-income countries, the other scholars conclude that political instability has a negative effect on investment. Results from the investigation by Busse and Hefeker (2007) of how the twelve political risk components of the ICRG database impact investment activity of multinational corporations are also in line with these results. Some scholars have focused on the effects of regulatory uncertainty on investments. By investigating investment behavior in election years compared to non-election years, Julio and Yook (2012) provide evidence that political uncertainty leads firms to reduce investments until the uncertainty is resolved. Gulen and Ion (2015) document a negative relationship between capital investment and the aggregate level of uncertainty associated with future policy and regulatory outcomes. Altogether, previous research finds political risk and regulatory uncertainty to significantly impact investments.

Cust and Harding (2015) estimate the effect of institutional quality on the location of oil and gas exploration. They use data on the location of exploration wells and national borders and find that exploration and production (E&P) companies drill on the side of a national border with better institutional quality, two times out of three. They also investigate the variation of this relationship across company types and find that the impact of institutional quality on investments is stronger for multinational oil companies than national oil companies (NOCs) and smaller specialized E&P companies. Bohn and Deacon (2000) investigate the forest and petroleum industries, and find that property rights significantly impacts extraction of these natural resources. To our knowledge, these are the only studies investigating the impact of institutional quality on oil and gas investments.

The model of Bohn and Deacon (2000) implies that differences in capital intensity may cause differences in sensitivity to political stability. Oil and gas extraction are typical examples of capital intensive processes, and developing oil and gas assets can be considered as an irreversible investment. The process involves three separate but closely interrelated activities: exploration, development, and extraction. From a real options point of view, having a licence for exploration drilling may be looked upon as owning an option. When deciding to drill, the exploration option is exercised and a development option is acquired. Development requires in most cases a large investment which makes this decision particularly interesting to investigate. The aim of this paper is to examine how this investment decision is influenced by political stability and property rights protection, while accounting for field specific variables. We study the appraisal lag, the time elapsed from discovery to development approval, for this purpose.

We use duration analysis to investigate the decision to invest. Duration analysis has previously been applied across scientific fields (see e.g. Singh et al. (2011)), and also to analyze investment behaviour. Within research on the oil and gas industry, Dunne and Mu (2010) apply hazard models in the study of petroleum refineries. The framework has also been employed to analyse oil and gas field developments. Using duration analysis, Favero et al. (1994) and Hurn and Wright (1994) examine empirically how oil price and oil price uncertainty affect the decision process on the United Kingdom Continental Shelf and find both oil price and volatility to be significant determinants of the development decision.

As opposed to the many studies employing aggregate measures of investments to investigate the effects of institutional quality and political stability, we use micro-level data on investment timing in the oil and gas industry around the world. Our data set on oil and gas assets is unique and has not been subject to any similar kind of analysis prior to our study. By combining this data set with measures of property rights protection and political stability, we are able to provide new insights into the link between oil and gas investments, institutions and politics. We find evidence that both property rights protection and political stability are important when oil and gas operators consider investing. Our empirical results show that major multinational companies are more sensitive to political risk than national oil companies. Interestingly, we find evidence that national oil companies invest faster in circumstances in which protection of property rights is weaker. Additional to country-specific conditions, firm characteristics may also affect the investment decision. We therefore conclude our analysis by examining the impact of a company's relative valuation (Tobin's Q) and indebtedness, and find that companies with higher relative valuation and lower debt invest faster.

The remainder of this paper is organized as follows. Section 2 describes the data, section 3 outlines the methodology used in our analysis and section 4 presents our results and discusses the empirical findings. The last section summarizes and concludes.

2 Data

2.1 Data on Oil and Gas Assets

We study micro-level data on oil and gas reservoirs (assets) worldwide between January 1970 and the end of December 2015. The data is retrieved from Rystad Global Upstream Oil an Gas Database UCube[1], which contains information on more than 28,000 oil and gas reservoirs. Due to missing data on essential variables and some assets having been discovered outside of our study period, we examine a selection of 13,269 assets.

The upstream database provides asset discovery dates and the dates of approval for assets approved for development.[2] In our data, 81% of all assets have been approved for development while the remaining 19% are discoveries. Each approved asset is categorized into one of three life cycle categories, stating whether they are under development (4%), producing (78%) or have been producing earlier, but are now abandoned (18%). Geographical location on country level is also provided and additionally, information on the different *types* of asset locations are relevant; whether an asset is located onshore, offshore shelf, offshore midwater, offshore deepwater or in arctic areas may affect the cost and complexity of development. Field specific variables like these are included in our study in an effort to eliminate heterogeneity across the assets. The approach is similar to that of Hurn and Wright (1994) who emphasize that the different characteristics of the assets should be modeled as an unobserved heterogeneity inherent in the investment problem.

We use the discovery and approval dates[3] to calculate the appraisal lag, which is simply the time difference between them, denoted in months. The appraisal lag in our study range from one month to 538 months (45 years) for approved assets, while for discovered but unapproved assets, the appraisal lag varies from two months to 552 months (46 years). More than 60% of the assets are however approved within four years after discovery. Figure 1 shows the distribution of the time lag from discovery to approval for approved assets, and for unapproved assets, the time lag from discovery until the end of December 2015 is shown.

[1]The database is owned and operated by the Norwegian oil and gas consultancy and research firm Rystad Energy. The data is proprietary, and has been released for the purpose of this paper only.

[2]Before oil companies can develop a discovered field, it is common that the authorities of the country to which the assets belongs, must approve a plan for development of the petroleum deposit.

[3]Ideally, the date on which the decision to develop a field was taken, would have been used. However, this date is not available. The approach in this study, as well as in previous studies (e.g. Favero et al. (1994) and Hurn and Wright (1994)), is using the date on which an oil company receives approval from the government to develop a field. The time lag from discovery date to approval date is an approximation of the time oil companies spend considering whether to invest. It includes the time spent by the government reviewing the development application, but we assume this additional time lag is approximately the same for all applications such that it cancels out across the appraisal lags.

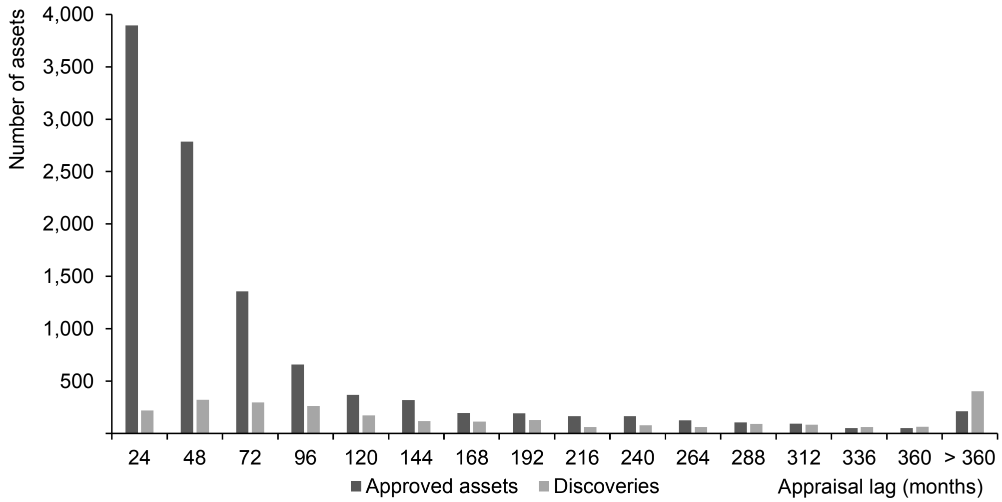


Figure 1. Appraisal lag for approved and censored assets

The oil and gas data is global, and covers assets belonging to 115 countries. The large variations in geographical and geological conditions introduce considerable heterogeneity across the assets. From Table 1, we observe that one fourth of all assets are located in North America while Western Europe, Russia and South America have assets constituting approximately 10% of the total assets each. Figure 2 highlights the variations in the appraisal lag of assets in the different geographical regions. We observe that assets in North America on average seem to be developed at a higher pace than assets in Western Europe and Russia, which are the other regions with a large number of assets, even though shale plays are excluded from our study.[4]

[4]Shale plays are excluded due to significant differences in cost structure, development procedures and the refining process.

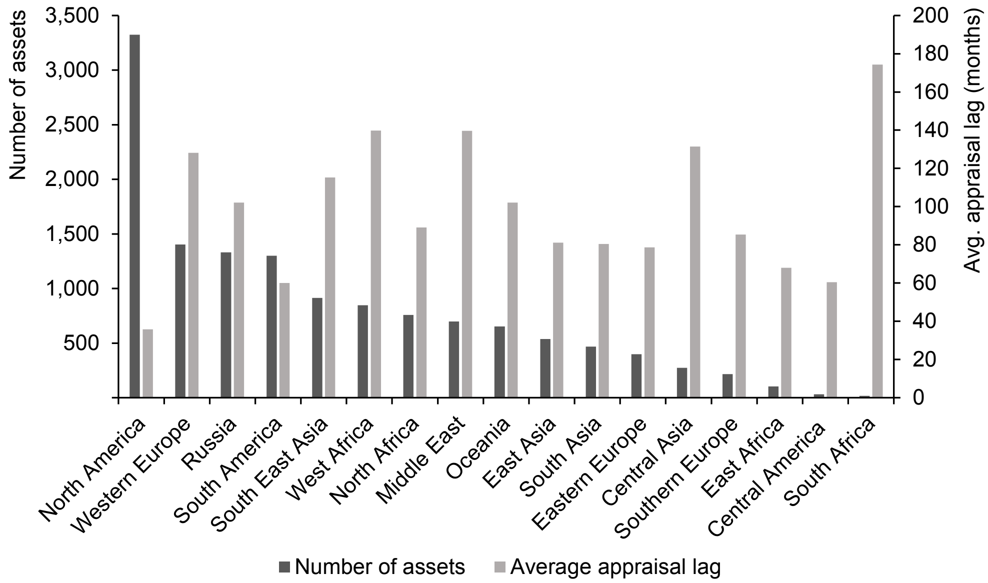


Figure 2. Average appraisal lag and number of assets by region

In Table 1, the breakdown of the oil and gas assets into the different supply segments is given. It is noticeable that 99% of all Russian assets and almost 90% of the North American assets are located either onshore or on offshore shelves, which are considered to be the most easily available. Table 1 summarizes characteristics of the oil and gas asset data.

