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No Evidence of an Oil Curse

Natural Resource Abundance, Capital Formation and Productivity

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Abstract

This chapter examines the relationship between labour productivity, capital formation, and natural resource extraction in countries with natural resource reserves. We develop a theoretical two-sector model for a closed economy that maximises consumption over time, and examine how the control variables – natural resource extraction and the savings rate – determine fixed capital investment. We find that in a closed economy, the overall labour productivity is a positive function of capital investment per labour. That is in turn related to the externally given natural resource price, natural resource reserves and the resource extraction ratio. High natural resource prices and extraction rates provide opportunities to increase the overall investment in fixed capital and thus boost the labour productivity.

We empirically test this model for oil as a natural resource. The data covers 36 years from 1980 to 2015 and includes 149 countries. 85 of these countries possessed commercially recoverable oil reserves in at least a part of the time period covered. We are able to exploit the panel and carry out the estimation using two-way fixed effects. We observe that oil price has an overall positive impact on labour productivity growth in the modern sector. The savings rate and schooling are positively correlated to labour productivity growth as well as fixed capital formation per capita. We find that the oil sector variables – oil reserves and oil extraction ratio – do not contribute to labour productivity growth directly, rather through increased capital formation per capita.

An important finding is that higher oil prices lead to increased fixed capital formation per capita. We also observe, while accounting for time period fixed effects and country-level heterogeneities, that countries with larger oil extraction ratios have higher fixed capital formation per capita. We do not observe a statistically significant relationship between

higher oil reserves ratio and fixed capital formation. However, we find that countries with larger oil reserves are found to have higher fixed capital formation during higher oil price periods. Simply put, higher oil revenues are related to greater investments into fixed capital. There are other mechanisms for higher fixed capital formation in oil extracting countries during high oil price periods that have not been considered here. One such mechanism may be that high oil prices increase the desirability of oil rich countries as a destination for foreign direct investments (FDI). The determination of the mechanism for the impact of high oil prices on non-oil economies is beyond the scope of this chapter and thesis. However, for non-oil economies, a positive relationship may be driven by FDI from oil-rich countries, increased exports of capital goods and consumption goods (and services) to oil-rich countries, and/or innovation in non-oil economies to counter the effects of reduced marginal returns because of increased energy costs per unit produced.

We find that the oil rich countries of the Gulf Cooperation Council (GCC) are able to exploit high oil prices and invest into fixed capital owing to their relatively large oil reserves per capita. Qatar is the most successful among the GCC countries in diverting its natural resource wealth towards fixed capital formation. The results indicate that natural resources by themselves do not constitute a curse. Countries with large natural resource reserves per capita can use their natural resource outputs to increase overall fixed capital formation. Investment into fixed capital in turn leads to higher labour productivity growth. We find that increasing the efficiency of the production systems through improved schooling can also lead to higher fixed capital formation and labour productivity growth in the modern sector. As such smart management of natural resources can support diversification of the economy. The so-called "natural resource curse" originates not in "simply having" natural resources. It is rather a result of mismanagement of natural resource rents that leads to lower productivity in the modern sector. There is no evidence that natural resource rich countries are more or less prone to mismanage their rents.

Keywords: structural change, natural resource curse, GCC, theoretical modelling, empirical application, capital formation

JEL Classification: E21, E24, O13, O47, Q32

1. Introduction

Countries rich in natural resources have been concerned about the extractive nature of their economies. The most important assets of these countries – natural resources – have not always been valued highly at world markets. After the 1970s and 1980s the world witnessed periods of high natural resource prices, but the volatility has remained high. For example, for hundred years before 1973, oil had stayed at around 20 USD per barrel in constant 2010 prices. It then went as high as 100 USD a barrel by 1980 and as low as 30 USD by 1989. By 1999 the oil prices had fallen to 15 USD per barrel. The 2000s saw oil prices as high as 130 USD and as low as 30 USD per barrel. The other natural resources followed similar patterns. The policy makers in the natural resource rich countries have long desired to diversify and move away from their heavy dependence on natural resources. Diversification has been on their agenda for three to four decades. Despite this effort, many natural resource rich countries have failed to diversify (van der Ploeg, 2011). In this chapter we explore if this failure to diversify is evident of a natural resource curse.

