Pontifícia Universidade Católica
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Cross-country differences in returns to capital in the oil and gas industry

Dissertação de Mestrado

Dissertation presented to the Programa de Pós-graduação em Macroeconomia e Finanças of the Departamento de Economia, PUC-Rio, in partial fulfillment of the requirements for the degree of Mestre em Macroeconomia e Finanças.

Advisor: Prof. Pablo Salgado

Co-advisor: Prof. Arthur Bragança

Rio de Janeiro
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Abstract

Solbraekke, Oskar Norald Nyheim; Salgado, Pablo (Advisor); Bragança, Arthur (Co-advisor). **Cross country differences in returns to capital in the oil and gas industry**. Rio de Janeiro, 2018. 58p. Dissertação de Mestrado, Departamento de Economia, Pontifícia Universidade Católica do Rio de Janeiro.

This thesis makes use of a unique and vast dataset of investment and production in the oil and gas industry from 1950 to 2016, to explore the Lucas Paradox and the drivers of returns to capital in the industry. Firstly, the thesis examines to what extent poor countries possess higher average returns to capital than rich countries. Secondly, it investigates whether the differences in returns between countries are correlated with institutional factors, variance and/or asymmetry in the returns. The results demonstrate that poorer countries have enjoyed significantly higher returns to capital than richer countries. Moreover, the findings show that institutional factors such as property rights protection, level of corruption and level of schooling possess a positive and statistically significant correlation with returns to capital. However, both these findings are not particularly economically significant. Variance and asymmetry of the returns appear to be an irrelevant explanation for the Lucas Paradox. On the other hand, asset-specific factors, that were, *ex-ante*, expected to be merely insignificant control variables, such as the size of the reservoir, or whether the asset is located onshore or offshore, have large R-squared impact on returns to capital. The findings in this thesis are important because the largely insignificant magnitude of country-specific variables highlight the importance of adapting economic development theory to account for sector-specific differences, as emphasized by Feyrer and Caselli (2008). Moreover, the results indicate that profit maximizing oil and gas companies considering new investments in a country should not be overly concerned with the GDP per capita nor the institutional quality of the country in question. Several potential explanations and paths for future studies are delineated.

Keywords

Capital flows; Lucas paradox; Development economics; Oil and gas economics; Institutions.

Resumo

Solbraekke, Oskar Norald Nyheim; Salgado, Pablo (Advisor); Bragança, Arthur (Co-advisor). **Diferenças de retornos de capital entre países na indústria de petróleo e gás.** Rio de Janeiro, 2018. 58p. Dissertação de Mestrado, Departamento de Economia, Pontifícia Universidade Católica do Rio de Janeiro.

Primeiramente, o trabalho examina em que medida os países pobres possuem retornos de capital mais elevados que os países ricos. Em segundo lugar, investiga se as diferenças nos retornos de capital entre países estão correlacionadas com fatores institucionais, variância e/ou assimetria nos retornos. Os resultados indicam uma relação negativa entre os retornos e o PIB per capita mas com pouca significância econômica. Ademais, os resultados indicam correlações significantes entre retornos de capital e alguns fatores institucionais, embora esses também não sejam economicamente significativos. O desvio padrão ou a assimetria nos retornos não parecem estar correlacionados com os retornos. Em suma, os achados indicam que uma pior qualidade institucional é, até certo ponto, uma explicação plausível para altos retornos de capital nos países pobres. Ainda assim, a falta de significância econômica encontrada destaca a natureza idiossincrática dos retornos nesta indústria devido a independência entre retornos e fatores específicos ao país. Os resultados indicam a necessidade de adaptar a teoria economia à differenças setoriais e também é importante na prática para empresas privadas no setor de petróleo e gás, pois os resultados indicam que estas não devem se preocupar particularmente com o PIB per capita ou as instituições dos países em que considera investir. Ao invés disso, os resultados indicam que as empresas devem olhar principalmente para características dos poços mesmo. Diversas explicações plausíveis para os resultados são delineadas.

Palavras-chave

Fluxos de capital; Paradoxo de Lucas; Desenvolvimento econômico; Economia de Petróleo e Gás; Instituições.

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1
Introduction

In 1990, Robert Lucas raised an important and puzzling question: *Why does capital not flow from rich to poor countries?*[1] According to Lucas' argument, the traditional Solow framework implies the marginal product of capital should be 58 times higher in rich countries than in poor countries to explain the existing differences in output per worker. Consequently, even when allowing for highly imperfect capital mobility, these differences would make investing in rich countries irrational and thus induce vast amounts of capital to move from rich to poor countries. However, the opposite has been observed empirically. This apparent economic development puzzle was later coined "the Lucas paradox". The Lucas paradox should thus be understood as a criticism of the neoclassical framework and has become a classic concept in modern development economics.[2] Another way of stating the underlying theoretical problem is as follows: Can one rationalize why capital does not flow from rich countries to poor countries despite the fact that poor countries exhibit higher marginal returns to capital? And, if it may indeed be rationalized, what are the most important factors impeding such capital flows? This thesis makes use of a unique, extensive and complete cross-country panel dataset of cash-flows and production figures for the oil and gas industry from 1950 to 2016 to examine the following: I) Ceteris paribus, do less developed countries exhibit higher rates of return to capital than more developed countries in the oil and gas industry? II) Can institutional quality or variance and/or asymmetry in returns help explain the return differentials between poor and rich countries?

A distinct feature making the oil and gas industry attractive for cross-country comparisons of returns to capital is that it is arguably the most homogenous industry in the world in terms of inputs and outputs of production. Both the technology used for production (inputs) and the final product (oil, gas

[1] Lucas, Robert. 1990. "Why doesn't capital flow from rich to poor countries? The American Economic Review, p.92-96.

[2] For a summary of the explanations and importance of the Lucas Paradox see Laura Alfaro et al 2008. "Why Doesn't Capital Flow from Rich to Poor Countries? An Empirical Investigation," The Review of Economics and Statistics, MIT Press, vol. 90(2), p.347-368.

and other natural liquids) are largely the same worldwide, which permits "comparing apples with apples". Moreover, the oil and gas industry is one of the largest industries in the world and represents a high percentage share of the GDP of many countries, in particular of developing countries. If one finds that the returns to capital in the oil and gas industry are substantially higher in poor than in rich countries, this would indicate a potential presence of the Lucas paradox in this specific industry.

The results found in this thesis indicate that that poor countries, as measured by GDP per capita, do not exhibit higher returns to capital (in the oil and gas sector) than rich countries. Moreover, results indicate that although some country-specific institutional factors, such as level of corruption, level of schooling, property rights protection possess a (mostly) robust and (almost always) statistically significant correlation with returns to capital between 1950 and 2016, such results are rather economically insignificant, while a myriad of other intuitional factors that are tested for do not at all correlate with returns to capital. Instead, other factors related to the characteristics of the assets (namely, the size of the hydrocarbon reserves and whether the asset is located *onshore* or *offshore)* are, under all specifications, more impactful than any institutional variables. Lastly, the thesis does not find evidence for any correlation between returns and variance nor asymmetry of the returns which could potentially help rationalize return differentials. A plethora of theoretical explanations for the Lucas paradox have emerged since 1990, but the evidence is not particularly robust and the explanations lack consensus. Alfaro et al. (2003) categorize the explanations in two main lines of reasoning: 1) differences in fundamentals affecting the production structure, such as factors of production, government policies and quality of institutions, and 2) international capital market imperfections, mainly sovereign risk and asymmetric information. For each of these two lines of reasoning, authors have adopted various methodologies to test the validity.

Regarding differences in fundamentals of the production function as an explanation for the paradox, a popular procedure, performed by Alfaro et al (2003), Caselli and Feyrer (2008) and Steger and Schularick (2008) for example, is performed by expanding the basic neoclassical production function so that it incorporates endowments of complementary factors of production, such as human capital. Subsequently, a calibration exercise for the expanded model is performed and tested against a given dataset.

One would expect poor countries to exhibit higher rates of return to capital simply because of the scarcity of capital per worker. Nonetheless, while factors such as human capital and low total factor productivity (TFP) decreases the marginal product of capital, bad government policies and low institutional quality increases its inherent risk since the marginal product of capital becomes more volatile. For instance, Besly (1995) provide convincing empirical evidence to support the view that poor property right protection has significantly lowered rates of investment in Ghana. As such, bad government policies (e.g. rent-seeking behavior or expropriation) and low institutional quality may be viewed as factors of production omitted by the neoclassical production function and, thus, as components representing *risk* for investors. Following this line of reasoning, a large return to capital disparity between poor and rich countries may be rationalized by the fact that investors require higher expected returns to compensate for the additional risk incurred by investing in poor countries. In other words, it is possible that the expected *risk-adjusted* returns to capital are actually quite similar across countries and that therefore there is no Lucas paradox.

Similar cross-country risk-adjusted returns to capital is often referred to as "return equalization". Alfaro et al. (2003) attempts to directly measure the determinants of capital inflows through cross-country regressions to "solve" the paradox. Their results showed that for the period 1971–1998, institutional quality is the most important and causal explanatory factor determining capital flows, while capital market imperfections, or market failures, play a role but are less economically significant. Furthermore, the authors point to the fact that international capital market failures cannot be an explanation for the lack of flows before 1945 since "during that time, the entire so-called third world was subject to European legal arrangements imposed through colonialism," meaning that the gap in institutional quality between poor and rich countries was negligible pre-WWII, but lack of capital flows was still occurring. A fundamental assumption for the return equalization approach is that under conditions approximating perfect competition in the global capital market, the marginal productivity to capital is equal to the rate of return to capital.