2.2 Crude Oil Price

Quoted prices on commodity markets for oils are different depending on the quality of the crude oil, which differs between producing regions.[5] Brent Crude is a major trading classification of high quality, sweet light crude oil that serves as a major benchmark price for purchases of oil worldwide.

The Brent Crude price is retrieved from Reuter's EcoWin Pro database and covers the period from 1970 to 2015. For years prior to 1970, we assume the 1970 Brent Crude price. Oil was however not traded actively before the end of the 1970s. Prior to this, prices were based on tariffs set by the Organization of Petroleum Exporting Countries (OPEC). Hence, there are periods spanning several months prior to 1978 over which the price remains constant. Between 1978 and 1986, prices are available only on a monthly basis but from 1987 and

[5] Quality is determined based on the gravity and sulphur level of the oil. American Petroleum Institute provides a gravity measure based on how heavy or light a petroleum liquid is, compared to water: if the gravity is greater than 10, it is lighter and floats on water; if less than 10, it is heavier and sinks. Furthermore, when the total sulfur level in the oil is more than 0.5% the oil is called "sour", and is generally sold with a discount.

Table 1. Summary: Oil and Gas Data
The left part of the table exhibits the number of oil and gas assets located in each geographical region as well as the number of countries they are distributed over. The percentage in brackets gives for each region the proportion of the assets in this region to total assets studied. The percentages shown in the right part of the table denote for each region the proportion of assets located in the different Supply segment categories.

Geografical region	Number of countries	Number of assets	Supply segment				
			Onshore	Offshore shelf	Offshore midwater	Offshore deepwater	Arctic
North America	3	3,324 (25,0%)	27.4 %	60.3 %	6.0 %	5.5 %	0.8 %
Western Europe	8	1,402 (10,6%)	20.6 %	56.3 %	20.1 %	0.8 %	2.2 %
Russia	1	1,331 (10,0%)	98.1 %	1.4 %	0.2 %	0.0 %	0.3 %
South America	12	1,299 (9,8%)	74.9 %	9.5 %	6.5 %	9.1 %	0.0 %
South East Asia	8	913 (6,9%)	33.5 %	60.2 %	4.4 %	1.9 %	0.0 %
West Africa	16	846 (6,4%)	28.7 %	41.3 %	10.6 %	19.4 %	0.0 %
North Africa	6	759 (5,7%)	73.9 %	17.9 %	7.2 %	0.9 %	0.0 %
Middle East	12	697 (5,3%)	82.2 %	15.9 %	0.7 %	1.1 %	0.0 %
Oceania	3	653 (4,9%)	55.0 %	22.8 %	15.9 %	6.3 %	0.0 %
East Asia	5	537 (4,0%)	64.2 %	30.9 %	4.1 %	0.7 %	0.0 %
South Asia	4	468 (3,5%)	74.6 %	19.7 %	3.4 %	2.4 %	0.0 %
Eastern Europe	9	398 (3,0%)	91.7 %	7.8 %	0.5 %	0.0 %	0.0 %
Central Asia	7	274 (2,1%)	86.9 %	10.6 %	2.6 %	0.0 %	0.0 %
Southern Europe	8	216 (1,6%)	51.9 %	39.8 %	7.4 %	0.9 %	0.0 %
East Africa	7	103 (0,8%)	60.2 %	2.9 %	5.8 %	31.1 %	0.0 %
Central America	4	31 (0,2%)	83.9 %	12.9 %	3.2 %	0.0 %	0.0 %
South Africa	2	18 (0,1%)	22.2 %	50.0 %	27.8 %	0.0 %	0.0 %
Total	115	13,269	52.9%	35.0%	7.1%	4.5%	0.5%

onwards, prices are recorded daily. The Brent Crude price over the period under study is plotted in Figure 3. Note that several price shocks have occurred, among which the oversupply in 2014 and the financial crisis in 2008 are the most recent.

The relevant oil price in the field development decision is the future expected oil price. Oil futures prices have had a widespread use as a predictor of the future spot price of oil at various financial institutions. However, Alquist and Kilian (2010) show that oil futures prices tend to be a less accurate predictor than no-change forecasts. Additionally, they consider the use of long term futures prices and conclude that the low liquidity limits the practical use of these contracts as predictor of the long term spot price. As the spot price is an adequate predictor of the expected future oil price and is easily obtained, it is often used in practice. Moreover, oil futures prices are not available for a large part of the period we study. We therefore use the spot price of oil in our analysis. The *Oil price* variable is the nominal price of oil adjusted for inflation,[6] recorded at a monthly frequency.

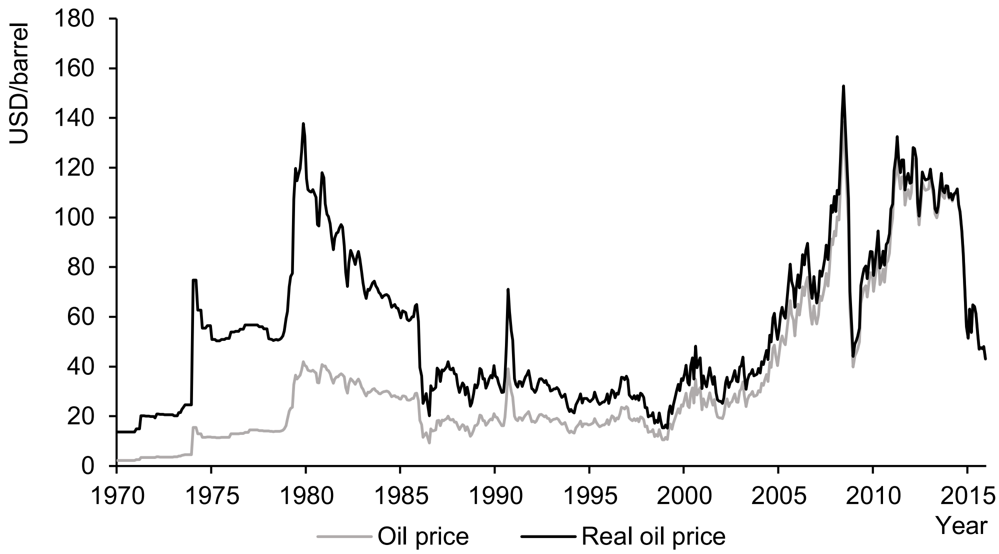


Figure 3. The Brent Crude price

2.3 Country-Level Data

Our main source of institutional data is The Political Risk Service's International Country Risk Guide (ICRG). The ICRG Political Risk Components are available for 146 countries in total, including 109 of the 115 countries in our study. Different political characteristics of each country are assessed, and given a risk rating in which the highest value is awarded to the lowest risk and the lowest value to the highest risk.

To measure the strength of property rights in a respective country, we use both risk components *Investment Profile* and *Law and Order.* In Investment Profile, factors related to government actors that might affect the risk of an investment are assessed. The category has three sub-components that each are scored between zero and four, giving the total score on Investment Profile to range from zero to twelve. The three sub-components include risk of expropriation and contract viability, profits repatriation and the risk of payment delays. To measure property rights risk imposed form other sources than the government, we follow the same approach as Knutsen and Fjelde (2013) in employing Law and Order. This measure consists of two components; a law component assessing the strength and impartiality of the

[6]This adjustment has been performed using the approach employed by the US Energy Information Agency in which the price is adjusted with respect to the American Consumer Price Index.

legal system, and an order component which assesses popular observance of the law. Both sub-components are rated from zero to three, hence Law and Order ranges from zero to six.

To evaluate the effect of political stability and the risk of conflict, we employ the ICRG components *Government Stability* and *Internal Conflict*. Both consists of three sub-components scored between zero and four, giving scales for the total risk components to range from zero to twelve. Government Stability comprise government unity, legislative strength and popular support. Hence, the risk component assesses both the government's ability to carry out its declared program and also its ability to stay in office. Internal Conflict comprises civil war, terrorism and political violence, as well as civil disorder. Ideally, the ICRG component *External Conflict* would have been included in our analysis too. However, we see it unfit for our purpose, as it records conflict for all part-taking countries including those that take no physical damage. Instead, we supplement our data set with measures of external conflict and political uncertainty from other sources. Data on war and conflicts is obtained from The Correlations of War Project. We have used both the COW War Data v4 database (Sarkees and Wayman, 2011) as well as Territorial Change v5 (Tir et al., 2015).[7] From this data we have created the dummy variable *War*, which equals one only if warfare took place in a respective country in a given year. Hence, we have excluded war participants that did not see significant damage to their country during war.[8] We also include the dummy variable *Loss of territory*, which equals one if a country has been involved as the losing side in a territorial exchange in a given year. We consider both variables to measure risk of conflict, contributing to increased robustness of our investigation of political stability.