In recent years, the focus on the "natural resource curse" research has led to the consensus that the curse is highly context-specific. The curse is best described as a lowering of labour productivity with an increase in revenues from the extraction of natural resources. The literature emphasises the complexities and conditionalities of the curse. This has led to a notion that the curse is not given but is rather a result of the specific policies and the conditions of the ecosystem in which the institutions exist. The presence and intensity of the resource curse depends on the types of resources, socio-political institutions and the linkages with the rest of the economy (Papyrakis, 2017). In this chapter, we focus on the relation between natural resource extraction and productivity.

Richard M. Auty (2007) argues that the models formulated in the mid-twentieth century, like the Cobb-Douglas and Harrod-Domar models, did not adequately account for the role of natural resources in the economy. We aim to estimate the dynamics of capital formation and the decision factors in oil extraction and investment. We start from the following premise: If the use of non-renewable extractive natural resources such as oil, gas, and minerals does not lead to the accumulation of other forms of productive capital, but instead is used to support only consumption, there will be no income-generating assets to replace it when it is exhausted (Canuto & Cavallari, 2012).

We develop a two-sector closed economy theoretical model with the natural resource sector and modern sector being the only two sectors in the economy. The decision variable (control) for the natural resource sector is limited to the natural resource extraction ratio. The second control variable is the savings ratio: the percentage savings from the income generated by the modern sector and the natural resource sector, leaving the rest for consumption. These savings are assumed to be invested into fixed capital. Next, we explore the empirical application of the theoretical model with oil as a natural resource, using data covering a period of 36 years and 149 countries. We impute the productivity and investment estimations using time period and country fixed effect. Accounting for time period fixed effects as well as individual country level heterogeneities enables us to comment on the causal mechanisms related to labour productivity growth in modern sector and fixed capital formation. Also, we are able to make additional inferences about the productivity and fixed capital formation in the individual Gulf Cooperation Council (GCC) countries.

The chapter is structured as follows. In section 2, we present a brief review of the relevant literature. In section 3, we develop the theoretical model. Then, we describe the empirical model, data, data reliability, results and post-estimation tests in sections 4 to 8, respectively. Finally, we summarise our main findings, discuss the limitations of this chapter and propose an outlook into future research avenues in section 9.

2. Literature Review

Academics studying the natural resource-based economies have argued varyingly whether these countries are cursed or blessed (van der Ploeg, 2011). The resource curse thesis "interprets a mineral boom as a net economic loss, where the present value of the positive effects of the boom is more than offset by the present value of the negative effects." (Davis, 1995, p. 4). It is also argued that the wealth resulting from natural resources should lead to prosperity as rents from natural resources can lead to government investment in public goods, infrastructure, and other development project expenditures. Such investment would not have been possible if these resources would not have been available. The welfare improving nature of resource-based development is often recognised as a consequence of a new equilibrium with higher incomes and higher consumption. Albeit so, to a great extent the increase in consumption of goods and services is based upon increased imports. There is historical evidence that the development in several European countries and United States of America (US) followed a similar natural resource-based trajectory (Lederman & Maloney, 2008). This is represented in the work of Alan Gelb and Associates as, "there is evidence that, at least in some cases, high-rent activities… have provided an important stimulus to growth" (Gelb & Associates, 1988, p. 33).

The discussion in literature shows that the short-term gains in welfare are often at the expense of long-term growth. Jeffery Sachs and Andrew Warner (1995) have presented a model for this discrepancy between long term and short term gains of natural resource richness based on the concept that manufacturing and non-resource tradable goods and services are better for growth due to their characteristic learning by doing effects and positive technological spill-overs. However, Lederman and Maloney (2007) not only question the robustness of the resource curse finding on econometric grounds but also question the validity of the argument that the natural resource sector is inferior to manufacturing in its growth enhancing characteristics. Many scholars have been critical of an idea of resource-based development, including Prebisch (1959), Singer (1950), Richard M. Auty (2001), and Jeffrey Sachs and Andrew Warner (2001). However, data from Maddison (1994) shows that from 1913 to 1950, resource rich countries grew faster than the industrialised countries (Ferranti, et al., 2002). Also, Maloney et al. (2002) and Stijns (2005) find no negative association between resource abundance and growth. The argument on whether resources are an actual curse to nations' development has come around to a point where it is considered that the curse essentially lies in the management or rather mismanagement of the resource revenues (Amuzegar, 1982, pp. 817-821; Levy, 1978; Davis, 1995, pp. 1773-1776), and thus can be avoided by learning and sound policy implementation (Stijns, 2005).