Steger and Schularick (2008) extend Lucas's original model to account for the impact institutional quality has on differentials of returns. The authors argue that the gap in institutional quality between poor and rich countries was much narrower before WWII because the legal and economic arrangements of private contracts were most of the time directly imposed by European powers, an effect often referred to as the "empire effect." Thus, they argue, the fact that flows of capital from rich to poor countries have decreased substantially between 1914 and today can be rationalized by the fact that the institutional gap, specifically property rights, has also substantially increased. An equivalent way of looking at it is that sovereign-risk in emerging markets is relatively higher today than in 1914, which may explain why capital flows from rich to poor countries have decreased. Hence, Steger and Schularick (2008) and Alfaro et al. (2003) agree that institutional quality is a paramount explanation for the paradox.

Caselli and Feyrer (2007) also analyzes the Lucas Paradox through analyzing differences in fundamentals of the production function, but they estimate the marginal returns to capital, instead of capital flows determinants as the aforementioned authors. They find that the marginal return to capital is remarkably similar across countries when explicitly adjusting the neoclassical model to account for the higher relative price of capital in poor countries than in rich countries and, simultaneously, distinguishing between *reproducible* rates of capital and *non-reproducible* rates of capital. The authors argue that standard measures of returns to capital use a capital share that is inappropriate because it conflates the incoming flowing to capital accumulated through investment flows with natural capital in the form of land and natural resources. Together, the two abovementioned facts are enough for returns to capital to be essentially equalized between the countries in their sample, which they argue means that one may rationalize all the cross-country variation in returns to capital without appealing to credit-market imperfections. Hence, according to these authors, there is no support for the view that international credit frictions play a major role in preventing capital flows from rich to poor countries.

The second main line of academic papers examines the credit market imperfection explanation for the Lucas paradox by measuring specific hypotheses through microeconomic data and natural experiments. Notably, Udry and Anagol

(2006) calculate the returns to capital in Ghana's agricultural sector. They show that the real return to capital in Ghana's informal sector is high. For farmers, they find annual returns ranging from 205–350% in the new technology of pineapple cultivation which is more informal and generally has less access to credit than other agricultural activities, and 30– 50% in well-established food crop cultivation. A more recent paper by David, Henriksen and Simonovska (2014) finds that poor and emerging markets do, in fact, present higher average returns to capital than rich countries through panel-regressions of a set of 144 countries between 1950 and 2011. However, crucially, the authors document that capital does not flow to poor countries until returns are equalized precisely because these countries represent the riskiest investments. More specifically, the authors document a strong correlation between the countries' expected returns and the beta of US stocks. "Countries that have high returns tend to have a high beta with US returns", they conclude. Both of these papers may be used as evidence to support the view that credit market imperfections are indeed a significant explanation for the Lucas Paradox.

Lastly, although not directly motivated by the Lucas Paradox, Hsieh and Klenow (2008) examine the source of resource misallocation and its negative effects on total factor productivity. The authors provide evidence that the variance and skewness of the marginal products of labor and capital in India and China is much higher than in the US. They then proceed to show that if the marginal products to capital and labor were as efficiently (more evenly distributed, that is) allocated as in the US, India and China could experience an increase between 30–60% in total factor productivity. This is a different branch of research, but nevertheless relevant to this thesis because high returns to capital in poor countries could be potentially be correlated with high variance or asymmetry in returns and thus serve as a potential underlying explanation for returns differentials. Nonetheless, the empirical evidence presented herein does not support standard deviation or asymmetry as possible explanations for the Lucas paradox.

2
The Data

2.1
The Rystad Energy Database

The database from which the sample originates is owned by Rystad Energy, a Norwegian-based consultancy and business intelligence firm used by investment banks, governments and universities around the world. Rystad Energy owns several databases, but only their "UCube" (an abbreviation for Upstream Cube) is used in this study. The UCube includes historical production and economic figures for about 65,000 oil and gas *upstream* assets and 3,200 operators in 70 countries[3]. The economic figures encompass capital expenditure, operational expenditure and government take[4] between 1900 and 2016. Furthermore, the economic and production data per asset are classified by whether they are located onshore or offshore and by country and operator. Assets located offshore are further broken down by categories of water depth.[5]

2.2
The sample

For the purpose of answering the questions proposed, several important restrictions were applied to the data. A subset of 29 countries was chosen from a total of 70 countries in the original database. The countries were selected according to a few criteria. First, assets within countries with the largest volume of oil and gas production in 2016 were selected. Second, only assets with a total sum of economics (capex + opex + government take) exceeding 20 million nominal USD over the *lifecycle*[6] of the asset were included. The rationale behind these exclusions is that oilfields with very small total cost are more prone to measurement error due to their small magnitudes and because these small assets

[3] *Upstream* is usually defined as a synonym of the exploration and production (E&P). However, to avoid confusions with *midstream* and *downstream* phases, perhaps "exploration and extraction of hydrocarbons" would be a more precise description of the term. *Assets* are synonymous of oil and gas fields. Operators are firms responsible for operations on the oilfield. See section 2.4 for details
[4] Or received, in the case of negative values for government take. See section 2.4.
[5] See section 2.4 for more detailed descriptions.
[6] See explanation and details about lifecycle in section 2.3.

are *less* closely followed by Rystad. Furthermore, estimating the average rate of return to capital within a country with very few and economically insignificant assets could potentially lead to miscomputing the variance and asymmetry of returns within that country. There is no reason to believe that this exclusion should lead to any systemic bias in the calculations, even though a large sample of countries could of course have increased the precision cross-country regressions. Lastly, observations before 1950 were excluded due to the presence of outliers and incomplete observations.

2.3
Description of variables

A short explanation of each of the relevant variables in my analysis is in order here, as follows:

ASSET

Asset refers to the name of a specific oil and gas field. Originally, the total number of assets was 10,524 assets. After making relevant exclusions, such as deleting assets for which no capex was listed and restricting the years of the sample to only 1950–2016, a total of 10,194 assets were included in the final dataset. I also used the same dataset but restricted to the interval 1996-2016 to check for correlations with a second dataset for institutional quality that was only available for 1996 to 2016.

COUNTRY

Naturally, the country variable refers to the country in which the asset is physically located. The countries included are selected on the basis of being the largest oil producing countries in 2016. It is important that the countries included have a significant amount of oil and gas assets because of the increased precision of my variance estimates later on. See Table A for an overview of countries and the number of assets in each country.

Table A: Number of assets and the income classification of the world bank by country

COUNTRY	Country Code	Number of assets	Income classification
United Arab Emirates	AE	42	High income
Angola	AO	83	Lower middle income
Argentina	AR	376	Upper middle income
Australia	AU	427	Upper middle income
Azerbaijan	AZ	40	Upper middle income
Brazil	BR	200	Lower middle income
Chile	CL	57	Upper middle income
China	CN	464	Lower middle income
Congo	CO	392	Low income
Denmark	DK	17	High income
Algeria	DZ	115	Lower middle income
Egypt	EG	20	Lower middle income
Great Britain	GB	306	Upper middle income
Indonesia	ID	493	Lower middle income
India	IN	228	Lower middle income
Iraq	IQ	56	Upper middle income
Iran	IR	91	Upper middle income
Kuwait	KW	11	High income
Libya	LY	114	Lower middle income
Mexico	MX	313	Upper middle income
Malaysia	MY	290	Low income
Nigeria	NG	244	Low income
Norway	NO	86	High income
Qatar	QA	24	High income

Saudi Arabia	SA	34	High income
Venezuela	VE	211	Lower middle income
Canada	CA	1492	Upper middle income
Russia	RU	1558	Upper middle income
United States	US	2142	High income

OPERATIONAL EXPENDITURE

Opex includes all operational expenses directly related to the oil and gas activities of an asset. Included items are production costs (i.e., salaries, lease costs and maintenance work), transport costs (processing costs and transport fees) and general and administrative costs. Negative values for opex should not occur and assets with such values were thus excluded in the final sample.

CAPITAL EXPENDITURE

Capex includes investment costs incurred related to the development of infrastructure, drilling and the completion of wells, as well as modifications and maintenance on installed infrastructures. It is important to note that this measure captures only the capital expenditure related to a specific oil field. Any capital expenditure spent by the operator on non-field-specific costs is not accounted for. On the other side, as most operators in the oil and gas supply-chain operate in several countries, there is little reason to believe this would create any type of systemic bias in my returns of capital estimates. Additionally, neither of my cost measures explicitly captures the exploration costs (costs related to encountering, evaluating and appraising the oil and gas fields) because this figure was not available. This creates a potential bias for my estimates of the real rate of return to capital because it is possible that some countries possess geological conditions that would make finding and appraising fields much costlier on average than in other countries. Controlling for whether the asset is located onshore or offshore should attenuate this problem, but there is no guarantee it resolves it entirely.

GOVERNMENT TAKE

Government take includes not only all cash flows destined for authorities and governments but also rent payments to private land owners (particularly relevant for the US), export duties, bonuses, income taxes and all other taxes and fees. Government take is the only one of my variables that includes negative values. Negative values for government take represent payments from authorities to the operators in the form of subsidies.

PRODUCTION

Production is the total amount of barrels of oil equivalents (BOE) produced from an asset. BOE is a form of combining and incorporating the production of natural gas and other liquids into an energy measure equivalent to that of oil and gas. Some imprecision is introduced through using BOE as a measure of production since the monetary value of natural gas is somewhat lower than crude oil. It is possible that this imprecision may lead to minor bias in the data if some countries possess much higher proportions of low quality liquids and natural gas, but this is not likely to yield major differences.

REVENUE

Revenue is simply equal to the production in a given year multiplied by the oil price in the corresponding year. The oil price utilized in the calculations is an average of the Brent and WTI prices. Revenue is given in nominal USD.

ONSHORE VS. OFFSHORE

This variable is a dummy variable, taking on the value 1 if the asset is located offshore (that is, at sea) and 0 if the asset is located onshore (that is, on land). It is important to make this distinction because one would expect that capex and opex are generally higher for assets located in the water due to geological and logistical challenges.