We employ data on national elections back to 1978 with the same purpose. The data has been obtained from Brandon Julio and is the same data as used in the Julio and Yook (2012) investigation of the effect of political uncertainty on investment. The data set provides information on election years in 48 countries and covers 40 of the countries in our study. The monthly *Election Year* dummy equals one in all the twelve months preceding an election, and zero otherwise.

Due to strong dependence of oil and gas extraction on advanced technology and facilities as well as extensive infrastructure, we seek to account for the degree of development in and wealth of a country by using *GDP per capita*. This macroeconomic data has been compiled from two sources. The Penn World Table (database 7.1) provides data on GDP at purchasing

[7]For observations in 2015 we assume similar values as for 2014, which is the last reported year in most databases. We follow this approach throughout the paper.

[8]For instance, the USA has been recorded as participant in war in later years, due to their part-taking in Iraq. The country has however not suffered from physical damages from the war, and is therefore excluded with the goal of having the variable capture the effect of war happening in a specific country.

power parity per capita, in constant 2005 USD, from 1970 until 2010. Data from the World Bank is used to cover the last part of our study period.[9] The data covers 113 out of the 115 countries we consider. We use the logarithmic transformation of GDP per capita because we expect diminishing marginal impact of the level of this variable.

Further, we employ data on the ratio of total country debt to GDP. Countries that are highly indebted may be more dependent on oil and gas income than other countries. Hence, governments of such countries might try to influence companies to invest faster. Data on total debt of 61 countries from 1970 until 2014 is obtained from the World Bank. The *Debt to GDP* ratio has been calculated dividing this data by the GDP time series. The resulting time series covers however only a rather small selection of the assets, and data is particularly scarce for the first part of our study period.

Table 2 provides a data summary for all the country-specific data, aggregated to the regional level. Table 3 provides summary statistics based on monthly observations for all but the dummy variables.

Table 2. Country-Level Data: Regional Data Summary
The table presents the average value within each region over all years for the four ICRG risk measures and the macroeconomic variables. For War, Loss of Territory and Election, the number of incidents within the region over all years, are given. The dash indicates no available observations.

	ICRG				COW		Elections	Macroeconomics	
Geographical region	**Law and Order**	**Investment Profile**	**Government Stability**	**Internal Conflict**	**War**	**Loss of Territory**	**Election Year**	**GDP per Capita**	**Debt / GDP**
South Africa	3.40	8.10	8.00	8.50	4	2	7	5,029	0.24
Russia	3.60	6.10	7.30	8.50	10	4	5	12,009	0.00
South America	3.10	6.80	7.10	8.20	17	0	38	7,227	0.37
Western Europe	5.70	9.30	8.00	11.00	3	17	67	27,929	0.01
Oceania	4.80	8.40	7.70	10.60	4	1	20	17,989	0.18
Southern Europe	4.20	7.90	7.60	9.70	11	10	36	14,721	0.54
North America	4.70	9.30	8.00	10.30	0	6	22	23,975	0.56
South Asia	2.70	6.10	6.80	6.60	52	6	15	1,335	0.09
South East Asia	3.80	7.40	8.00	9.00	85	2	25	12,576	0.36
Eastern Europe	4.30	7.40	7.60	10.60	1	4	21	10,044	0.02
East Asia	4.30	8.20	7.90	10.70	2	0	19	13,396	0.04
Central America	3.00	6.00	7.20	8.60	12	0	–	11,488	0.79
East Africa	2.90	5.80	7.00	6.30	72	1	–	806	4.91
West Africa	2.30	5.90	7.30	7.40	86	5	–	2,174	0.85
Central Asia	3.90	8.10	10.10	9.30	14	2	–	4,347	0.26
North Africa	3.30	6.70	8.00	7.50	41	2	–	5,548	0.69
Middle East	3.80	7.30	8.00	8.20	66	17	16	19,438	0.46
Total	3.80	7.30	7.70	8.90	480	79	291	11,178	0.62

[9] World Bank provides data from 1990-2014 on purchasing power parity adjusted GDP per capita, in constant 2011 USD. Merging the two databases has been done by the assumption of a multiplicative relationship between them. The overlapping years (1990-2010) have been used to calculate an average ratio between the estimates in the two databases. This ratio has been used to calculate GDP estimates for the four missing years in the Penn World Table, from 2011-2014.

Table 3. Country-Level Data: Summary Statistics
The table presents summary statistics of the monthly recorded data set for all continuous variables.

Variable	Mean	Median	Standard Deviation	Skewness	Kurtosis	Observations
Law and Order	4.05	4.00	1.45	−0.16	1.99	962,638
Investment Profile	7.57	7.50	2.49	0.03	2.28	962,638
Government Stability	7.85	7.83	2.23	−0.36	2.52	962,638
Internal Conflict	9.15	9.00	2.06	−0.88	3.76	962,638
GDP per capita	15,993	11,151	14,317	1.15	4.40	1,143,517
Debt/GDP	0.21	0.01	0.56	15.56	652.90	574,345

2.4 Company-Level Data

In order to investigate differences across companies, we perform a sub-analysis of the 29 largest companies in our data set.[10] These companies have been grouped and categorized either as a Major, a national oil company (NOC) or an exploration and production (E&P) company. Majors include the seven largest publicly traded international petroleum companies often referred to as "Big Oil" or "Supermajors", and includes BP, Chevron, ConocoPhillips, Eni, ExxonMobil, Royal Dutch Shell and Total. Eleven companies are categorized as NOCs, all national oil companies fully or majority-owned by a national government. Finally, eleven local or international E&P companies constitutes the E&P group. These are smaller companies with main focus on oil and gas exploration and production.[11] The three types of companies are likely to have various strategies and goals, and may therefore behave differently in investment decisions. For a complete overview of all companies included in the three categories, the reader is referred to Appendix A.

We employ the *Tobin's Q* measure as well as the ratio of *Debt to assets* to investigate firm-specific characteristics. Accounting data on the 29 companies is obtained from the Capital IQ database and includes income statements and balance sheets from the years 1990 to 2014. To calculate Tobin's Q, we measure the market value of a company's assets by the market value of outstanding stock, adding total debt and dividing the sum by the replacement cost of the company's assets as measured by the book value of assets. If Tobin's Q is larger than one, firms have an incentive to increase their capital stock, hence invest, because capital once installed is priced higher by the market than its cost. This is usually the case for companies

[10]Size measured as the number of assets operated.

[11]E&P is a specific sector within the oil and gas industry. Companies operating in this sector focus on finding and producing different types of oil and gas. The sector is often considered to involve high risk and high reward (Deutsche Bank, 2013). In our categorization, the E&P group consists of companies that are not super-majors or national oil companies, but is a more heterogeneous group with smaller companies.

with future potential for growth, hence Tobin's Q is often used as a measure of growth opportunities. The debt to assets ratio is used as an indicator of financial leverage and is calculated by dividing total debt by the total book value of assets. For both measures, the ending balance for the previous fiscal year is employed.

Table 4. Company Group Data Summary

	Number of Companies	**Total Number of Assets**	**Average Tobin's Q**	**Average Debt/Assets**
Majors	7	1,877	1.43	0.18
NOC	11	1,638	1.22	0.19
E&P	11	861	1.39	0.26

3 Methodology

In this section, we present the statistical framework of duration analysis that is used to explain the appraisal lag and investigate the investment decision. Regression models within this framework are developed to investigate data from a well-defined time origin until an end point, at which a particular event of interest occurs.

The dependent variable in duration analysis, the duration, is assumed to have a continuous probability density function *f(t)*. We denote the associated cumulative distribution function as *F(t)*. The survival function is defined as the probability that the duration will be *at least* t:

$$S(t) = 1 - F(t) = Prob(T \geq t). \tag{1}$$

The Kaplan-Meier estimate is the most important and widely used estimate of the survival function (Collet, 1994) and The Kaplan-Meier estimate of the survival function is specified as

$$\hat{S}(t) = \prod_{j=1}^{k} (\frac{n_j - d_j}{n_j}). \tag{2}$$

The hazard rate is the probability that an object will experience the event of interest at time t conditional on not having experienced the event already. In our case, it is the probability that a firm will invest at time t given that it has not yet invested. The hazard rate is thus the instantaneous rate of experiencing an event for an object surviving to time t and can be defined as

$$h(t) = \frac{f(t)}{S(t)}. \tag{3}$$

It may be estimated from un-grouped data by taking the ratio of the number of events at a given time to the number of objects at risk, at that time. If there are d_j events occurring at the jth event time, the hazard function on the interval from t_j to t_{j+1} can be estimated by

$$\hat{h}(t) = \frac{d_j}{n_j \tau_j}. \tag{4}$$

These fairly simple non-parametric procedures are not able to analyse the effect of different explanatory variables on the duration. For this purpose, we will use the Cox (1972) regression model with several covariates. This model has the following form

$$h(t, x, \beta) = h_0(t)e^{x\beta}, \quad (5)$$

where x is a vector of covariates and β is a vector of parameters.