A review of the natural resource curse studies by Papyrakis (2017) concludes that the presence or absence of the resource curse is dependent on the type of resources, socio-political institutions and linkages with the rest of the economy. Good institutions that ensure property rights protection can discourage rent-seeking behaviour in mineral-rich contexts and hence prevent the resource curse phenomena and stimulate economic development (Boschini, et al., 2007; Sarmidi, et al., 2014). The central message is that good institutions in the form of secure property rights, efficient bureaucracies and low levels of corruption, ensure better natural resource sector output management and can turn the curse into a blessing (Anshasy & Katsaiti, 2013; Mehlum, et al., 2006).

The inability of the neo-classical growth models to account for the role that natural resources play in a country's path towards economic growth and stability has been highlighted, among others, by Sachs & Warner (1995) and Auty (2007). In an attempt to introduce non-renewable resources in addition to labour and capital in the neo-classical model, Henry Thompson does not find evidence of natural resource rent contribution to maintaining a stable per capita income (Thompson, 2012). Even though the majority of the countries in the world rely on natural resources for meeting their economic objectives to a considerable extent, we also find that theoretical models accounting for natural resource sector are rare. Keeping in mind this critical limitation in the literature, we have attempted to construct a theoretical model that accounts for natural resource output in the total economic output that is either consumed or saved for investment in fixed capital. In addition to that we explore the empirical application of the theoretical model that we develop. In order to do this, we build upon the literature that focuses on the mechanisms and policies that create a robust economy through investments from the natural resource sector. In the following section, we present the model accommodating the decision factors in oil extraction and investment into fixed capital.

3. **Modelling the relationship between natural resource extraction and investment in capital**

We consider a two-sector economy where the total output is the sum of output of the natural resource sector and the non-natural resource sector. The output of the non-natural resource sector (Barro & Salai-i-Martin, 2004) is given by,

$$Q = K^{\alpha} A L^{1-\alpha} \quad (1)$$

Where Q is the output of the non-oil sector, K is the total capital in the non-oil sector, L is the labour force in the economy. Assuming constant growth of labour,

$$\dot{L} = \beta L \quad (2)$$

A is the efficiency parameter and is often considered to be the absorptive capacity of the economy. It is considered exogenous in this equation and represents the efficiency with which the capital and labour is converted to output. The output elasticity of the capital is represented by α. It is the responsiveness of output to a change in the level of capital used in production, ceteris paribus. For example, if α = 0.75, a 1% increase in capital usage would approximately lead to a 0.75% increase in output. The output elasticity of labour is 1 - α. The growth rate of labour is β.

Dividing Equation 1, $Q = AK^{\alpha}L^{1-\alpha}$, by L on both sides we get:

$$\frac{Q}{L} = A\left(\frac{K}{L}\right)^{\alpha} \quad (3)$$

Let q be defined as total output per labour and k be defined as total capital per labour in the economy,

$$q = \frac{Q}{L} = Ak^{\alpha} \quad (4)$$

Where, $$k = \frac{K}{L} \quad (5)$$

Let us consider the example of the oil sector as the only natural resource sector in the economy. R represents the producible oil reserves in constant price equivalent of barrels. In such case, the change in the natural resource reserves is given by the total reserves extracted (Hoel, 2015).

$$O = -\dot{R} \quad (6)$$

Where O is the oil extraction expressed as the total number of barrels produced (evaluated in constant prices; note that in case of other natural resources, this is simply the total units of the natural resource produced, evaluated at constant prices). With an externally given price of oil P_{oil} and the total producible reserves of oil in barrels $R_{bbl,}$ the producible oil reserves in constant price equivalent of barrels are given as $R = P_{oil}.R_{bbl.}$ Also, the extracted reserves are a fraction of the total reserves. This fraction is given by 'o' and is called the natural resource extraction ratio

$$O = oR \quad (7)$$

Dividing on both sides with L we get,

$$\frac{O}{L} = \frac{oR}{L} \quad (8)$$

Let q_{oil} be defined as total output of the oil sector per labour and r be defined as total producible oil reserves per labour in the economy,