WATER DEPTH CATEGORY

Water depth splits the assets into categories of different water depth. The "depth" is a measure of the distance between the facility (platform, FPSO, etc.) and the wellbore. In general, a lengthier distance implies greater operational and capital expenditure due to the logistical and geological challenges. For very deep water depths, such as the pre-salt region in Brazil, the operator will have to drill through thousands of meters of water, salt and various rock formations, which makes production in these areas costlier. The intervals of the categories are 25 meters up to 200 meters, and hence the intervals increase with the water depth. This variable is thus an important control variable in the methodology because it serves as a control for geological difficulties in extracting the hydrocarbons. Unfortunately, this variable is the sole control variable for geological challenges in my regressions. Ideally, one would also control for variables that relate more directly to the geological and geophysical particularities of the reservoirs in each asset (such as the type of rock formation, porosity, permeability, pressure, etc.). Unfortunately, figures for such characteristics were not available in the database. On the other hand, there is little reason to believe that this omission would lead to a systemic bias when measuring differences of returns to capital between poor and rich countries. Instead, it likely represents a source of imprecision of unknown magnitude.

INSTITUTIONAL MEASURES

As earlier described, one would expect countries with poorer institutional quality to display higher marginal return. To measure the role of institutional quality, I run my three distinct measures of returns to capital against two different datasets of institutional quality. The first regressions rely on data derived from the World Governance Indicators (WGIs) by the World Bank. These measures range between 1996 and 2016 and include four distinct measures of institutional quality: control of corruption, government effectiveness, political stability and absence of violence/terrorism and regulatory quality. The measures of the institutional quality in each country are derived from the World Bank's governance indicators. The Worldwide Governance Indicators (WGI) cover over 200 countries and territories, measuring six dimensions of governance starting in 1996. Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption. Political stability and absence of violence/terrorism measures perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism. Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Control of corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption as well as the "capture" of the state by elites and private interests.[7] Government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation and the credibility of the government's commitment to such policies.

A second source for institutional measures is derived from the "Quality of Government" database provided by Oxford University Press in 1999. Differently than the above-mentioned dataset, this dataset is not longitudinal but only cross-section. One may argue, nevertheless, that this is not a problem for the precision of the results given the slow-paced change of measures of institutional quality.

GDP PER CAPITA

As the research question clearly stated, the first objective of this thesis is to verify whether poor countries exhibit higher returns to capital than rich countries in the oil and gas industry. The results, summarized in tables I-VIII indicate, as expected, that low income countries do possess higher returns to capital than high income countries in my sample, although the effect is generally quite small in terms of magnitude. As previously mentioned, one would expect, based on previous academic findings, a *negative* correlation between GDP per capita and returns to capital in the oil and gas sector. The GDP per capita measures provided by the Institute for Health Metrics and Evaluation have been used in this thesis because they contain complete data for all countries in the sample and between years 1950 and 2016.

2.4
The lifecycle of oil and gas assets

It is important to elaborate and clarify what is meant by the *lifecycle* of an oil and gas asset to understand how many years are included in the calculation of the returns to capital and thus better understand the data. Lifecycle refers to the

[7] https://info.worldbank.org/governance/wgi/pdf/cc.pdf

lifespan of the field divided into distinct phases. Some of the phases may overlap and possess more detailed information, but this summary should nonetheless suffice for the purpose of this exercise. Below I present these phases in a stereotypical, simplistic and summarized manner.

PHASE 1 – LICENSING

Licensing consists of screening and identifying prospective areas to explore. Then the operator acquires leased acreage from the government, typically in exchange for a fee and some form of performance or work obligation, such as the acquisition of seismic data or drilling a well.

PHASE 2 – SEISMIC, SURVEYS AND EXPLORATION DRILLING (3–5 YEARS)

Seismic, and sometimes magnetic and electromagnetic, surveys are developed to understand the geology below the surface. If the results indicate the existence of potential hydrocarbon reservoirs, the oil and gas company, or *operator*, may continue with site surveys. The site surveys are performed to gain more information on the prospect area. Next, the operator can drill one or more exploration wells to gather further data to evaluate whether the well is viable for production. This includes information such as flow rates, pressures and temperatures.

PHASE 3 – APPRAISAL (4–10 YEARS)

If substantial hydrocarbon reservoirs are confirmed, a field appraisal is used to determine the methodology of extraction and whether the field is indeed economically viable.

PHASE 4 – DEVELOPMENT (1–7 YEARS)

After a prospect has been judged commercially and technically viable, a development plan is submitted to the authorities, and necessary goods and services are procured. Production wells are then drilled, followed by the commissioning of the area to attain a stable production level.

PHASE 5 – PRODUCTION (10–30 YEARS)

There is a large variety of alternatives for how an oil and gas asset will produce, depending on the type of field (onshore vs. offshore, deep water vs. shallow water, pre vs. post salt, etc.), the country and environmental conditions. Production is generally gradually increased to peak production, the level at which the asset will produce at plateau level for some time. At some point, the production starts to decline due to falling pressure, at which point the operator may inject water or gas to maintain the pressure or, alternatively, use techniques such as infill drilling to connect nearby reservoirs to the developed facility.

As previously mentioned, the very concept of life cycles in the reason why I have chosen to include future projections for production, capex and opex. The database provider I have used can easily deliver unbiased, albeit not necessarily exact, estimates for the remaining life cycles of an oil and gas asset. For example, if an asset has been explored, appraised and produced for one year *up until* 2016, Rystad Energy knows, with a high degree of certainty, that more oil and gas will be produced. If this future production is not accounted for, the returns to capital for countries with many such assets will be unrealistically penalized. In other words, a cutoff in year 2016 would create a bias for countries with a large number of assets that are in the later stages of production. Of course, cost projections are also included. The scenario used for projecting the cost values (Opex and Government take) is based on the taxation and subsidy regimes per 2016. Such cost projections are subject to changes in government policy, for example changes in taxation, which would alter government take in the future and hence this is a source of potential measurement errors. Nevertheless, there is little reason to believe there are any systematic differences between poor and rich countries with this regard. All this means that we can effectively and fairly compare assets in different countries. To put it even more informally, the concept of lifecycles allows us not only to compare apples to other apples, but *whole* apples to *whole* apples. Lastly, in table A you may see descriptive statistics showing the countries included, number of assets, income classification to give on overview of which countries are included in the study.

3
Method

3.1
Creating measures of return to capital

There are several ways of measuring returns to capital. The calculation in this thesis is based on a simple methodology commonly used in finance and accounting for which the return on capital (ROC) or returns on invested capital (ROIC) is given by the following:

$$\text{ROIC} = \frac{\text{Net Operating Profit} - \text{Adjusted Taxes}}{\text{Invested Capital}}$$

Naturally, ROIC is an attempt at measuring a firm's ability to generate an operating return per unit of invested capital. In accounting, the components of ROC or ROIC are normally calculated within a single calendar year. However, for the purpose of measuring the rates of return of oil and gas assets, it would be misleading to simply measure the return to capital within single calendar years.

Considering the fact that the exercise of directly measuring the returns to capital of oil and gas assets has, to my knowledge, never before been performed, it is unavoidable that the intervals of years one should measure are somewhat arbitrary. To circumvent possible biases and imprecisions arising from this arbitrariness, three distinct measures of returns to capital were calculated: "return lifecycle," "return twenty" and "return ten." These are outlined and explained below.

3.1.2
"Return lifecycle" (R_{LC})

The return lifecycle measure refers to the gross profit generated over the entire lifecycle of the oil and gas asset (see section 2.4 on lifecycle). It is given by:

$$R_{LC} = \frac{\sum(Revenue_{t:\,0\ to\ lifecycle} - Opex_{t:\,0\ to\ lifecycle} - GovTake_{t:\,0\ to\ lifecycle})}{\sum(Capex_{t:-10\ to\ 10}+)}$$

where "t" refers to the time horizon for each variable. The reference point (t = 0) is the first year of observed production of each particular asset.

The reference point (t = 0) is the first year of observed production of each particular asset.

"$Opex_{t:\,0\ to\ lifecycle}$" refers to the sum of all operational expenses for an asset incurred between the first year of production (t = 0) and the last year of production (lifecycle).

"$Revenue_{t:\,0\ to\ lifecycle}$" refers to the sum of all revenue generated for an asset between the first year of production (t = 0) and the last year of production (lifecycle).

"$Gov\_Take_{t:\,0\ to\ lifecycle}$" refers to the sum of all government take incurred/received between the first year of production (t = 0) and the last year of production (lifecycle).

"$Capex_{t:\,-10\ to\ 10}$" refers to the sum of all capital expenses for an asset incurred 10 years before the first year of production (t = -10) and the 10th year of production (t = 10).

This is the benchmark, or standard, measure of returns to capital on an asset used in this thesis. It is realistic in the sense that it includes all the observed cash flows for a particular asset. Thus, it provides a good estimate of how much gross revenue has been generated per capital expenditure invested. It is important to note, however, that one potential issue with this measure is that the number of years of revenue will vary between assets. In other words, the time span between the first and last year of production is not constant.

3.1.3 "Return twenty" (R_{20})

The "return twenty" measure is the return in the 20 subsequent years after the first year of production.

$$R_{20} = \frac{\sum(Revenue_{t:\,0\ to\ 20} - Opex_{t:\,0\ to\ 20} - Gov\_Take_{t:\,0\ to\ 20)}}{\sum(Capex_{t:-10\ to\ 10} +)}$$

The advantage of this measure compared with "return lifecycle" is that the time span between the first and last years of production is always 20 years. The disadvantage is, naturally, that we are actually not capturing what realistically has been produced after the first 20 years.

3.1.4
"Return ten" (R_{10})

$$R_{10} = \frac{\sum(Revenue_{t:\,0\,to\,10} - Opex_{t:\,0\,to\,10} - Gov\_Take_{t:\,0\,to\,10)}}{\sum(Capex_{t:-10\,to\,10} +)}$$

The only difference between "return ten" and "return twenty" is the time span from the first year of production. The advantage of this measure compared with "return lifecycle" is that the time span between the first and last years of production is always 10 years. Again, the reason why I chose to create three different measures of return to capital is simply to increase the robustness of my findings.