Using the Cox model, there is no need to assume a particular probability distribution for the survival times. As a result, the hazard function is not restricted to a specific functional form, and the model has flexibility and widespread applicability. The model may be generalized to the situation in which some of the explanatory variables are time-dependent. We let $x_{ji}(t)$ denote the value of the jth explanatory variable at time t, in the ith asset. The adjusted model is

$$h_i(t) = \exp\left\{ \sum_{j=1}^{p} \beta_j x_{ji}(t) \right\} h_o(t), \quad (6)$$

where the values of the variables $x_{ji}(t)$ depend on the time t, therefore the relative hazard is also time-dependent. The interpretation of the β-parameters in this model, considering the ratio of the hazard functions at time t for two assets r and s, is given by

$$\frac{h_r(t)}{h_s(t)} = \exp\Big[\beta_1\big\{x_{r1}(t) - x_{s1}(t) + ... + \beta_p\{x_{rp}(t) - x_{sp}(t)\big\}\Big]. \quad (7)$$

The coefficient $\beta_j, j = 1, 2, ..., p$, can be interpreted as the log hazard ratio for two assets whose value of the jth explanatory variable at time t differs by one unit, with the assets having the same values of all other variables at the time (Collet, 1994).

4 Results

In this section, our empirical findings are presented and discussed. We begin with nonparametric duration analysis, followed by estimation of a Cox hazard regression of the baseline model, controlling for field specific conditions and the oil price. The baseline model is then extended to investigate the effect of political risk on investment. Next, we exploit variation in the sensitivity of investment to country-specific characteristics across firm types. Finally, we examine the firm characteristics Tobin's Q and indebtedness as investment determinants.

4.1 Nonparametric Duration Analysis

Figure 4 displays the estimated Kaplan-Meier curve. The graph shows the estimated survival rate at each time t, meaning the proportion of discovered fields that is unapproved. As expected, the curve begins at 1.00 indicating that none of the discovered fields have been approved. As events are experienced, the survival rate decreases as a stepwise function.

Looking at Figure 4 we observe that at time $t = 40$ months, approximately 50% of the assets have been approved. This point is therefore the median of the data set, and its exact value is 37 months. The estimated mean is 86 months, but since the largest observed appraisal lag is censored, the mean is underestimated.

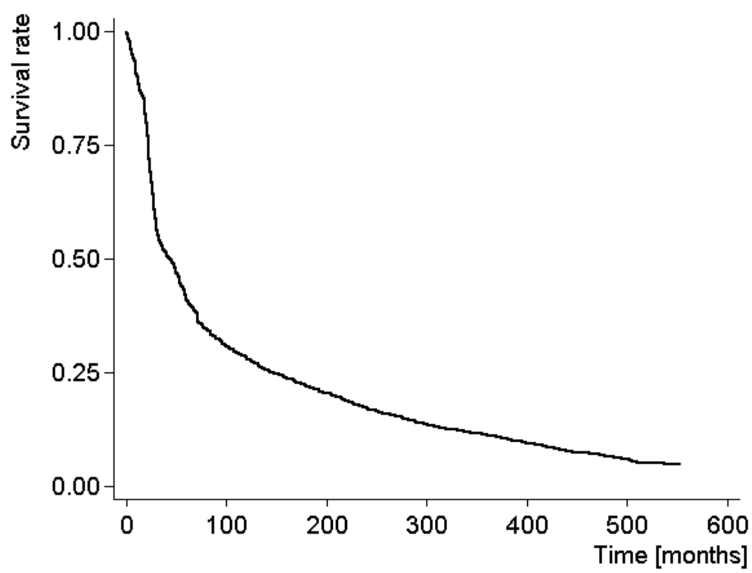
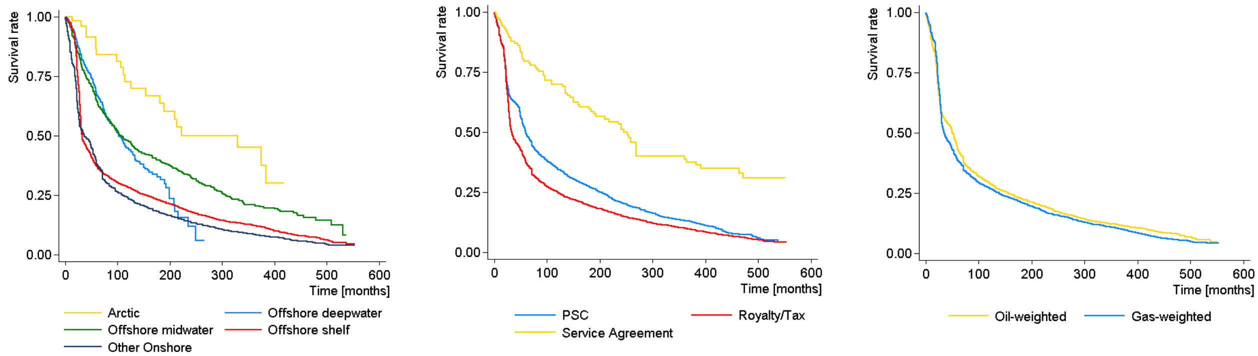


Figure 4. Kaplan-Meier estimate

We include the categorical variables *Supply segment*, *Fiscal regime* and *Oil-weighted* to capture heterogeneity across the oil and gas assets. To compare the survival time of the different categories within these variables, we calculate the Kaplan-Meier estimate for each variable, grouping by these categories. Looking at Figure 5a, we observe that onshore assets have been approved faster than offshore assets, and assets located on offshore shelves have been developed quicker than those located in areas defined as offshore midwater, deepwater and arctic. Assets in arctic areas have clearly had the slowest development. The differences in the development period are likely related to how easily oil and gas may be extracted from a reservoir. More inconvenient locations and rougher climate can make oil and gas extraction more difficult. Hence, for assets in arctic areas, there are likely higher risks and larger costs related to extraction. More advanced and costly technology and possibly new and extensive infrastructure may be needed. This may contribute to explain the lengthened development period for these assets.

Figure 5b exploits survival rates for the different categories of the Fiscal regime variable. The most common taxation contracts are royalty/tax (concession) and production sharing contracts (PSC). Under a royalty/tax agreement, an oil and gas company is granted exclusive rights to exploration and production of the concession area. This means that the company owns the oil and gas produced, receives all income from this production, and typically pays royalties and corporate income tax. When using a PSC, a NOC or a host government enters into a contract directly with an oil and gas company which finances and carries out all exploration and production operations. To recover its costs, the company receives an amount of the oil or gas, as well as a share of the profits. For the third category, the Service Agreement, a company performs a well-defined job for a host country's national oil company, often with a fixed duration and receives a fixed fee per barrel, above reimbursement of the costs it incurs. Thus, with this agreement, the operating company does not receive any of the oil or gas it produces (Deutsche Bank, 2013).

Oil production in OECD countries and countries with a long history of oil production tend to work on the basis of concessions (e.g. the US, UK, Venezuela and the UAE), whilst those in the developing world tend to be based on PSCs or Service Agreements (Deutsche Bank, 2013). From Figure 5b, we observe that Service Agreement is the category with the highest survival rate. This agreement is generally less attractive than most concessions and PSC agreements (Deutsche Bank, 2013). Figure 5c exploits the Kaplan-Meier estimate for oil-weighted and gas-weighted assets. We observe that asset reservoirs of which more than half of the resources is oil, are developed marginally faster than gas-weighted assets. This would be the expected result as oil extraction historically has been more profitable than gas extraction.



(a) Assets split on supply segment

(b) Asset split on fiscal regime in country

(c) Asset split on the categories of the Oil-weighted variable

Figure 5. Kaplan-Meier estimates for categorical variables

Log rank tests on the suggested categorical variables confirm significant differences in duration between the observations falling into the categories of the *Supply segment*, *Fiscal regime* and *Oil-weighted* variables. In other words, the appraisal duration of assets belonging to different supply segment groups differ, as it does for assets subject to different types of fiscal regimes and oil- or gas-weighted assets. For more details on the log rank tests, please see Table 11 in Appendix B.

The smoothed hazard estimate is displayed in Figure 6.[12] We limit the graphing range to t = 360 months as there is not enough data to determine a precise hazard rate after this. The hazard rate is approximately 1.5% at t = 50 months and decrease quickly to 0.50% at t = 100. After this point it slowly decreases towards 0.3%. From these results we can see that the decision to develop an asset is mostly made within the first 100 months (8 years) after discovery.

[12]Gaussian kernel smoothing with a width of 15 months is used to obtain these results, which requires averaging values over a moving data window. At the endpoints of the plotting range, these windows contain insufficient data for accurate estimation, and so these results are said to contain *boundary bias* and is therefore not plotted in the graph.

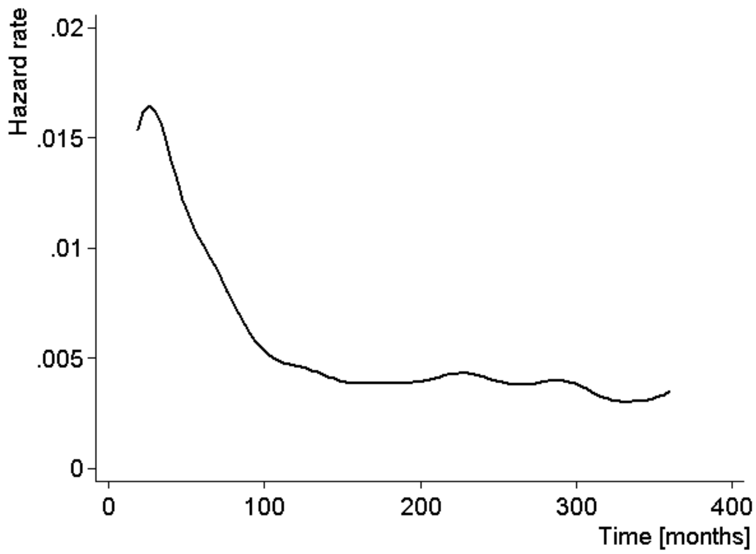


Figure 6. Hazard rate of global oil and gas development data

4.2 Cox Hazard Regression

4.2.1 Baseline Model

In order to test country-specific variables in an organized manner, we develop a baseline model that remains constant over all model variations. The baseline model is presented in Table 5 and includes the variables *Oil price*, *Oil-weighted*, *Fiscal regime* and *Supply segment*, in an effort to capture heterogeneity across the assets in our data set.