$$q_{oil} = \frac{O}{L} = \frac{oR}{L} = or \quad (9)$$

Where, $$r = \frac{R}{L} \quad (10)$$

Taking the derivative with respect to time, we obtain the change in reserves per labour as follows:

$$\dot{r} = \frac{\dot{R}}{L} - \beta r$$

$$= -(o + \beta)r \quad (11)$$

Combining equation 4 and 9, the total output of the economy per labour is given by:

$$y = q + q_{oil}$$

$$= Ak^{\alpha} + or \quad (12)$$

The change in the capital stock in the economy is driven by depreciation of the capital stock and new investment. Assuming δ is the depreciation rate of capital and 'I' is the total new investment into the non-oil sector of the economy,

$$\dot{K} = I - \delta K \quad (13)$$

'I' is a function of the total output and the savings rate for the economy, as given by,

$$s = {S}/{Y} \quad (14)$$

where S is total saving and S=I

$$I = sY \quad (15)$$

Dividing by L on both sides gives us,

$$i = sy \quad (16)$$

Where,

$$i = \frac{I}{L} \quad (17)$$

And,

$$y = \frac{Y}{L} \quad (18)$$

Given Equation 12 and 16:

$$i = s(Ak^{\alpha} + or) \quad (19)$$

With total output of the economy given as Y = Q + O

$$\dot{K} = sAk^{\alpha}L - soR - \delta kL \qquad 20$$

Also, taking derivative of $k = \frac{K}{L}$ with respect to time:

$$\dot{k} = sAk^{\alpha} - sor - (\delta + \beta)k \qquad 21$$

Let consumption of the population be given by c, that is the total output of the economy excluding investment per labour,

$$c = y - i \qquad 22$$

Putting y and i from Equations 12 and 19 in this equation we get:

$$c = Ak^{\alpha} + or - s(Ak^{\alpha} + or) \qquad 23$$

$$c = (1 - s)(Ak^{\alpha} + or) \qquad 24$$

Presenting Equation 11 and 21,

$$\dot{r} = -(o + \beta)r$$

$$\dot{k} = sAk^{\alpha} - sor - (\delta + \beta)k$$

The Hamiltonian function can be setup as follows to maximise consumption per capita accounting for per capita changes in capital and oil reserves (Barro & Salai-i-Martin, 2004):

$$H = c + \lambda_1\dot{k} + \lambda_2\dot{r} \qquad 25$$

$$H = (1 - s)(Ak^{\alpha} + or) + \lambda_1[sAk^{\alpha} - sor - \delta(k + \beta)k] - \lambda_2(o + \beta)r \qquad 26$$

Since the technological change is exogenous, oil price P_{oil} is given externally and total reserves in barrels per effective labour is given as r_{bbl}. Substituting for $r = P_{oil}.r_{bbl}$, we have four equations by taking partial derivative of the Hamiltonian with respect to the control and state variables:

$$\frac{\partial H}{\partial s} = -(Ak^{\alpha} + oP_{oil}r_{bbl}) + \lambda_1(Ak^{\alpha} + oP_{oil}r_{bbl}) \qquad 27$$

$$\frac{\partial H}{\partial o} = (1-s)P_{oil}r_{bbl} - \lambda_1 sP_{oil}r_{bbl} - \lambda_2 P_{oil}r_{bbl} \quad 28$$

$$\frac{\partial H}{\partial k} = (1-s)A\alpha k^{\alpha-1} + \lambda_1(sA\alpha k^{\alpha-1} - \delta - \beta) \quad 29$$

$$\frac{\partial H}{\partial r_{bbl}} = (1-s)oP_{oil} + \lambda_1 so - \lambda_2(o+\beta) \quad 30$$

There is no analytical solution to this utility maximisation problem involving a fixed capital driven sector and the extractive natural resource-based sector. Our purpose here is to understand the nature of the relationship between oil sector variables and productivity growth in the modern sector through savings invested in fixed capital. Computational solution for parameters can be carried out to explain the dynamics of the economy through sound reasoning. Given the time limitations, unfortunately, such an exercise remains out of scope for this dissertation. A useful exercise is to have separate controls for savings in extractive sector and fixed capital driven sector where the oil sectors saving rate is connected to either the technological state of the economy or the level of fixed capital. This is because of two reasons. Firstly, the oil extraction decision is not a yes or no decision but in reality, is related to the technological state of economy. In reality, technological advances such as "Enhanced Oil Recovery"[1] can be used to increase the extraction ratios as well as the total extractable oil reserves. Secondly, investments the in modern sector are expected to be more productive in economies with higher absorptive capacity or technological state. Countries are more likely to invest more of their natural resource sector rents into the modern sector when they have higher absorptive capacity. Without such absorptive capacity their capital investments are likely to be inefficient.