3.2
Multivariate regression: What explains the returns to capital during the lifecycle of oil and gas assets?

The factors affecting returns to capital over the lifecycle of an oil and gas assets is estimated for a given asset. The benchmark OLS estimation equation is given by:

(1)

〖Y(lnR_LC)〗 _(Asset, First year of production of asset i) =
a + β_1 〖($Level\ of\ schooling$)〗 _(Country, 1997) +
β_2 〖($Level\ of\ corruption$)〗 _(Country, 1997) 〖 +
β_3 〖($Property\ rights\ protection$)〗 _(Country, 1997) 〖 +
β〗 _4 〖($lnGDP\ per\ capita$)〗 _(Country, First year of production of asset i) +
β〗 _5 〖($lnReservoir\ Size$)〗 _(Asset, First year of production of asset i) 〖 +
β〗 _6 〖($Onshore\ vs\ Offshore\ dummy$)〗 _(Asset, First year of production of asset i) +
$i.(Fixed\ effect\ year)$ + ε_(Asset i)

The dependent variable, R_{LC}, is a logarithmic transformation of "return lifecycle". The first independent variable is the level of schooling in 1997 in the country which each asset is located. Level of schooling is a scale from 1 to 10 and is a "level variable", which means that, *ceteris paribus*, if the level of schooling is augmented by 1 point, R_{LC} increases by approximately 100 x β_1%. The second independent variable the level of corruption in 1996, which is also measured on a scale from 1 to 10. The third independent variable is Property rights protection in 1997, again measured on a scale from 1 to 10. All these institutional variables possess the same above-mentioned interpretation. The fourth independent variable is a natural log transformation of the Gross Domestic Product per capita in the country in which the asset is located and in the first year of observed production of each asset. The interpretation of this result is that a 10% increase in GDP per capita is associated with a $10 \times \beta_4\%$ decrease in R_{LC}. The fifth independent variable is the log transformation of the total reservoir size of each asset in order to control for returns to scale effects. The interpretation of this result is that a 10% rise in the total volume of reserves in the field implies an average of increase of approximately $10 \times \beta_5\%$ in returns to capital. The sixth regressor is a dummy variable, taking on the value 1 if an asset is located offshore and 0 if the asset is located onshore. The interpretation is that if an asset is located onshore, $R_{LC}$is on average approximately $100 \times \beta_4\%$ higher than if the asset is located offshore. The last control variable that is introduced is a fixed year effects in order to control for economic cycles and technological advancements that may have occurred in the period from 1950 to 2016.

Table I presents OLS coefficients for specifications in which the independent variables are gradually introduced. In column 1, three variables measuring the institutional quality of the variables are introduced without any additional controls. Both level control of corruption and property rights protection are both have a positive influence on R_{LC}, while, surprisingly "level of schooling" actually has a strong negative correlation under this specification (as one introduces more control variables, however, this strange result disappears). Column 2 introduces the log of GDP per capita as a control variable. As one would expect, the results show a negative correlation which makes sense according to the logic of Lucas Paradox; countries with higher GDP per capita, should exhibit lower marginal returns to capital. Furthermore, column 3 adds a fixed-effect for each year in the sample, which increases the R-squared from 0.14 to 0.62. In other words, it is essential to control for economic boom and bust cycles and the development of relative cost of capital in my sample period. The same pattern may be recognized in different specifications. In column 4, the log of the reservoir size as a control variable is introduced, as a manner of controlling for the returns to scale, since larger assets are expected to yield lower fixed (operational and capital) costs. This variable has a coefficient of about 0,98, which means that a 1% increase in reservoir size, leads to a 0,98% rise in R_{LC}. Lastly, a dummy variable indicating whether a given asset is located onshore or offshore was introduced as a control variable. The results indicate that onshore assets exhibit an R_{LC} that is approximately 21,6% higher than offshore assets. Column 5 is the final benchmark multivariate regression with all controls in place. The results indicate that an increase in 1 in the index for level of schooling increases R_{LC} by 32,5%, that a 1 point increase in level of corruption increases R_{LC} by 9% and that a 1 point increase in property rights protection increases R_{LC} by 8,7%. In other words, as expected, institutional quality plays a significant role for returns to capital over the lifecycle of oil and gas assets. Moreover, the log of GDP per capita in the first year of production of a given asset is negatively correlated with R_{LC}. An asset located in a country with 10% higher GDP in the first year of production exhibits an average of approximately 2,31% lower R_{LC}. It this benchmark regression, all the coefficients are statistically significant at 1% confidence interval, which is of course mostly a consequence of the sizeable number of observations.

Table I: Results are derived from equation (1). The table shows OLS coefficients with ln of R_{LC} (Return lifecycle) from 1950-2016 as dependent variable. Column (1) has control of corruption in 1996, level of schooling in 1996 and property rights in 1997 as independent variables. Column (2) adds the natural logarithm of GDP per capita in the first year of production as an additional independent variable. Column (3) adds fixed effects per year as a control variable. Column (4) adds adds reservoir size, measuring the size of total reserves in the field over its lifecycle, as a control measure of returns to scale. Column (5) adds the "onshore or offshore" dummy, as a control for natural given differences. Robust standard errors are reported in parenthesis. Significance: p<0.01 = ***, p<0.05 = **, p<0.10 = *

Panel A: ln R_{LC} vs Property rights, Corruption and level of schooling under different specifications	(1)	(2)	(3)	(4)	(5)
Dependent variable = ln(R_{LC})					
Level of schooling in 1996	-2.05*** (.138)	-0.861*** (.150)	-1.107*** (.085)	0.397*** (.055)	0.325*** (.053)
Control of corruption in 1996	0.342*** (.019)	0.501*** (.018)	0.291*** (.0147)	0.091*** (.008)	0.090*** (.008)
Property rights protection 1997	0.543*** (.070)	0.179* (.065)	0.492*** (.038)	0.024*** (.022)	0.087*** (.022)
Log of GDP per capita (first year of production)		-1.113*** (.030)	-0.243*** (.029)	-0.227*** (.023)	-0.231*** (.020)
Log of reservoir size				0.973*** (.011)	0.982*** (.007)
Onshore vs Offshore dummy					0.216*** (.019)
Fixed effects year			Yes	Yes	Yes
R^2	0.001	0.14	0.62	0.87	0.88
Number of assets	6539	6539	6488	6488	6488
Average number of assets per country	272	272	270	270	270
Average number of assets per year	99	99	98	98	98

3.3 Robustness Exercise: Testing one institutional factor at a time

In order to increase the robustness of the findings in section 3.2, specifications using only one of the institutional variables at the time have also been tested. The OLS estimation equation for table II, below, is given by:

(2):

$$\llbracket Y(\ln R\_LC) \rrbracket\_(\text{Asset, First year of production of asset i})$$
$$= a \llbracket + \beta\_1 \llbracket(\text{Property rights prorection})\rrbracket\_(\text{Country}, 1997) \llbracket$$
$$+ \beta \rrbracket\_2 \llbracket(\text{lnGDP per capita})\rrbracket\_(\text{Country, First year of production of asset i})$$
$$+ \beta \rrbracket\_3 \llbracket(\text{lnReservoir Size})\rrbracket\_(\text{Asset, First year of production of asset i}) \llbracket$$
$$+ \beta \rrbracket\_4 \llbracket(\text{Onshore vs Offshore dummy})\rrbracket\_(\text{Asset, First year of production of asset i})$$
$$+ \text{i.}(\text{Fixed effect year}) + \varepsilon\_(\text{Asset i})$$

When running this multivariate regression (2), with Property Rights protection being the only institutional variable, the most significant change is that log of GDP per capita decreases from the benchmark regression (1), even though the effect is still negative and significant. It is also worth noting that the difference in average R_{LC} between offshore and onshore shrinks to approximately 14,3% (compared to 21,6% in table II). The results for regression (2) are summarized in table II.

The next regression estimated includes control of corruption as the sole institutional variable, as portrayed in equation (3) below:

(3):

$$\llbracket Y(\ln R\_LC) \rrbracket\_(\text{Asset, First year of production of asset i})$$
$$= a \llbracket + \beta\_1 \llbracket(\text{Control of corruption})\rrbracket\_(\text{Country}, 1997) \llbracket$$
$$+ \beta \rrbracket\_2 \llbracket(\text{lnGDP per capita})\rrbracket\_(\text{Country, First year of production of asset i})$$
$$+ \beta \rrbracket\_3 \llbracket(\text{lnReservoir Size})\rrbracket\_(\text{Asset, First year of production of asset i}) \llbracket$$
$$+ \beta \rrbracket\_4 \llbracket(\text{Onshore vs Offshore dummy})\rrbracket\_(\text{Asset, First year of production of asset i})$$
$$+ \text{i.}(\text{Fixed effect year}) + \varepsilon\_(\text{Asset i})$$

Under this specification, summarized in table III, the influence of GDP per capita and onshore vs offshore differential also decreases slightly compared with (1), while the coefficients for reservoir size and the control of corruption remains very similar to the benchmark specification.

Lastly, a multivariate regression with level of schooling as the only institutional variable is estimated, according to the following regression equation:

(4):

$$\begin{aligned}
&Y(\ln R_LC)_{(\text{Asset, First year of production of asset i})} \\
&= a + \beta_1 (\text{Level of schooling})_{(\text{Country, 1997})} \\
&+ \beta_2 (\ln\text{GDP per capita})_{(\text{Country, First year of production of asset i})} \\
&+ \beta_3 (\ln\text{Reservoir Size})_{(\text{Asset, First year of production of asset i})} \\
&+ \beta_4 (\text{Onshore vs Offshore dummy})_{(\text{Asset, First year of production of asset i})} \\
&+ i.(\text{Fixed effect year}) + \varepsilon_{(\text{Asset i})}
\end{aligned}$$

The results, summarized in table IV, indicate that level of schooling has statistically significant and relatively large effect on R_{LC}. The correlation is about twice as large as the result from the benchmark specification (1). It indicates that an increase in 1 point in the level of schooling index, leads to an average 75,5% increase in R_{LC}.