When larger than one, the hazard rate indicates a positive effect of the covariate on the probability of the subject under study to experience the event of interest. Thus, it indicates an increase of the probability of a shorter appraisal lag and hence of the probability of an oil field being developed. The model indicates a small positive impact of the oil price on the investment decision. Interpretation of the hazard rates of the categorical variables differs from that of the continuous variable. For Oil-weighted, Supply segment and Fiscal regime, the first category is used as a reference category. The estimate of the hazard rate given for the other categories is the probability of event occurrence, relative to this reference category. Hence, we observe an increased probability of investment if the reservoir of an assets consists of more than 50% oil compared to those with a lower proportion of oil and correspondingly more gas. We observe that the interpretation of the hazard rate for the service agreement category is counter-intuitive, but note that it must be interpreted with caution due to service agreement assets amounting to less than 1% of total assets. Finally, the hazard rate increases when an oil and gas reservoir is located on more shallow grounds. The baseline model indicates that onshore assets are almost six times more likely to be developed than assets located in arctic areas. All categorical except Fiscal regime indicate the results we expect from the non-parametric analysis. All variables are significant at conventional levels. Country fixed effects are captured by including dummy variables for all countries studied (the reader is referred to Appendix C for a list of these countries).

Table 5. Baseline Investment Regression

*This table presents estimates from a Cox hazard regression of the appraisal duration on the covariates Oil price, Oil-weighted, Fiscal regime, Supply segment. These are our baseline model variables. Country fixed effects are also accounted for. Standard errors of the coefficient estimates are given in brackets while *** indicates 1% significance, ** indicates 5% significance and * indicates 10% significance. Dash indicates which category is used as the reference category for a categorical variable.*

Numerical variable		**Hazard rate**
Oil price		1.002*** (0.0003)
Categorical variables		
Oil-weighted	Oil-weigthed	–
	Gas-weighted	0.751*** (0.017)
Fiscal regime	PSC	–
	Royalty/Tax	1.137** (0.068)
	Service Agreement	1.830** (0.556)
Supply segment	Offshore arctic	–
	Offshore deepwater	1.516* (0.346)
	Offshore midwater	2.284*** (0.509)
	Offshore shelf	3.434*** (0.758)
	Onshore	5.736*** (1.266)
Country fixed effects	Yes	Yes
No. of observations (monthly)		1,145,652
No. of assets		13,269
No. of approvals		10,740

4.2.2 Impact of Political Stability and Property Rights Protection

A Cross-Country Analysis

Table 6 presents the results from extending the baseline model with country characteristic variables to investigate the impact of property rights protection and political stability on the investment decisions of oil and gas companies. As we study 13,269 assets which are spread over 115 countries, a large number of the assets will be recorded with the same value of the country-level variables we wish to identify the impact of. As we lack data enabling us to capture more granular variations, such as within-country heterogeneity, multivariate regression models will not be able to distinguish between the separate effects of each country-level variable. Also, correlations between several of the variables are fairly high.[13] As a result, we test each country-level variable separately with the baseline model, which is similar to the approach of Cust and Harding (2015).

Model (1) indicates a significant increase in the probability of an oil and gas company deciding to develop a discovered asset, given that the asset is located in country with a strong and impartial legal system. Interpreting the hazard rate yields that for a one unit increase in the risk rating of Law and Order, there is a 9.5% increase in the probability of investing from one month to the other. Hence, characteristics of a country's legal system seem to be considered thoroughly in the investment process. As these are factors reckoned to be important determinants of property rights protection, we find by Model (1) strong results of increased investment rate when increasing the protection of property rights in a respective country.

We investigate the impact of property rights protection further in Model (2), by estimating the effect of Investment Profile which captures essential risk factors such as the risk of expropriation and profits repatriation. Our findings indicate a highly significant impact of Investment Profile on the investment decision of oil and gas companies. Improving the risk rating by one unit from one month to the next, would increase the probability of investment by 3.7%. Together, Model (1) and Model (2) provide solid, consistent evidence that solid property rights promote investment in the oil and gas industry. This would be expected for investments in general, and the results are in line with research looking into the effects of property rights on more general measures of investment (e.g. Svensson (1998), Li and Resnick (2003) and Li (2006)). Theoretically it may be particularly important in the oil and gas industry as this is a highly capital intensive industry, often requiring large irreversible capital outlays.

[13]The correlation matrix is given in Appendix D.

Next, we estimate five models to investigate the effect of political stability on the oil and gas investment decision. In Model (3), we find that countries in which governments are considered stable, are more likely to attract investments to their oil and gas industry, compared to countries that score lower on factors such as government unity and legislative strength. When improving the risk score of Government Stability, we find investment to be 3.7% more probable.

By estimating Model (4), we examine to what extent oil and gas companies are concerned with the risk of conflict in a respective country. Our findings indicate a significant negative causality from higher risk of internal conflict, comprising the risk of different types of disputes within the country's borders such as civil war and political violence, to oil and gas investment. The appraisal lag is significantly shortened when decreasing the risk of such conflicts; an improvement in the risk rating is found to increase the probability of investment by as much as 4.5%. This may be explained by elaborating on the risks an investor faces in the situation of domestic instability and civil war. Firstly, profitability of operating in such a country may be reduced due to possible impairment of domestic sales and export. Secondly, there is an increased possibility of disrupted production or facilities being damaged or destroyed. Also, the value of the currency in the host country is likely to be affected by political instability, which may reduce the value of investments as well as the value of future profits generated. These risks are also increased in situations of conflicts with neighbouring and other countries, which are examined next.

Model (5) and Model (6) provide insights into the impact of external conflicts on investments. Model (5) indicates that incidents of war, which is likely to turn the investment environment into a highly risky one, reduce the probability of investment. The War variable is however not significant at conventional levels. Looking back at Table 2, we observe that only a few incidents of war are recorded during our study period, which is likely to be an important reason why we obtain lower significance for this variable. In estimating Model (6), we obtain the hazard rate estimate of Loss of Territory, which implies that participating in disputes in which land areas are lost, not necessarily war, significantly impacts investment rates negatively. Hence, these findings are consistent with the results in Models (3) through (5), providing further insights into how political instability affect investments as well as robustness to our findings that these effects are negative.

Election Year is the last variable we investigate to analyse political instability and uncertainty effects. The hazard rate of Election Year indicates a smaller probability of oil and gas investments in the periods leading up to an election, which is what we would expect. This variable is however subject to somewhat similar conditions as War and Loss of Territory;

the data covers a rather small selection of our countries and only roughly half of the assets are included in the analysis, which might cause the observed insignificance. While Julio and Yook (2012) find evidence that investments in general decrease before an election due to possible policy uncertainty related to the elections, our findings do not provide solid evidence of the manifestation this policy uncertainty in investments of oil and gas operators. We are only able to provide an indication of the effect being in the same direction. Due to low data coverage and significance, this variable is not included in further analysis.

Model (8) indicates a fairly strong and highly significant impact of GDP per capita on the decision to invest. As GDP per capita is a recognized measure of wealth and development in a country, our findings suggest higher probability of oil and gas investment in more developed countries. This is likely the case because more developed countries may have better infrastructure and other facilities that may decrease the barrier of developing oil and gas fields. The degree of development of a country may also be related to strength of the legal system in that country. Wealthier countries are more likely to afford larger investments in legal infrastructure (Svensson, 1998), promoting a stronger legal system, which in turn is more likely to result in better property rights protection (ref. Model (1) estimating the effect of Law and Order). Our findings in Model (8) therefore indicate higher investment rates in more developed countries and may be seen to support our findings on the impact of property rights protection as well.

The estimated coefficient of Debt to GDP per capita in Model (9) give a significant indication of investments being more likely in countries with higher debt. As discussed in Section 2.3, an important part of explaining this may be that highly indebted countries are likely to be more dependent on oil income, causing them to implement policies to favor oil and gas investments. We note however that data on this variable is scarce, thus some caution should be taken when interpreting it.

All model estimations indicate a significant positive effect of the price of oil on the hazard rate. The categorical variables are fairly stable across all specifications, with effects similar to those indicated by the baseline model. In general, assets of which more than half of the resources is crude oil, are developed faster than gas-weighted assets. Further, assets located onshore and on an offshore shelf are developed substantially faster than those in more challenging segments. We note that far fewer assets are located in arctic areas and offshore deepwater than in the other segments, which may contribute to the slightly lower significance of these categories.[14]

[14] For more details on the distribution of assets among supply segments, the reader is referred to Table 2.