In equation 27, we observe that the change in consumption/savings per unit of output is a function of the productive efficiency of the economy (A), the fixed capital per labour (k), oil extraction ratio (o), the price of oil (P_{oil}) and the oil reserves per labour (r_{bbl}). In equation 29, we observe that the change in fixed capital per labour is a function of the productive

[1] Enhanced oil recovery (EOR), also called tertiary recovery, is the extraction of crude oil from an oil field that cannot be extracted without using EOR advancements. EOR can extract 30% to 60% or more of a reservoir's oil, compared to 20% to 40% using primary and secondary recovery.

efficiency of the economy (A), the fixed capital per labour (k) and the savings per unit of output (s). Equations 28 and 30 show that the oil reserves per capita (r_{bbl}) and oil extraction ratio (o) are endogenous and related to the savings rate per unit of output (s) and the exogenously given price of oil (P_{oil}).

The change in the stock of fixed capital per labour is as such a function of the initial fixed capital stock (k_o), the efficiency of the economy (A), the extraction ratio of oil (o), the total oil reserves per labour (r_{bbl}), the price of oil (P_{oil}) and, the savings rate (s). The savings rate (s) determines the total contribution of the output of the economy towards the fixed capital formation. The savings per unit of output are determined after the consumption decision is made. The output of the economy used for consumption originates from both the modern sector as well as the natural resource sector.

The functions for labour productivity growth in the modern sector and the fixed capital investment that we adapt in section 4 for the empirical application of our theoretical model are given as follows,

$$\frac{\Delta q}{q_o} = f(A, q_o, k_o, s, r_{bbl}, P, o) \qquad 31$$

$$\Delta k = f\left(k_{o,}, A, s, r_{bbl}, P, o\right) \qquad 32$$

4. Empirical Model

We derive the functions of labour productivity growth in the modern sector and fixed capital formation. The first equation explains the one year growth rate of labour productivity in the modern sector as a function of initial labour productivity, initial stock of fixed capital in the economy, initial efficiency of the production system proxied by school life expectancy from primary to tertiary level, the savings rate lagged by one year, the oil price lagged by one year, the rate of extraction of the total oil reserves lagged by one year and the total oil reserves per capita as a ratio of the world oil reserves per capita lagged by one year.

Productivity Equation

$$
\begin{aligned}
&\Delta\, log(labour\ productivity\ in\ modern\ sector)_{t,\ t-1} \\
&= \alpha_o \\
&+ \beta_1\, log(labour\ productivity)_{t-1} \\
&+ \beta_2\, log(fixed\ capital\ stock\ per\ capita)_{t-1} \\
&+ \beta_3 (schooling)_{t-1} \\
&+ \beta_4 (savings\ rate)_{t-1} \\
&+ \beta_5\, log(oil\ price)_{t-1} \\
&+ \beta_6 \left(\frac{country\ oil\ reserves\ per\ capita}{world\ average\ reserves\ per\ capita}\right)_{t-1} \\
&+ \beta_7 (oil\ extraction\ ratio)_{t-1} \\
&+ \sum_{i=1}^{149} \gamma_i (country\ dummies)_t \\
&+ \sum_{j=1}^{8} \gamma_j (time\ period\ dummies)_t + \epsilon_t
\end{aligned} \qquad 33
$$

The investment equation explains the change in gross fixed capital stock per capita *(not including depreciation of existing assets)* over one year by initial stock of fixed capital per capita, initial school life expectancy from primary to tertiary, the savings rate lagged by one year, one-year growth of GDP lagged by one year, oil price lagged by one year, the oil reserves per capita as a ratio of world oil reserves per capita lagged by one year and the oil extraction as a ratio of total reserves lagged by one year.