Table II: Results are derived from equation (2). The table shows OLS coefficients with ln of R_{LC} (Return lifecycle) from 1950-2016 as dependent variable. Column (1) has only property rights protection in 1997 as an independent variable. Column (2) adds the natural logarithm of GDP per capita in the first year of production. Column (3) adds fixed effects per year as a control variable. Column (4) adds adds reservoir size which is a category variable measuring the size of total reserves in the field over its lifecycle, as a control measure of returns to scale. Column (5) adds the "onshore or offshore" dummy variable. Robust standard errors are reported in parenthesis. Significance: p<0.01 = ***, p<0.05 = **, p<0.10 = *

Panel A: ln R_{LC} vs Property rights under different specifications	(1)	(2)	(3)	(4)	(5)
Dependent variable = ln(R_{LC})					
Property rights protection 1997	0.052*** (.14)	0.414*** (.02)	0.043** (.015)	0.065*** (.008)	0.077*** (0.009)
Log of GDP per capita (first year of production)		- 0.554*** (.02)	-0.025** (.012)	-0.021*** (.006)	-0.031*** (.006)
Log of reservoir size				1.01*** (.007)	1.006*** (.007)
Onshore vs Offshore dummy					0.143*** (.028)
Fixed effects year			Yes	Yes	Yes
R^2	0.02	0.48	0.54	0.88	0.88
Number of assets	9395	9395	9224	9224	9224
Average number of assets per country	319	319	318	318	318
Average number of assets per year	140	140	140	140	140

Table III: Results are derived from equation (3). Table shows coefficients for OLS regressions with ln of R_{LC} (Return lifecycle) from 1950-2016 as dependent variable. Column (1) has only control of corruption in 1996 as an independent variable. Column (2) adds the natural logarithm of GDP per capita in the first year of production as an additional independent variable. Column (3) adds fixed effects per year as a control variable. Column (4) adds adds reservoir size which is a category variable measuring the size of total reserves in the field over its lifecycle, as a control measure of returns to scale. Column (5) adds the "onshore or offshore" dummy variable. Robust standard errors are reported in parenthesis. Significance: p<0.01 = ***, p<0.05 = **, p<0.10 = *

Panel A: ln R_{LC} vs Control of corruption under different specifications	(1)	(2)	(3)	(4)	(5)
Dependent variable = ln(R_{LC})					
Control of corruption in 1996	0.088*** (.008)	0.401*** (.0189)	0.192*** (.012)	0.089*** (.007)	0.096*** (0.009)
Log of GDP per capita (first year of production)		-0.598*** (.027)	-0.228*** (.017)	-0.083*** (.009)	-0.094*** (.009)
Log of reservoir size				0.996*** (.007)	0.985*** (.007)
Onshore vs Offshore dummy					0.133*** (.014)
Fixed effects year			Yes	Yes	Yes
R^2	0.01	0.12	0.57	0.63	0.88
Number of assets	7680	7680	7509	7509	7509
Average number of assets per country	274	274	268	268	268
Average number of assets per year	116	116	113	113	113

Table IV Results are derived from equation (4). The table shows OLS coefficients with ln of R_{LC} (Return lifecycle) from 1950-2016 as dependent variable. Column (1) has only control of corruption in 1996 as an independent variable. Column (2) adds the natural logarithm of GDP per capita in the first year of production as an additional independent variable. Column (3) adds fixed effects per year as a control variable. Column (4) adds adds reservoir size which is a category variable measuring the size of total reserves in the field over its lifecycle, as a control measure of returns to scale. Column (5) adds the "onshore or offshore" dummy variable. Robust standard errors are reported in parenthesis. Significance: p<0.01 = ***, p<0.05 = **, p<0.10 = *

Panel A: ln R_{LC} vs Level of schooling under different specifications	(1)	(2)	(3)	(4)	(5)
Dependent variable = ln(R_{LC})					
Level of schooling in 1996	0.278*** (.044)	2.794*** (.123)	0.715*** (.085)	0.711*** (.007)	0.755*** (.0666)
Log of GDP per capita (first year of production)		-.969*** (.041)	- 0.166*** (.017)	-0.196*** (.009)	- 0.203*** (.020)
Log of reservoir size				1.000*** (.010)	0.982*** (.007)
Onshore vs Offshore dummy					0.191*** (.017)
Fixed effects year			Yes	Yes	Yes
R^2	0.001	0.14	0.57	0.87	0.88
Number of assets	6539	6539	6488	6488	6488
Average number of assets per country	272	272	270	270	270
Average number of assets per year	99	99	98	98	98

3.4
Robustness Exercise II: Testing different measures of returns

In this section I emulate the regressions reported in table I with one important dissimilarity; the dependent variable (that is, the way of measuring returns to capital). In equation (5) below, the only difference from (1) is that R_{LC} is substituted for R_{10}. The results are reported in table V. Similarly, in equation (6), the only difference from (1) is that $R_{LC}$is exchanged for R_{20}. In table V, the most notable discrepancy from (1) is that “level of schooling” is now both economically and statistically insignificant. Also, the coefficient for the reservoir size is considerably smaller than the benchmark, while the difference in return to capital between onshore and offshore asset is slightly larger than the benchmark under this specification. In table VI, “level of schooling” is still statistically significant, but only at 10% level of significance and with a relatively small economic effect. Other than that, the results only differ slightly in magnitude from table V.

(5)

$$
\begin{aligned}
&Y(\ln R_{10})_{\text{Asset, First year of production of asset } i} \\
&= a + \beta_1 (\textit{Level of schooling})_{\text{Country, 1997}} \\
&+ \beta_2 (\textit{Level of corruption})_{\text{Country, 1997}} \\
&+ \beta_3 (\textit{Property rights protection})_{\text{Country, 1997}} \\
&+ \beta_4 (\textit{lnGDP per capita})_{\text{Country, First year of production of asset } i} \\
&+ \beta_5 (\textit{lnReservoir Size})_{\text{Asset, First year of production of asset } i} \\
&+ \beta_6 (\textit{Onshore vs Offshore dummy})_{\text{Asset, First year of production of asset } i} \\
&+ i.(\textit{Fixed effect year}) + \varepsilon_{\text{Asset } i}
\end{aligned}
$$

(6)

$$
\begin{aligned}
&Y(\ln R_{20})_{\text{Asset, First year of production of asset } i} = \\
&a + \beta_1 (\textit{Level of schooling})_{\text{Country, 1997}} + \\
&\beta_2 (\textit{Level of corruption})_{\text{Country, 1997}} + \\
&\beta_3 (\textit{Property rights protection})_{\text{Country, 1997}} + \\
&\beta_4 (\textit{lnGDP per capita})_{\text{Country, First year of production of asset } i} + \\
&\beta_5 (\textit{lnReservoir Size})_{\text{Asset, First year of production of asset } i} + \\
&\beta_6 (\textit{Onshore vs Offshore dummy})_{\text{Asset, First year of production of asset } i} + \\
&i.(\textit{Fixed effect year}) + \varepsilon_{\text{Asset } i}
\end{aligned}
$$

Table V: Results are derived from equation (5). The table shows OLS coefficients with ln of R_{10}(Return lifecycle) from 1950-2016 as dependent variable. Column (1) has control of corruption in 1996, level of schooling in 1996 and property rights in 1997 as independent variables. Column (2) adds the natural logarithm of GDP per capita in the first year of production as an additional independent variable. Column (3) adds fixed effects per year as a control variable. Column (4) adds adds reservoir size, measuring the size of total reserves in the field over its lifecycle, as a control measure of returns to scale. Column (5) adds the "onshore or offshore" dummy, as a control for natural given differences. Robust standard errors are reported in parenthesis. Significance: p<0.01 = ***, p<0.05 = **, p<0.10 = *

Panel A: ln R_{10} vs Property rights, Corruption and level of schooling under different specifications	(1)	(2)	(3)	(4)	(5)
Dependent variable = ln(R_{10})					
Level of schooling in 1996	-1.338*** (.083)	-1.779*** (.111)	-0.978*** (.099)	-0.037 (.072)	0.043 (.072)
Control of corruption in 1996	0.104*** (.012)	0.085*** (.012)	0.136*** (.011)	0.016* (.009)	0.016* (.009)
Property rights protection 1997	0.573*** (.037)	0.641*** (.039)	0.453*** (.035)	0.171*** (.028)	0.104*** (.030)
Log of GDP per capita (first year of production)		0.156*** (.021)	-0.096*** (.029)	-0.093*** (.023)	-0.094*** (.020)
Log of reservoir size				0.599*** (.011)	0.625*** (.016)
Onshore vs Offshore dummy					0.227*** (.023)
Fixed effects year			Yes	Yes	Yes
R^2	0.05	0.06	0.25	0.52	0.52
Number of assets	6809	6809	6809	6809	6809
Average number of assets per country	235	235	235	235	235
Average number of assets per year	105	105	105	105	105

Table VI: Results are derived from equation (6). The table shows OLS coefficients with ln of R_{20} (Return lifecycle) from 1950-2016 as dependent variable. Column (1) has control of corruption in 1996, level of schooling in 1996 and property rights in 1997 as independent variables. Column (2) adds the natural logarithm of GDP per capita in the first year of production as an additional independent variable. Column (3) adds fixed effects per year as a control variable. Column (4) adds adds reservoir size, measuring the size of total reserves in the field over its lifecycle, as a control measure of returns to scale. Column (5) adds the "onshore or offshore" dummy, as a control for natural given differences. Robust standard errors are reported in parenthesis. Significance: $p<0.01$ = ***, $p<0.05$ = **, $p<0.10$ = *