Table 6. Cross-Country Analysis: Impact of Political Risk

*This table presents estimates from Cox hazard regressions of the appraisal duration on political risk measures and the baseline covariates. Standard errors of the coefficient estimates are given in brackets while *** indicates 1% significance, ** indicates 5% significance and * indicates 10% significance. Dash indicates which category is used as the reference category for a categorical variable.*

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Numerical variables		**Law and Order**	**Investment Profile**	**Government Stability**	**Internal Conflict**	**War**	**Loss of Territory**	**Election Year**	**GDP per Capita**	**Debt / GDP**
Country Characteristic		1.095***	1.037***	1.037***	1.045***	0.956	0.915**	0.982	1.400***	1.247***
		(0.020)	(0.006)	(0.006)	(0.010)	(0.043)	(0.040)	(0.030)	(0.052)	(0.074)
Oil price		1.004***	1.003***	1.004***	1.004***	1.002***	1.002***	1.002***	1.001***	1.003***
		(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0003)	(0.0003)	(0.0004)	(0.0003)	(0.0005)
Categorical variables										
Oil-weighted	Oil-weighted	–	–	–	–	–	–	–	–	–
	Gas-weighted	0.781***	0.789***	0.782***	0.786***	0.750***	0.751***	0.810***	0.746***	0.762***
		(0.019)	(0.020)	(0.020)	(0.020)	(0.017)	(0.017)	(0.217)	(0.017)	(0.021)
Fiscal regime	PSC	–	–	–	–	–	–	–	–	–
	Royalty/Tax	1.090	1.096	1.091	1.088	1.137**	1.137**	1.310***	1.106*	1.152
		(0.069)	(0.069)	(0.069)	(0.069)	(0.068)	(0.068)	(0.144)	(0.066)	(0.074)
	Service Agreement	1.805*	1.800*	1.827*	1.813*	1.839**	1.834**	2.107	1.830**	*Omitted*
		(0.572)	(0.569)	(0.579)	(0.574)	(0.556)	(0.557)	(1.088)	(0.553)	
Supply segment	Offshore arctic	–	–	–	–	–	–	–	–	–
	Offshore deepwater	1.331*	1.256	1.266	1.305	1.513*	1.504*	1.407	1.378	1.525
		(0.321)	(0.302)	(0.305)	(0.314)	(0.346)	(0.344)	(0.325)	(0.315)	(0.553)
	Offshore midwater	2.083***	2.069***	2.041***	2.082***	2.275***	2.272***	2.231***	2.192***	2.538***
		(0.492)	(0.488)	(0.481)	(0.491)	(0.509)	(0.508)	(0.502)	(0.491)	(0.910)
	Offshore shelf	3.979***	2.980***	2.936***	2.985***	3.437***	3.436***	3.477***	3.416***	4.032***
		(0.694)	(0.695)	(0.684)	(0.696)	(0.758)	(0.758)	(0.769)	(0.754)	(1.430)
	Onshore	4.899***	4.823***	4.784***	4.884***	5.740***	5.726***	5.588***	5.581***	6.471***
		(1.139)	(1.121)	(1.112)	(1.135)	(1.266)	(1.263)	(1.234)	(1.231)	(2.299)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of assets		10,991	10,991	10,991	10,991	13,269	13,269	8,732	13,240	8,034
No. of observations (monthly)		962,638	962,638	962,638	962,638	1,145,652	1,145,652	669,458	1,143,517	574,345
No. of approvals		8,470	8,470	8,470	8,470	10,740	10,740	7,343	10,721	7,010

Variations Across Company Types

Having found that oil and gas investments are systematically higher in countries with solid protection of property rights and a more stable political environment, we now deepen the analysis by investigating variations of this relationship across company types. We perform a sub-analysis comprising the 29 largest companies in our study, categorized into one of the three groups: Majors, E&P companies and NOCs. As discussed in Section 2.4, these types of companies are likely to have various strategies and goals, hence the sensitivity to the different country characteristics is postulated to vary across the different company types. We expect the most significant differences between the multinational Majors and NOCs due to particularly large differences between these groups. The E&P classification is more heterogeneous and less intuitive in terms of expected effects. The companies investigated in this section are recorded as operators of almost one third of the assets in our data set. However, due to employing only a data subset, we obtain lower significance for some variables in our estimations in this sub-analysis. Overall, the baseline variables are stable and indicate similar effects as seen in the cross-country analysis.

The empirical findings in Model (1) suggest Majors are more concerned with the quality of a country's legal system compared to the other two company groupings, and particularly compared to NOCs. Improving the risk rating of the Law and Order variable by one unit, makes it 21% more probable that a Major will invest from one month to another, while it only suggests a probability increase of approximately 7% for NOCs. Statistical tests confirm significant differences in sensitivity of Law and Order between the Majors and NOCs.[15] Thus, these results likely reflect NOCs being subject to different incentives and risks compared to multinational companies, and hence need not be equally concerned with property rights protection.

Further investigation of the impact of property rights protection is provided in Model (2). We find again Majors to consider risks of expropriation and profits repatriation more seriously than NOCs. When increasing the risk rating of the Investment Profile component by one unit, Majors are 7.8% more likely to invest from one month to another, E&P companies are 4.4% more likely to invest, and interestingly, NOCs are 5.6% *less* likely to make an investment. Statistical tests confirm the difference in sensitivity between Majors and NOCs with regard to this variable. The negative hazard rate is particularly interesting as it indicates that NOCs are actually more likely to invest under circumstances in which the risk of expropriation and

[15] By performing Cox regressions in which we interact the company variable by the country characteristic and also include both interaction variables on their own, we obtain estimated significance for the different categories in the company group relative to each other. These indicate whether the given country characteristic affects the three company types statistically different.

profits repatriation, at least for firms operating by market principles, is higher. Since national oil companies are majority owned by the state, they are likely less dependent on political risk and might not follow the same objectives as firms operating by market principles (Pirog, 2007). Together, Model (1) and (2) provide solid evidence that Majors are more concerned with the protection of their property rights when investing, particularly compared to NOCs.

We consider next the impact of political stability. In model (3), we estimate how sensitive the three company types are to stability of the government in a country, when considering whether to invest. We obtain the highest hazard rates for Majors, again indicating they are more sensitive than the other company groups to political risk. When increasing stability of the government by one unit as measured by the ICRG risk rating, Majors are 7.8% more likely to make an investment from one month to the next. While not significant at conventional levels, the model indicates a much smaller impact of Government Stability on NOCs than both other groups. Statistical tests indicate significant differences between the hazard rate of Majors and NOCs, and hence of the difference in sensitivity to Government Stability.

In Model (4) we examine the impact of several investor risks that may be present in situations of civil war and other internal disputes, as discussed in the cross-country analysis. We find again indications of Majors being more concerned than the other company groups. Statistical tests are however not able to confirm significance of the difference in sensitivity to Internal Conflict between the three company types.

We investigate the effects on investment of external conflict and disputes in Model (5) and Model (6), estimating the impact of War and Loss of Territory on Majors, E&P companies and NOCs. Together, these models exhibit somewhat ambiguous results. NOCs are estimated to be more sensitive to War than the other two company types, suggesting they are the least likely to invest in a country with an ongoing war. However, statistical tests are not able to provide evidence of significantly different hazard rates. As noted earlier, few incidents are recorded for this variable and even fewer are included when performing this sub-analysis. These may be important reasons as to why we do not obtain significant results. We therefore interpret the results indicated by War with caution. Findings for Loss of Territory are in line with the indications from our previous models, and estimate Majors to be more sensitive than the other two groups and NOCs to be the least concerned. When a country experiences an incident in which a land area is lost, Majors are 35.9% less likely to invest in development of an oil or gas field in that country. Even though the coefficients seem meaningful, statistical tests are not able to confirm significant differences between the three categories of the company group variable. Altogether, Model (3), Model (4) and Model (6) indicate consistently that Majors are more more concerned with political stability when deciding to invest, particularly compared to NOCs.

We see similar effects when investigating the impact of GDP per capita; higher sensitivity of Majors compared to both E&P companies and NOCs. Statistical tests confirm significance of the difference in sensitivity between Majors and NOCs, hence, Majors are once again indicated to be more cautious with their investments than NOCs, and are thoroughly considering which environments they invest in. The effect of debt to GDP per capita is estimated in Model (8). While the hazard rates for Majors and NOCs are consistent with the results indicated by the variables investigated previously, significance at the conventional level is not met, likely due to the scarce data on this variable. Statistical tests provide however evidence of difference in hazard rates between Majors and NOCs, but are not able to confirm with sufficient level of confidence a larger coefficient for Majors.

Overall, our empirical findings clearly suggest that Majors are more concerned with property rights protection and political risk, particularly compared to NOCs. We discuss two possible explanations for this. Firstly, Majors may, as multinational companies operating by market principles, be subject to harder competition than NOCs. Secondly, being publicly traded, they may be more reliant on a solid reputation. These factors may contribute to making Majors more risk-averse compared to NOCs and hence more sensitive to political risk when deciding to invest. Specialised E&P companies, typically of smaller size than the other two company types, which could make the decision process simpler and quicker, may have owners willing to take on projects with a higher risk. It is however more difficult to provide solid results for this group, as it is more heterogeneous. Our results are in line with the findings of Cust and Harding (2015) in the way that we find Majors to be generally more risk-averse. However, while Cust and Harding (2015) studies institutional quality in general, we employ more specific measures of property rights protection and political stability.