Investment Equation

$$\begin{aligned} log(gross\ fixed\ capital\ formation\ per\ capita)_t &= \alpha_1 \\ &+ \gamma_1\ log(fixed\ capital\ stock\ per\ capita)_{t-1} \\ &+ \gamma_2 (schooling)_{t-1} \\ &+ \gamma_3 (savings\ rate)_{t-1} \\ &+ \gamma_4 (gdp\ growth)_{t-1,\ t-2} \\ &+ \gamma_5\ log(oil\ price)_{t-1} \\ &+ \gamma_6 \left(\frac{country\ oil\ reserves\ per\ capita}{world\ average\ reserves\ per\ capita}\right)_{t-1} \\ &+ \gamma_7 (oil\ extraction\ ratio)_{t-1} \\ &+ \sum_{i=1}^{149} \gamma_i (country\ dummies)_t \\ &+ \sum_{j=1}^{8} \gamma_j (time\ period\ dummies)_t + \epsilon_t \end{aligned} \quad 34$$

Where, t = 1982, 1983, 1984, … 2015, and, β and γ are the coefficients of the explanatory variables in equations 33 and 34, respectively. In Table 1 we present the names and definitions of the variables used in the estimation models. We will refer to the variables by their short names describes in hereon.

Table 1 – Variable names and definitions

Variable	Definition
$\Delta \log \begin{pmatrix} labour\ productivity \\ in\ modern\ sector \end{pmatrix}_{t,\ t-1}$ Productivity Growth	log of the ratio of final to initial labour productivity (one-year growth rate of labour productivity)
$\log \begin{pmatrix} gross\ fixed\ capital \\ formation\ per\ capita \end{pmatrix}_{t}$ Fixed Capital Formation	log of gross fixed capital formation per labour in the economy (not including depreciation of existing stocks)
$\log(labour\ productivity)_{t-1}$ Log of Initial Labour Productivity	log of labour productivity lagged by one year
$\log \begin{pmatrix} fixed\ capital \\ stock\ per\ capita \end{pmatrix}_{t-1}$ Fixed Capital Stock	log of fixed capital stock per capita lagged by one year
$\begin{pmatrix} school\ life\ expectancy \\ primary\ to\ tertiary \end{pmatrix}_{t-1}$ Schooling	school life expectancy primary to tertiary lagged by one year
$(gdp\ growth\ rate)_{t-1,\ t-2}$ Lagged GDP Growth	log of the ratio final gdp to initial gdp lagged by one year (one-year growth rate of gdp lagged by one year)
$(savings\ rate)_{t-1}$ Savings Rate	savings rate lagged by one year
$\log(oil\ price)_{t-1}$ Oil Price	log of the price of oil lagged by one year
$\left(\frac{country\ oil\ reserves\ pc.}{world\ average\ reserves\ pc.}\right)_{t-1}$ Oil Reserves Ratio	average of the ratio of country oil reserves per capita to the average world oil reserves per capita lagged by one year
$(oil\ extraction\ ratio)_{t-1}$ Oil Extraction Ratio	oil extraction ratio lagged by one year

5. Data

The data for labour productivity in the modern sector is calculated as real GDP in constant 2011 USD per number of employees excluding the share of natural resource and agricultural sector. The number of employees' data is sourced from the Penn Worlds Table (PWT) Version 9.1 (Feenstra, et al., 2015). The share of natural resource rents and agricultural value added is sourced from World Bank Development Indicators that is agglomerated from national accounts data (World Bank, 2019). Where, total natural resource rents as a percentage of GDP is defined as the sum of; oil rents, natural gas rents, coal rents, mineral rents, and forest rents, and Agriculture in Agricultural value added corresponds to International Standard Industrial Classification (ISIC) divisions 1-5 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production (World Bank, 2019). The real GDP in constant 2011 USD, the fixed capital stock data and the gross fixed capital formation data is sourced from "IMF Investment and Capital Stock Data, 2017" and is in constant 2011 USD (Gupta, et al., 2006; Kamps, 2004).

According to the description of the IMF Investment and Capital Stock Data, "Information on public and private investment and GDP comes from three main sources: the OECD Analytical Database (August 2016 version) for OECD countries, and a combination of the National Accounts of the Penn World Tables and the IMF World Economic Outlook for non-OECD countries. Information on PPP investment comes from two main sources: The World Bank Private Participation in Infrastructure Database and European Investment Bank (EIB) data sourced from the European PPP Expertise Centre (EPEC) at the EIB. Information on country income groupings used in depreciation rates' assumptions is from the World Bank World Development Indicators."