Panel A: ln R_{20} vs Property rights, Corruption and level of schooling under different specifications	(1)	(2)	(3)	(4)	(5)
Dependent variable = ln(R_{20})					
Level of schooling in 1996	-1.608*** (.088)	-1.191*** (.109)	-0.996*** (.108)	0.077 (.079)	0.139* (.079)
Control of corruption in 1996	0.170*** (.013)	0.195*** (.013)	0.196*** (.013)	0.048*** (.008)	0.049*** (.011)
Property rights protection 1997	0.566*** (.041)	0.525* (.042)	0.440*** (.040)	0.096** (.032)	0.044** (.0335)
Log of GDP per capita (first year of production)		-0.166*** (.024)	-0.172*** (.026)	-0.150*** (.022)	-0.147*** (.023)
Log of reservoir size				0.715*** (.014)	0.735*** (.007)
Onshore vs Offshore dummy					0.176*** (.025)
Fixed effects year			Yes	Yes	Yes
R^2	0.001	0.14	0.19	0.50	0.51
Number of assets	6621	6621	6621	6621	6621
Average number of assets per country	228	228	228	228	228
Average number of assets p. year	102	102	102	102	102

3.5 Robustness Exercise III: Running the regressions without government take

In this section I re-run regression (1) except one important distinction; I exclude government take from the numerator. Thus, the dependent variable becomes simply:

$$R_{LC-Gov_{take}} = \frac{\sum(Revenue_{t:\,0\;to\;lifecycle} - Opex_{t:\,0\;to\;lifecycle}}{\sum(Capex_{t:-10\;to\;10} +)}$$

The reasoning behind this exclusion is that "government take" has a much more exogenous nature than the other cost variables and is a result of policy, not productivity. Either way, the results change only slightly from the benchmark regressions, which is due to the small portion government take represent of the total fraction.

Table VII: Results are derived from equation (1). The table shows OLS coefficients with ln of R_{LC-gov}(Return lifecycle – without government take) from 1950-2016 as dependent variable. Column (1) has control of corruption in 1996, level of schooling in 1996 and property rights in 1997 as independent variables. Column (2) adds the natural logarithm of GDP per capita in the first year of production as an additional independent variable. Column (3) adds fixed effects per year as a control variable. Column (4) adds adds reservoir size, measuring the size of total reserves in the field over its lifecycle, as a control measure of returns to scale. Column (5) adds the "onshore or offshore" dummy, as a control for natural given differences. Robust standard errors are reported in parenthesis. Significance: p<0.01 = ***, p<0.05 = **, p<0.10 = *

Panel A: ln R_{LC-gov} vs Property rights, Corruption and level of schooling under different specifications	(1)	(2)	(3)	(4)	(5)
Dependent variable = ln(R_{LC-gov})					
Level of schooling in 1996	-2.124*** (.138)	0.596*** (.139)	-1.499*** (.109)	0.023*** (.039)	-0.012*** (.039)
Control of corruption in 1996	0.333*** (.019)	0.478*** (.022)	0.266*** (.015)	0.045*** (.008)	0.045*** (.005)
Property rights protection 1997	0.548*** (.053)	0.225* (.055)	0.501*** (.038)	-0.015*** (.014)	0.015*** (.014)
Log of GDP per capita (first year of production)		-1.033*** (.049)	-0.118*** (.026)	-0.057*** (.013)	-0.060*** (.013)
Log of reservoir size				1.044*** (.008)	1.03*** (.008)
Onshore vs Offshore dummy					0.102*** (.013)
Fixed effects year			Yes	Yes	Yes
R^2	0.007	0.21	0.64	0.93	0.93
Number of assets	6550	6550	6550	6550	6550
Average number of assets per country	226	226	226	226	226
Average number of assets per year	101	101	101	101	101

3.6
Robustness Exercise IV: Running the regressions with different institutional variables

In this section I run the same regressions as in section 3.2, but with a different sample period (1996-2016) and, very importantly, with a different dataset of institutional quality variables. The institutional variables in this section are derived from the World Governance Indicators, created by the World Bank and span from 1996 to 2016.

The regression run is of the following form:

(8)

$$Y(\ln R_{LC})_{\text{Asset, First year of production of asset } i} = a + \beta_1 (Control\ of\ corruption)_{\text{Country, } 1996-2016} + \beta_2 (Government\ effectiveness)_{\text{Country, } 1996-2016} + \beta_3 (Political\ Stability)_{\text{Country, } 1996-2016} + \beta_4 (Regulatory\ Quality)_{\text{Country, First year of production of asset } i} + \beta_5 (lnReservoir\ Size)_{\text{Asset, First year of production of asset } i} + \beta_6 (Onshore\ vs\ Offshore\ dummy)_{\text{Asset, First year of production of asset } i} + i.(Fixed\ effect\ year) + \varepsilon_{\text{Asset } i}$$

The results are summarized in table VIII. Overall, the results indicate that these novel institutional factors were less statistically significant than the previous specifications, while the coefficients for reservoir size and offshore vs onshore dummy remain positive and large in magnitude. More specifically, the measures of control of corruption and regulatory quality are actually statistically insignificant, while political stability has a slightly negative and significant impact.

Table VIII: Results are derived from equation (1). The table shows OLS coefficients with ln of R_{LC} from 1996-2016 as dependent variable. Column (1) has control of corruption between 1996-2016, Government effectiveness 1996-2016, Political Stability 1996-2016 and regulatory quality 1996-2016 as independent variables. Column (2) adds the natural logarithm of GDP per capita in the first year of production as an additional independent variable. Column (3) adds fixed effects per year as a control variable. Column (4) adds adds reservoir size, measuring the size of total reserves in the field over its lifecycle, as a control measure of returns to scale. Column (5) adds the “onshore or offshore” dummy, as a control for natural given differences. Robust standard errors are reported in parenthesis. Significance: p<0.01 = ***, p<0.05 = **, p<0.10 = *

Panel A: ln R_{LC} vs Control of corruption, Government effectiveness, political stability and regulatory quality.	(1)	(2)	(3)	(4)	(5)
Dependent variable = R_{LC}					
Control of corruption 1996-2016	0.313** (.075)	0.313*** (.139)	0.202*** (.078)	-0.067 (.039)	-0.071 (.032)
Government effectiveness 1996-2016	-0.618*** (.063)	-.620*** (.022)	-0.424*** (.062)	0.207*** (.027)	0.206*** (.027)
Political Stability 1996-2016	0.186*** (.049)	0.178*** (.051)	0.151*** (.047)	-0.097*** (.020)	-0.079*** (.021)
Regulatory Quality 1996-2016	0.135 (.053)	0.259*** (.055)	0.108 (.050)	-0.001 (.021)	0.023 (.021)
Log of GDP per capita (first year of production)		0.200*** (.049)	-0.075*** (.018)	.0127*** (.009)	-0.013 (.009)
Log of reservoir size				0.974*** (.008)	0.969*** (.008)
Onshore vs Offshore dummy					0.145*** (.013)
Fixed effects year			Yes	Yes	Yes
R^2	0.03	0.05	0.23	0.87	0.93
Number of assets	4863	4863	4863	4863	4863
Average number of assets per country	168	168	168	168	168
Average number of assets per year	75	75	75	75	75

3.7
Relationship between average returns to capital and variance and assymetry of returns

As explained in the introduction, and in line with the results of Hsieh and Klenow (2008), one would expect poor countries to exhibit higher variance of returns to capital than rich countries. An intuitive way of understanding this is that the least productive firms in a developing nation are likely to be far less efficient than the least productive firms in a developed nation. On the other hand, the disparity between the most productive firms in a developing nation and the most productive firms in a developed nation is likely to be much smaller. If this reasoning holds true, one would thus expect the standard deviation of returns to capital in the oil and gas industry to be higher in less developed countries than in more developed countries. The standard deviation of returns is of course a direct way of verifying a risk component of an investment. Thus, if one finds that poor countries exhibit significantly higher standard deviation in returns, this may help rationalize why poor countries have higher *average* returns to capital. The standard deviation was calculated for each country and compared simply per income classification. Contrary to what was expected, however, the results, summarized in the bottom of table B, indicate that the standard deviation of returns is actually higher in high income countries than in low income countries. Certainly, the data does not indicate that returns are more volatile in low income countries than high income countries, as hypothesized.

Lastly, inspired by Klenow and Hsieh (2008), following the same line of reasoning as above, it was analyzed whether asymmetry in returns might help rationalize high returns to capita in poor countries. In other words, whether assets located in poor countries possess thicker tails in the distribution of returns to capital. For instance, one would expect that the difference in average returns to capital between the $90^{th}/10^{th}$ percentile of returns in a poor country to be larger than in rich countries. That is because one would expect a larger disparity in returns between highly competitive companies and weaker companies in less developed countries. The results, however, are counterintuitive to this logic and indicate that the disparity between the 90^{th} and 10^{th} percentile of assets is actually larger in rich countries than in poor countries, as may be observed in table C. Tables 16-18 in the appendix provide even more detailed information on standard deviation and the percentile ratios and even adds a second percentile ratio ($99^{th}/90^{th}$ percentile), with all this data telling the same story as elucidated above.

Table B: Standard deviation of returns to capital by income classification group

Income Classification	Return Ten SD	Return Twenty SD	Return Lifecycle SD
Low income	N/A	N/A	N/A
Low middle income	9.94	72.95	98.50
High middle income	122.45	206.68	656.50
High income	93.71	242.22	504.27

Table C: 90th / 10th percentile of returns to capital by country and income classification group. There seems to be no correlation between the income classification and the tails of the return distribution.