Table 7. Impact of Political Risk: Variation Across Company Types

*This table presents estimates from Cox hazard regressions of the appraisal duration on the interaction between political risk measures on country level and company type, as well as the baseline covariates. Standard errors of the coefficient estimates are given in brackets while *** indicates 1% significance, ** indicates 5% significance and * indicates 10% significance. Dash indicates which category is used as the reference category for a categorical variable.*

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Numerical variables		**Law and Order**	**Investment Profile**	**Government Stability**	**Internal Conflict**	**War**	**Loss of Territory**	**GDP per Capita**	**Debt/GDP**
Country Characteristic × Company Group	Majors	1.210***	1.078***	1.078***	1.055**	0.770*	0.641*	1.733***	1.015
		(0.059)	(0.018)	(0.020)	(0.027)	(0.120)	(0.165)	(0.246)	(0.172)
	E&P	1.137**	1.044*	1.075**	1.027	0.735*	0.865	1.675***	0.804
		(0.073)	(0.026)	(0.031)	(0.039)	(0.133)	(0.212)	(0.265)	(0.236)
	NOC	1.072	0.944**	1.010	1.030	0.615**	1.150	1.490***	0.820
		(0.065)	(0.027)	(0.031)	(0.040)	(0.121)	(0.421)	(0.204)	(0.123)
Oil price		1.005***	1.003***	1.005***	1.004***	1.003***	1.004***	1.002*	1.005***
		(0.0007)	(0.0008)	(0.0008)	(0.0007)	(0.0007)	(0.0007)	(0.0010)	(0.0009)
Categorical variables									
Company group	Majors	–	–	–	–	–	–	–	–
	E&P	2.019**	1.907**	1.461	1.921*	1.485***	1.467***	2.029	2.334***
		(0.575)	(0.503)	(0.444)	(0.783)	(0.113)	(0.110)	(1.750)	(0.331)
	NOC	1.649*	2.895***	1.686*	1.227	0.985	0.965	3.941*	1.258
		(0.436)	(0.762)	(0.522)	(0.503)	(0.084)	(0.082)	(2.949)	(0.149)
Oil-weighted	Oil-weighted	–	–	–	–	–	–	–	–
	Gas-weighted	0.765***	0.774***	0.766***	0.771***	0.767***	0.770***	0.767***	0.737***
		(0.040)	(0.040)	(0.040)	(0.040)	(0.040)	(0.041)	(0.040)	(0.043)
Fiscal regime	PSC	–	–	–	–	–	–	–	–
	Royalty/Tax	0.813*	0.710**	0.813*	0.809*	0.808*	0.809*	0.809*	0.870
		(0.094)	(0.093)	(0.094)	(0.094)	(0.094)	(0.094)	(0.094)	(0.112)
	Service Agreement	4.272	4.498	4.240	4.129	4.151	4.110	4.380	*Omitted*
		(5.260)	(5.529)	(5.201)	(5.089)	(5.098)	(5.048)	(5.394)	*Omitted*
Supply segment	Offshore arctic	–	–	–	–	–	–	–	–
	Offshore deepwater	1.023	0.933	0.976	1.002	1.003	0.996	0.984	0.730
		(0.341)	(0.312)	(0.327)	(0.335)	(0.335)	(0.330)	(0.329)	(0.433)
	Offshore midwater	1.632	1.596	1.606	1.629	1.613	1.621	1.609	1.361
		(0.537)	(0.525)	(0.530)	(0.536)	(0.532)	(0.534)	(0.530)	(0.804)
	Offshore shelf	1.932**	1.877*	1.923**	1.938**	1.935**	1.930**	1.900**	1.600
		(0.629)	(0.610)	(0.627)	(0.631)	(0.630)	(0.628)	(0.618)	(0.939)
	Onshore	2.562***	2.451***	2.556***	2.597***	2.591***	2.590***	2.541***	2.319
		(0.833)	(0.796)	(0.833)	(0.845)	(0.843)	(0.843)	(0.826)	(1.361)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of assets		3,031	3,031	3,031	3,031	3,033	3,033	3,027	1,657
No. of observations (monthly)		266,566	266,566	266,566	266,566	266,627	266,627	266,043	126,880
No. of approvals		2,032	2,032	2,032	2,032	2,033	2,033	2,029	1,235

4.2.3 Firm Characteristics: Tobin's Q and Indebtedness

Our final empirical analysis examines the effect of firm characteristics on the investment decision of the 29 companies in our data subset. We employ Tobin's Q to estimate the impact of relative firm valuation. We also investigate how indebtedness affects the decision process and employ the ratio of debt to assets for this purpose.

Table 8 presents the results of models incorporating the effect of Tobin's Q.[16] We find in Model (1) that increasing Tobin's Q by one unit, makes oil and gas investment 10% more likely from one month to the next. This indicate that oil and gas companies with higher relative valuation are more likely to invest. According to these results, oil and gas companies follow the Q theory of investment. Multivariate regressions in Model (2) and (3) confirm this relation also when accounting for risks related to property rights. The positive causality between higher ratios of Tobin's Q and investment is also confirmed for the models (4) through (7), which capture political stability affects, as well as Model (8), accounting for the degree of development in the host country. We consider in Model (9) differences in the extent to which the three company types depend on their relative valuation when investing. The results indicate that Tobin's Q is a more important determinant of the investment decision for major multinational companies compared to national oil companies. This may be seen as yet another indication of majors being more risk-averse than national oil companies. The impact of Tobin's Q is stable across Model (1) through Model (9), and altogether, these models provide solid evidence that increasing Tobin's Q makes it more probable that an oil and gas firm will invest.

Table 9 presents the results from investigating the impact of firm indebtedness. The estimated hazard ratios of the debt variable indicate, as expected, a decreased investment rate with increasing firm debt. We note however that the debt ratio variable is not significant at conventional levels. A possible reason for the lack of significance may be that it is generally harder to obtain solid data on company debt, compared to equities data such as market capitalization (as used in calculating Tobin's Q). Still, the negative relation between high firm debt and investments found, is stable across all models.

Effects estimated for all political risk measures in the multivariate models presented in Table 8 and Table 9, confirm our empirical findings that oil and gas companies are highly sensitive to these measures. Hence, additional to providing evidence of Tobin's Q and debt affecting investment activity in the oil and gas industry, these models reaffirms and proves robust the previous findings in this paper.

[16] Due to particularly low data coverage on Debt/GDP for the data subset, this variable is not included in the investigation of firm characteristics.

Table 8. Firm Characteristic: Tobin's Q

*This table presents estimates from Cox hazard regression of the appraisal duration on Tobin's Q and the baseline covariates (Model 1), and including also the country characteristic variables (Model (2) - Model (8)). Model (9) presents results from interacting Tobin's Q with Company group. Standard errors of the coefficient estimates are given in brackets. *** indicates 1% significance, ** indicates 5% significance and * indicates 10% significance. Dash indicates which category is used as the reference category for a categorical variable.*

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Numerical variables		**Baseline**	**Law and Order**	**Investment Profile**	**Government Stability**	**Internal Conflict**	**War**	**Loss of Territory**	**GDP / capita**	**Tobin's Q**
Tobin's Q		1.107***	1.091**	1.080*	1.023	1.106**	1.112***	1.107***	1.095**	
		(0.044)	(0.043)	(0.043)	(0.043)	(0.044)	(0.044)	(0.044)	(0.043)	
Country characteristic			1.178***	1.052***	1.0726***	1.031	0.753***	0.802	1.375***	
			(0.048)	(0.014)	(0.014)	(0.022)	(0.076)	(0.119)	(0.158)	
Oil price		1.004***	1.005***	1.003***	1.005***	1.004***	1.004***	1.004***	1.003***	1.004***
		(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0009)	(0.0009)
Tobin's Q	Majors									1.316***
× Company group										(0.126)
	E&P									0.837*
										(0.080)
	NOC									1.220***
										(0.092)
Categorical variables										
Company group	Majors									–
	E&P									2.694***
										(0.534)
	NOC									1.171
										(0.221)
Oil-weighted	Oil-weighted	–	–	–	–	–	–	–	–	–
	Gas-weighted	0.746***	0.741***	0.744***	0.734***	0.745***	0.742***	0.745***	0.742***	0.800***
		(0.037)	(0.037)	(0.037)	(0.037)	(0.037)	(0.037)	(0.037)	(0.037)	(0.042)
Fiscal regime	PSC	–	–	–	–	–	–	–	–	–
	Royalty/Tax	0.768**	0.773**	0.766**	0.788**	0.767**	0.766**	0.767**	0.771**	0.787**
		(0.085)	(0.086)	(0.085)	(0.087)	(0.085)	(0.085)	(0.085)	(0.085)	(0.092)
	Service Agreement	2.660	2.720	2.795	2.582	2.734	2.757	2.667	2.725	3.735
		(2.668)	(2.728)	(2.804)	(2.590)	(2.743)	(2.765)	(2.675)	(2.733)	(4.593)
Supply segment	Offshore arctic	–	–	–	–	–	–	–	–	–
	Offshore deepwater	1.084	1.114	1.051	1.047	1.082	1.100	1.080	1.085	1.021
		(0.360)	(0.371)	(0.350)	(0.349)	(0.360)	(0.362)	(0.359)	(0.361)	(0.343)
	Offshore midwater	1.961**	1.978**	1.975**	1.943**	1.961**	1.965**	1.960**	1.972**	1.651
		(0.642)	(0.648)	(0.647)	(0.637)	(0.642)	(0.644)	(0.642)	(0.646)	(0.546)
	Offshore shelf	2.264**	2.287**	2.279**	2.247**	2.263**	2.275**	2.264**	2.277**	1.968**
		(0.734)	(0.741)	(0.739)	(0.729)	(0.733)	(0.737)	(0.734)	(0.738)	(0.644)
	Onshore	3.100***	3.093***	3.082***	3.019***	3.093***	3.104***	3.095***	3.099***	2.667***
		(1.003)	(1.001)	(0.999)	(0.979)	(1.001)	(1.005)	(1.002)	(1.004)	(0.872)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of assets		3,209	3,207	3,207	3,207	3,207	3,209	3,209	3,203	3,009
No. of observations (monthly)		293,369	293,296	293,296	293,296	293,296	293,369	293,369	292,761	263,622
No. of approvals		2,198	2,197	2,197	2,197	2,197	2,198	2,198	2,194	2,009