The world bank definition of fixed capital includes "land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchase; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings" (World Bank, 2018). Moreover, it consists of resident producers' investments, deducting disposals, in fixed assets during a given period. It also includes certain additions to the value of non-produced assets realised by producers or institutional units. Fixed assets are tangible or intangible assets produced as outputs from production processes that are used repeatedly, or continuously, for more than one year.

PWT data on capital formation covers, "nine asset types: residential buildings, other structures, information technology, communication technology, other machinery, transport equipment, software, other intellectual property products and cultivated assets (such as livestock for breeding and vineyards). These investment data are drawn from country National Accounts data, supplemented by estimates based on total supply of investment goods (import plus production minus exports) and data on spending on information technology. Note that coverage is limited to assets currently covered in the System of National Accounts. This means that land and inventories are omitted, as well as other forms of intangible capital – such as from product design or organisation capital – and subsoil assets – such as oil or copper."

The Savings Rate is measured using the Final Consumption Expenditure as a percent of GDP that is sourced from the World Bank Development Indicators (World Bank, 2019). The Savings Rate is calculated as one (1) minus the Final Consumption Expenditure as percent of GDP. The efficiency of the economy is proxied by the school life expectancy from primary to tertiary level (UNESCO, 2018). It is calculated as the sum of the age specific enrolment rates for the levels of education specified. The part of the enrolment that is not distributed by age is divided by the school-age population for the level of education they are enrolled in, and multiplied by the duration of that level of education. The result is then added to the sum of the age-specific enrolment rates. A relatively high school life expectancy indicates greater probability for children to spend more years in education and higher overall retention within the education system.

The oil extraction ratio is proxied by the total oil extraction by a country in a given year divided by total oil reserves. The data for oil extraction is based on total petroleum and other liquids production in barrels, meanwhile the data for oil reserves is based on crude oil proven reserves in barrels from Energy Information Administration (EIA, 2019). The data for total proven reserves of oil is taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and geological conditions. Market-linked pricing is the main method for pricing crude oil in international trade. The current reference, or pricing markers, are Brent, West Texas Intermediate (WTI), and Dubai crudes. Note that the price variation of Brent, WTI and Dubai crude resembles each other as such using any one of them for pricing serves the purpose well. However, in order to ensure representative world crude oil price in this chapter we have used the average price of oil indicated in World Bank Commodity Price Data. The world bank defines the price as the equally weighted average spot price of Brent, Dubai and WTI crude oil (GEM Commodities, World Bank Group, 2019).

In case where we consider time period and country fixed effects the reference time period is period number eight (8) that runs from 2010 to 2015 and the reference country is US. The time periods are based on the US business cycles reported by Nation Bureau of Economic Research (NBER). The economic “Peak” and “Trough” announcements provided by NBER since 1980 form the start and end year of each period (NBER, 2019). The only exception is addition of period number five (5) where 1997 is considered as the Trough Year instead of 2001 March which was the first recession in US following 1991 Peak according to NBER. The added period considers the Asian Financial Crises (1997), Russian Financial Crises (1998) and the oil price crash of 1999 and runs from 1997 to 2001.

6. Data Reliability

The first concern that we address is the objection to the use of labour productivity in capital driven sectors defined to exclude the natural resource and agricultural sector. It is argued that modern agricultural technology, modern mineral recovery technology and enhanced oil recovery (EOR) are examples of change in productivity through fixed capital investments. In our theoretical background such examples may be considered as part of the capital driven sector. In terms of our estimation excluding the natural resource and agricultural output (as such the modern, fixed capital driven part of this output) from the labour productivity is justified as the portion and usage of modern mineral recovery technology and EORs is much smaller in comparison to the usage of traditional recovery. The same is true for agricultural technology albeit the usage is higher. However, it is much more important for us to exclude the traditional productivity and productivity of extractive sector in contrast to capturing all capital driven productivity. Owing the data limitations, we find that our technique is the most suitable way to account for labour productivity in the modern sector.