Income Classification	Return Ten 90th/10th per.	Return Twenty 90th/10th per.	Return Lifecycle 90th/10th per.
Low income	N/A	N/A	N/A
Low middle income	8.63	9.71	58.15
High middle income	35.18	29.99	43.72
High income	20.43	15.24	67.90

Table D: Correlation between returns to capital and Offshore/Onshore dummy. Shows that Onshore assets have significantly higher average returns to capital than offshore assets.

Variables	(1) Return Ten	(2) Return Twenty	(3) Return Lifecycle
OnOff dummy	-8.972	-23.46**	-279.7***
	(8.205)	(9.404)	(15.74)
Constant	18.80***	52.44***	311.4***
	(4.501)	(7.691)	(15.59)
Observations	9,908	9,908	9,908
R-squared	0.000	0.000	0.014

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

4
Discussion of results

4.1
Discussion of results

When running multivariate regressions of the *log* of GDP per capita against the log of returns to capital in section, all specifications in section 3 indicate a negative correlation, as hypothesized. However, the miniscule economic significance certainly deserves to be highlighted. The GDP per capita of the country in which an asset is located is not an important predictor of returns to capital. By comparison, whether an asset is located onshore or offshore (a purely geological factor) is far more relevant for the magnitude of the returns under all specifications and sample periods. The size of the hydrocarbon reserves in also a far more important determinant of returns to capital in the oil and gas industry from 1950 to 2016 under all specifications and sample periods. Furthermore, some institutional factors, namely, level of corruption, level of schooling and property rights protection possess a statistically significant and positive correlation with returns to capital, also as hypothesized. Nevertheless, as was the case with GDP per capita, even though robust statistical correlations were identified, the correlations were without exception economically quite insignificant in terms of incremental R-squares.

One may contemplate several potential explanations for the above-mentioned lack of strong correlations between returns to capital and institutional quality. To begin with, an important argument is that these rates of return to capital are, as Caselli and Feyrer (2008) highlighted, so-called “non-reproducible rates of capital”. For example, the type of rock formations, reservoir quality (porosity, permeability and the existence of trap) and weather conditions are all factors that determine the potential revenue (and thus returns to capital) of an oil and gas asset. Hence, even when holding constant the size of the reservoir and whether the asset is located onshore or offshore, as is done in this thesis, there are still a plethora of factors affecting returns to capital that are not country-specific, but rather geologically determined. As such, this represents an important potential source of omitted variable bias.

Secondly, an important reason that may help explain why returns to capital are largely independent of country specific variables is that only realized projects are included in the data. Therefore, capital investments in assets that were not completed due to high risk or low expected returns are not incorporated in the data. Since one would expect less developed countries with weaker institutions to be characterized by higher risk than rich countries, this could be a source for overestimating the actual returns in poor countries. In other words, a project that has a marginally positive expected return to capital (and would thus decrease the average returns in that country) in a poor country would not be completed due to higher inherent risk. If a geologically similar project were evaluated in a developed nation, that project could potentially be completed. This is of course speculative and not observable in the data, but it is consistent with financial theory, in particular net present value and discount factor theory.

Finally, this thesis finds no evidence that poor countries possess a higher standard deviation or asymmetry of returns to capital than richer countries in the oil and gas industry from 1950 to 2016. As stated in the introduction, the standard deviation and asymmetry of returns were factors that could potentially help rationalize the difference in returns to capital between poor and rich countries. My data (counter-intuitively) shows that both the variance and asymmetry are actually largest in middle-income countries and lowest in lower-middle income countries. In other words, according to this data, they are not valid or important factors that may rationalize returns to capital differentials. Supplementary details on asymmetry can be found in tables 17 and 18 in the appendix.

4.2
Limitations and assumptions

A fundamental assumption is that under conditions approximating perfect competition in the global capital market, the marginal productivity to capital is equal to the rate of return to capital. This is an assumption used by Feyrer and Caselli (2008), which has also been applied in this thesis. It is of course not entirely realistic, but given the global nature of the oil and gas industry, it might not be an excessive abstraction, and it is difficult to imagine how the assumption would create systemically biased results.

Moreover, the sole manner of controlling for geological differences in this study is through controlling for the water depth of the oil and gas asset. Albeit important, this is, however, likely to be an insufficient way of controlling for geological differences between countries. Other geological characteristics are very likely to affect the rates of return to capital. This includes, but is not restricted to, the type of rock formation, porosity, permeability, etc. Future studies could try to hold these factors constant and verify whether this fundamentally changes the rate of return differentials between poor and rich countries.

Another limitation of this thesis is the small sample size of countries. However, this is partly justified by the fact that there simply is not a vast amount of countries with significant historical production of oil and gas and that countries with insignificant amounts of production would be more prone to measurement errors and less precise estimates of variance and asymmetry in returns.

5
Conclusion

This thesis provides robust evidence demonstrating that poorer countries enjoyed significantly higher returns to capital than richer countries, in the oil and gas industry between 1950–2016. Although the results are not particularly economically significant, this finding is in accordance with what was hypothesized. Furthermore, the findings providee evidence that certain institutional factors such as property rights protection, level of corruption and level of schooling possess a positive and statistically significant correlation with returns to capital, whilst some other institutional measures tested were not statistically significant under all specifications. Lastly, neither variance nor asymmetry in returns look like plausible explanations for returns to capital in the oil and gas industry, since they are both, differently than hypothesized, lower in poor countries than rich countries.

The findings in this thesis are important for several reasons. From a theoretical standpoint, the largely insignificant magnitude of country-specific variables (as opposed to factors related to the characteristics of the assets) highlights the importance of adapting economic development theory to account for sector-specific differences, for example by distinguishing between reproducible and non-reproducible returns to capital, as emphasized by Feyrer and Caselli (2008). Lastly, from a practical viewpoint, the results indicate that oil and gas operators considering making investments in an oil and gas asset should not be particularly concerned with neither the stage of development nor the institutional quality of the country in which the asset is located (perhaps, and most likely, with the exception of very high levels of corruption, big risk of expropriation or very low levels of schooling). Future studies could further explore forms of controlling for additional geological factors besides the water depth of the assets, and, additionally, look for more robust ways of testing which the validity and magnitude of institutional measures.

6
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7
Appendix

Table 6.1: Correlation between log of returns to capital and GDP per capita. Shows a non-robust relationship.

Variables	(1) Log Return Ten	(2) Log Return Twenty	(3) Log Return Lifecycle
GDP per capita (IHME)	3.95e-06***	7.68e-07	-8.05e-06***
	(1.22e-06)	(1.28e-06)	(2.12e-06)
Constant	1.823***	2.580***	3.273***
	(0.0231)	(0.0239)	(0.0318)
Observations	4,081	4,023	3,968
R-squared	0.003	0.000	0.006

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 6.2: Correlation between log of returns to capital and log of GDP per capita. For return twenty and return lifecycle one may see that assets located in countries with lower GDP do indeed exhibit (slightly) higher returns to capital.

Variables	(1) Log Return Ten	(2) Log Return Twenty	(3) Log Return Lifecycle
Log of GDP per capita (IHME)	-0.00799	-0.0446***	-0.163***
	(0.00994)	(0.0108)	(0.0128)
Constant	1.930***	2.943***	4.475***
	(0.0820)	(0.0870)	(0.103)
Observations	4,081	4,023	3,968
R-squared	0.000	0.004	0.033

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Summary of correlations between returns to capital measures and various measures of institutional quality (Significant and robust results are reported in more detail in separate tables)

Variable	Log Return Ten	Log Return Twenty	Log Return Lifecycle
Bureaucratic delays	0.0115	-0.0228***	-0.0140
Infrastructure quality	0.00760	-0.00932*	0.00919
Corruption level (see table 7)	**0.0228*** **	**0.0342*** **	**0.0877*** **
Tax Evasion	0.0819***	-0.0133	-0.133***
Level of Schooling (see table 8)	**0.101*** **	**0.0852*** **	**0.302*** **
Adult illiteracy rate (see table 9)	**0.0146*** **	**0.00911*** **	**0.00690*** **
Av.Gov.wages/GDP per cap (see table 10)	**0.113*** **	**0.0880*** **	**0.103*** **
Political rights index	-0.0235***	-0.0137**	0.00767
Democracy Score	0.0108***	0.00519*	0.0152***
Property Rights Index (see table 11)	**0.0240** **	**0.0185* **	**0.0509*** **
Business Regulation Score (see table 12)	**0.0552*** **	**0.0532*** **	**0.108*** **

*** p<0.01, ** p<0.05, * p<0.1

Table 8: Correlation between returns to capital and Level of corruption

	(1)	(2)	(3)
Variables	Log Return Ten	Log Return Twenty	Log Return Lifecycle
Corruption level	0.0228***	0.0342***	0.0877***
	(0.00524)	(0.00579)	(0.00878)
Constant	1.688***	2.384***	2.780***
	(0.0404)	(0.0432)	(0.0606)
Observations	8,136	8,079	7,963
R-squared	0.002	0.004	0.013

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9: Correlation between returns to capital and Level of schooling

	(1)	(2)	(3)
Variables	Log Return Ten	Log Return Twenty	Log Return Lifecycle
Level of schooling	0.101***	0.0852***	0.302***
	(0.0260)	(0.0277)	(0.0376)
Constant	1.597***	2.416***	2.761***
	(0.0537)	(0.0568)	(0.0733)
Observations	6,955	6,897	6,792
R-squared	0.002	0.001	0.007

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 10: Correlation between returns to capital and Adult illiteracy rate

	(1)	(2)	(3)
Variables	Log Return Ten	Log Return Twenty	Log Return Lifecycle
Adult illiteracy rate	0.0146***	0.00911***	0.00690***
	(0.00127)	(0.00140)	(0.00179)
Constant	1.454***	2.380***	3.104***
	(0.0396)	(0.0438)	(0.0534)
Observations	3,669	3,612	3,576
R-squared	0.033	0.012	0.004

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 11: Correlation between returns to capital and Av.Gov.wages/GDP per capita

Variables	(1) Log Return Ten	(2) Log Return Twenty	(3) Log Return Lifecycle
Av.Gov.wages/GDP per cap	0.113***	0.0880***	0.103***
	(0.0220)	(0.0227)	(0.0276)
Constant	1.625***	2.503***	3.420***
	(0.0332)	(0.0333)	(0.0370)
Observations	6,823	6,824	6,734
R-squared	0.004	0.002	0.002

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 12: Correlation between returns to capital and Property rights index

Variables	(1) Log Return Ten	(2) Log Return Twenty	(3) Log Return Lifecycle
Property rights index	0.0240**	0.0185*	0.0509***
	(0.0101)	(0.0107)	(0.0148)
Constant	1.716***	2.549***	3.250***
	(0.0418)	(0.0431)	(0.0550)
Observations	9,708	9,652	9,531
R-squared	0.001	0.000	0.001

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 13: Correlation between returns to capital and Business regulation index

Variables	(1) Log Return Ten	(2) Log Return Twenty	(3) Log Return Lifecycle
Business regulation index	0.0552***	0.0532***	0.108***
	(0.0120)	(0.0128)	(0.0176)
Constant	1.639***	2.456***	3.114***
	(0.0395)	(0.0409)	(0.0512)
Observations	9,708	9,652	9,531
R-squared	0.002	0.002	0.004

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 14: Summary of correlations between returns to capital measures and the world bank's dataset of institutional quality between years 1996-2016.