Table 9. Firm Characteristic: Indebtedness

*This table presents estimates from Cox hazard regression of the appraisal duration on the ratio of debt to assets and the baseline covariates (Model 1) as well as regressions including also the country characteristic variables (Model (2) through Model (8)). Standard errors of the coefficient estimates are given in brackets while *** indicates 1% significance, ** indicates 5% significance and * indicates 10% significance. Dash indicates which category is used as the reference category for a categorical variable.*

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Numerical variables		**Baseline**	**Law and Order**	**Investment Profile**	**Government Stability**	**Internal Conflict**	**War**	**Loss of Territory**	**GDP / capita**
Debt / Assets		0.660	0.663	0.794	0.789	0.675	0.654	0.656	0.689
		(0.184)	(0.185)	(0.225)	(0.222)	(0.188)	(0.182)	(0.183)	(0.193)
Country characteristic			1.144***	1.058***	1.074***	1.036*	0.748***	0.866	1.498***
			(0.051)	(0.016)	(0.017)	(0.023)	(0.081)	(0.139)	(0.201)
Oil price		1.004***	1.004***	1.003***	1.005***	1.004***	1.003***	1.004***	1.002**
		(0.0007)	(0.0008)	(0.0008)	(0.0008)	(0.0007)	(0.0008)	(0.0007)	(0.0010)
Categorical variables									
Oil-weighted	Oil-weighted	–	–	–	–	–	–	–	–
	Gas-weighted	0.736***	0.733***	0.735***	0.730***	0.734***	0.730***	0.735***	0.733***
		(0.039)	(0.039)	(0.039)	(0.038)	(0.039)	(0.039)	(0.039)	(0.039)
Fiscal regime	PSC	–	–	–	–	–	–	–	–
	Royalty/Tax	0.810*	0.810*	0.808*	0.816*	0.810*	0.809*	0.809*	0.803*
		(0.095)	(0.095)	(0.095)	(0.095)	(0.095)	(0.094)	(0.095)	(0.094)
	Service Agreement	5.200	5.306	5.540	5.303	5.354	5.277	5.194	5.286
		(6.383)	(6.512)	(6.800)	(6.510)	(6.571)	(6.476)	(6.375)	(6.487)
Supply segment	Offshore arctic	–	–	–	–	–	–	–	–
	Offshore deepwater	1.071	1.091	1.037	1.043	1.071	1.076	1.069	1.070
		(0.360)	(0.366)	(0.349)	(0.351)	(0.359)	(0.361)	(0.359)	(0.359)
	Offshore midwater	1.783*	1.796*	1.785*	1.767*	1.784*	1.786*	1.783*	1.783*
		(0.590)	(0.594)	(0.591)	(0.586)	(0.590)	(0.591)	(0.590)	(0.590)
	Offshore shelf	2.110**	2.138**	2.106**	2.098**	2.110**	2.120**	2.111**	2.111**
		(0.690)	(0.699)	(0.690)	(0.687)	(0.690)	(0.693)	(0.690)	(0.691)
	Onshore	2.788***	2.802***	2.756***	2.747***	2.786***	2.791***	2.787***	2.787***
		(0.910)	(0.915)	(0.901)	(0.898)	(0.909)	(0.912)	(0.910)	(0.910)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of assets		3,009	3,007	3,007	3,007	3,007	3,009	3,009	3,003
No. of observations (monthly)		261,438	261,377	261,377	261,377	261,377	261,438	261,438	260,854
No. of approvals		1,983	1,982	1,982	1,982	1,952	1,983	1,983	1,979

5 Conclusion

This paper documents that oil and gas investments are highly sensitive to political risk. We provide evidence that improving the protection of property rights and increasing the political stability in a host country, systematically increase the probability of investment. Specifically, we find that improving the risk rating of the property rights protection proxies Law and Order and Investment Profile by one unit, have consistent effects, and increase the probability of oil and gas investments by 9.5% and 3.7%, respectively. In investigating the impact of political stability, we obtain strong, consistent results over five different model estimations. Oil and gas investments are significantly affected by government stability, within-border conflicts and external conflicts, altogether documenting a negative causality from political instability to investment. Additional to country-specific conditions, firm characteristics also affect the investment decision. We provide evidence that oil and gas companies with higher relative valuation (Tobin's Q) and lower debt invest faster.

We also examine variation in the impact of property rights protection and political stability across company types. We find particularly large differences in the sensitivity to property rights protection. When increasing the risk score of Law and Order by one unit, major multinational companies are 21.0% more likely to invest, while no significant impact on the investment decision of national oil companies is indicated. Considering Investment Profile, we find that majors are 7.8% more likely to invest when the risk measure increases by one unit. Interestingly, this variable indicates that national oil companies are more likely to invest in circumstances of less secure property rights. An increase of one unit in Investment Profile makes it 5.6% less probable that national oil companies will invest. Since national oil companies are majority owned by the state, they are likely less dependent on political risk and might not follow the same objectives as firms operating by market principles. Overall, we conclude that major multinational companies are are more sensitive to political risk when investing, compared to the other company types studied. This is in line with the findings in Cust and Harding (2015).

Altogether, our results based on a unique data set with micro-level data show that political risk significantly impacts investments in the oil and gas industry. As an avenue for further research, we suggest similar investigations in other industries as micro-level data can provide insight not available from analyzing aggregated data. It would be particularly interesting to see whether the response of investment activity to political uncertainty depends on the capital intensity of an industry.

6 Appendix

A. Company Grouping

Table 10. *Categorization of the 29 companies in our data subset, into company type.*

Majors	NOC	E&P
BP	CNOOC	Anadarko
Chevron	Gazprom	BG
ConocoPhillips	MOL	Gazprom Neft
Eni	OMV	Hess
ExxonMobil	ONCG	Lukoil
Royal Dutch Shell	Pertamina	Noble Energy
Total	Petrobras	Repsol
	PetroChina	Stone Energy
	Sinopec	Vermillion Energy
	Statoil	W&T Offshore
	YPF	Woodside

B. Log Rank Tests for Categorical Variables

Table 11. *Results from log-rank tests on the categorical variables we employ.*

Variable	P-value	Categories
Supply segment	0.000	Arctic Offshore deepwater Offshore midwater Offshore shelf Onshore
Fiscal regime	0.000	PSC Royalty/Tax Service Agreement
Oil-weighted	0.002	Oil-weighted Gas-weighted

C. Country Sample

Afghanistan, Albania, Algeria, Angola, Argentina, Australia, Austria, Azerbaijan, Bangladesh, Barbados, Belarus, Belize, Bolivia, Brazil, Brunei, Bulgaria, Cambodia, Cameroon, Canada, Chad, Chile, China, Colombia, Congo, Cote d'Ivoire, Croatia, Cuba, Cyprus, Czech Republic, Democratic Republic of Congo, Denmark, Ecuador, Egypt, Equatorial Guinea, Ethiopia, Falkland Islands, France, French Guiana, Gabon, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Guyana, Hungary, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Japan, Jordan, Kazakhstan, Kenya, Kuwait, Kyrgyzstan, Liberia, Libya, Lithuania, Malaysia, Mauritania, Mexico, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Netherlands, New Zealand, Niger, Nigeria, Norway, Oman, Pakistan, Papua New Guinea, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russia, Saudi Arabia, Senegal, Serbia, Sierra Leone, Slovakia, Somalia, South Africa, South Korea, South Sudan, Spain, Sudan, Syria, Taiwan, Tajikistan, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, United Arab Emirates, Uganda, Ukraine, United Kingdom, United States, Uzbekistan, Venezuela, Vietnam, Yemen

D. Correlation Matrix: Country-Level Variables

Table 12. *Correlation between all country-level variables calculated with the maximum amount of observations available in each case.*

	Law and Order	**Investment Profile**	**Government Stability**	**Internal Conflict**	**War**	**Loss of Territory**	**Election Year**	**GDP per Capita**	**Debt/GDP**
Law and Order	1.00								
Investment Profile	0.49	1.00							
Government Stability	0.22	0.50	1.00						
Internal Conflict	0.72	0.35	0.24	1.00					
War	-0.27	-0.23	-0.03	-0.34	1.00				
Loss of Territory	0.00	-0.11	-0.03	-0.06	0.14	1.00			
Election Year	0.08	0.00	0.05	0.08	0.06	0.07	1.00		
GDP per Capita	0.71	0.58	0.12	0.51	-0.24	-0.03	0.04	1.00	
Debt/GDP	0.09	0.17	0.07	0.05	-0.09	-0.06	-0.02	0.12	1.00

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