Institutional Variable	Log Return Ten	Log Return Twenty	Log Return Lifecycle
Control of corruption	0.0521***	0.0281***	0.0115
Government Effectiveness	0.0538***	-0.00501	-0.0563***
Corruption level	0.103***	0.0770***	0.0142
Political Stability	0.0567***	0.0196	-0.00157

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 15: Shows the three different average returns to capital of all assets in each country and income group in detail.

COUNTRY	Return Ten Average	Return Twenty Average	Return Lifecycle Average
United Arab Emirates	15.87	51.28	507.19
Angola	8.87	14.51	23.09
Argentina	15.31	46.62	66.82
Australia	9.23	27.08	23.97
Azerbaijan	5.95	13.61	69.04
Brazil	11.78	35.80	494.87
Chile	6.58	14.84	32.06
China	12.45	25.52	66.10
Congo	7.30	17.15	21.10
Denmark	13.72	73.79	45.70
Algeria	115.87	193.80	327.85
Egypt	0.55	1.20	114.49
Great Britain	11.14	70.74	23.65

Indonesia	10.69	24.12	56.48
India	9.41	26.38	61.46
Iraq	11.85	22.18	115.16
Iran	83.78	166.42	590.50
Kuwait	16.50	34.83	470.26
Libya	10.58	25.16	82.80
Mexico	-1.09	-3.04	-4.20
Malaysia	11.08	48.64	24.06
Nigeria	12.63	30.45	105.06
Norway	11.49	23.54	29.10
Qatar	16.50	29.85	65.95
Saudi Arabia	11.29	33.91	497.26
Venezuela	6.07	14.65	125.15
Canada	39.49	132.67	934.19
Russia	10.47	28.00	74.21
United States	8.65	17.84	52.00
Lower income	**N/A**	**N/A**	**N/A**
Lower middle income	**8.65**	**23.21**	**56.93**
High middle income	**26.77**	**52.21**	**206.77**
High income	**14.65**	**46.42**	**242.64**

Table 16: Shows the standard deviation of returns to capital by country and income classification group

COUNTRY	Return Ten SD	Return Twenty SD	Return Lifecycle SD
United Arab Emirates	15.38	90.14	1403.46
Angola	6.97	18.37	30.09

Argentina	68.22	150.62	140.66
Australia	8.71	87.61	52.31
Azerbaijan	6.93	14.84	65.50
Brazil	19.72	78.44	2344.13
Chile	4.28	28.69	69.82
China	11.61	24.16	153.83
Congo	25.81	69.30	33.75
Denmark	16.01	201.52	40.08
Algeria	964.68	1524.31	1792.87
Egypt	0.68	1.48	160.61
Great Britain	9.18	862.42	37.89
Indonesia	9.68	60.55	149.19
India	7.70	36.79	103.97
Iraq	14.97	26.32	180.30
Iran	149.78	276.45	1067.73
Kuwait	21.68	33.76	382.60
Libya	9.09	21.03	101.82
Mexico	3.00	7.76	14.85
Malaysia	9.28	286.03	21.58
Nigeria	9.49	38.09	145.38
Norway	14.15	32.13	37.56
Qatar	16.00	22.61	50.41
Saudi Arabia	13.72	37.75	721.64
Venezuela	9.09	16.58	137.91
Canada	924.58	1300.15	2307.56
Russia	35.61	76.86	119.12
United States	12.65	59.44	366.06

Low income	**N/A**	**N/A**	**N/A**
Low middle income	**9.94**	**72.95**	**98.50**
High middle income	**122.45**	**206.68**	**656.50**
High income	**93.71**	**242.22**	**504.27**

Table 17: Shows the 90th / 10th percentile of returns to capital in more detail and by country and income classification group.

COUNTRY	Return Ten 90th/10th per.	Return Twenty 90th/10th per.	Return Lifecycle 90th/10th per.
United Arab Emirates	11.27	11.77	56.11
Angola	5.67	7.24	14.67
Argentina	19.85	21.76	76.62
Australia	9.04	13.19	12.77
Azerbaijan	196.39	115.00	18.18
Brazil	12.30	13.71	138.17
Chile	4.71	6.79	10.50
China	13.48	13.62	23.14
Congo	5.96	8.13	14.97
Denmark	9.54	12.54	38.86
Algeria	16.81	12.66	35.07
Egypt	14.65	15.12	266.03
Great Britain	8.55	10.32	15.20
Indonesia	11.39	10.56	18.56
India	7.60	8.04	22.62
Iraq	14.15	22.60	32.45
Iran	50.83	71.59	106.68
Kuwait	106.33	14.63	9.69

Libya	9.73	10.70	37.87
Mexico	-0.36	-0.17	-0.59
Malaysia	7.36	9.43	26.34
Nigeria	7.78	9.43	43.89
Norway	5.45	11.27	23.85
Qatar	14.10	12.12	12.97
Saudi Arabia	27.92	26.67	32.50
Venezuela	15.51	18.99	18.28
Canada	15.81	29.98	507.33
Russia	22.97	21.22	27.93
United States	12.63	11.80	18.40
Low income	**N/A**	**N/A**	**N/A**
Low middle income	**8.63**	**9.71**	**58.15**
High middle income	**35.18**	**29.99**	**43.72**
High income	**20.43**	**15.24**	**67.90**

Table 18: Shows the 99th / 90th percentile of returns to capital in more detail and by country and income classification group.

COUNTRY	Return Ten 99th/90th per.	Return Twenty 99th/90th per.	Return Lifecycle 99th/90th per.
United Arab Emirates	2.33	5.92	9.15
Angola	2.46	5.57	3.82
Argentina	15.16	8.10	2.62
Australia	2.15	8.17	6.63
Azerbaijan	1.64	1.64	2.14
Brazil	4.16	6.96	113.67
Chile	2.48	8.42	7.74

China	2.27	1.85	5.00
Congo	4.46	8.49	3.74
Denmark	2.01	8.86	1.49
Algeria	38.51	26.24	5.43
Egypt	1.00	1.00	1.00
Great Britain	1.91	3.64	6.03
Indonesia	1.83	3.23	4.74
India	1.97	3.21	4.20
Iraq	4.31	2.17	2.54
Iran	3.77	2.87	3.58
Kuwait	1.21	1.17	1.25
Libya	2.28	1.67	1.86
Mexico	1.67	2.50	5.37
Malaysia	2.08	11.71	2.25
Nigeria	1.71	2.47	2.98
Norway	5.68	4.53	4.06
Qatar	1.71	1.62	1.14
Saudi Arabia	1.88	1.25	4.16
Venezuela	4.15	2.40	2.31
Canada	2.86	7.48	2.55
Russia	2.79	4.00	3.14
United States	3.10	3.72	9.66
Low income	**N/A**	**N/A**	**N/A**
Low middle income	**2.22**	**5.10**	**3.25**
High middle income	**6.55**	**5.23**	**14.50**
High income	**3.54**	**5.24**	**4.71**

Table 19: Descriptive statistics for the measures of GDP per capita from IMHE (Given in USD and normalized to 2005 and PPP) from 1950 to 2016.

COUNTRY	Average	SD	Minimum	Maximum
United Arab Emirates	56193	14625.23	34652	80779
Angola	3811	1383.719	1988	6123
Argentina	8852	1883.721	5469	16179
Australia	29601	7452.065	10679	41723
Azerbaijan	3740	2590.375	846	11421
Brazil	7125	2346.822	2259	11808
Chile	8555	4151.68	3413	15662
China	4341	3103.167	206	10467
Congo	3134	618.2883	1225	3714
Denmark	23192	8576.685	9547	36738
Algeria	5100	1263.975	2744	7624
Egypt	2829	1528.004	1112	6471
Great Britain	27679	6431.241	10107	35613
Indonesia	2354	1176.747	575	5178
India	1878	1119.193	541	4354
Iraq	4588	1423.372	2028	9296
Iran	7403	2352.306	2744	11137
Kuwait	60672	29021.88	23930	115403
Libya	18134	7335.086	3665	32449
Mexico	9115	2846.069	3900	14756
Malaysia	747	381.4898	154	1269
Nigeria	1590	410.2086	986	2551
Norway	36264	14030.08	10033	51644
Qatar	85291	23045.21	45958	124998

Saudi Arabia	18202	7081.96	5453	31696
Venezuela	8972	1170.762	6747	12106
Canada	24005	8531.667	11180	38229
Russia	10247	3070.476	4964	16944
United States	28218	7612.025	13168	48242