Another uncertainty that we face is that, different countries and companies from which the oil data is agglomerated from, have varying abilities to precisely estimate the recoverable oil reserves. We consider that our source EIA makes every effort to come up with a consistent series for reserves based on a common definition. However, the use of different methodologies is apparent in the data. An example in case is that of Bangladesh, Equatorial Guinea, Morocco, South Africa where the EIA data shows oil extraction exceeding oil reserves, or oil extraction for two subsequent years at a level very close to the total reserves. This by definition is impossible, as such the data was excluded from the set. The excluded data consists data points for Bangladesh, Equatorial Guinea, Morocco and South Africa. We also observed that oil extracting countries that are facing war or sanctions tend to have very low oil extraction ratios. In addition to that Canada shows very low oil extraction ratio because large quantities of difficult to extract and heavy tar sands distorts the total recoverable oil reserves measure. Note that we also tested our models by excluding this set of countries and the results are covered in postestimation tests and reliability section.

We also checked the pairwise correlation between our explanatory variables. The correlation is considered low and is not expected have effect on the coefficients of the estimation. Another important concern is that a small set of data points may affect the coefficients of the regression disproportionately. In this regard, we carry out an influence analysis for the regression with respect to the explanatory variable. We use dfbeta values that measure the difference between the regression coefficient calculated for all of the data and the regression coefficient calculated with the observation deleted, scaled by the standard error calculated with the observation deleted. This value can then be used to limit the variance in the estimations by using a rule of thumb. For this case we tested for where n is the total number of observations. In the following we term the data points with dfbeta higher than as outliers. We will go through the implications in our post-estimation test and reliability section. The data was also visually inspected in correlation matrix graphs and the data was confirmed to be free from outliers.

The time range of the data runs from 1980 to 2015. As such the total number of years is 36. The minimum number of years for a country was four (4) years and the maximum was 36 years. The explained variables for investment estimation include growth of GDP over one year lagged by one year. As such, the first set of observations is from the year 1982. The average number of years per country is 23 years. The total number of countries in the data for the productivity and the investment estimation is 149. Out of these 85 had an oil sector for at least part of the time period in consideration. We carry out ordinary least squares regression with estimates efficient for homoskedasticity and standard errors robust to heteroskedasticity and autocorrelation (HAC) using robust and Newey-West estimation with lag of one (Newey & West, 1987). The summary statistics for the data used in productivity estimation and investment estimation are presented in Table 2.

Table 2 – Summary statistics for productivity estimation

Variable	Countries	Years	Obs.	Mean	Std. Dev.	Min	Max
Productivity Growth	149	1982-2015	3337	0.019	0.105	-1.415	1.475
Fixed Capital Formation	149	1982-2015	3337	8.026	1.505	2.915	11.352
Initial Labour Productivity	149	1982-2015	3337	9.536	1.397	4.713	12.017
Fixed Capital Stock	149	1982-2015	3337	10.471	1.378	5.212	12.960
Savings Rate	149	1982-2015	3337	0.193	0.156	-1.420	0.884
Schooling	149	1982-2015	3337	11.115	3.651	1.437	23.282
GDP Growth	149	1982-2015	3337	0.036	0.046	-0.670	0.296
Oil Price	149	1982-2015	3337	3.691	0.595	2.766	4.557
Oil Reserves Ratio	149	1982-2015	3337	0.847	4.391	0	60.027
Oil Extraction Ratio	149	1982-2015	3337	0.048	0.066	0	0.811

The mean and standard deviation of productivity growth in the modern sector over a period of one year was 0.019 and 0.105 respectively. The fixed capital formation had a mean of 8.026 with a standard deviation of 1.505. The mean of log of initial labour productivity was observed to be 9.536 while the standard deviation was 1.397. The log of initial stock of fixed capital had a mean of 10.471 with a standard deviation of 1.378. The mean of savings rate was 0.193 with a standard deviation of 0.156. The mean of school life expectancy from primary to tertiary (schooling) was 11.115 and the standard deviation was 3.651. The explanatory variable of lagged log of oil price, lagged oil reserves to world oil reserves ratio and lagged oil extraction ratio had means of 3.691, 0.847 and 0.048, respectively. Their respective standard deviations were observed to be 0.595, 4.391 and 0.066.

7. Results

Here we present the observed influences of the explanatory variables of concern, on the explained variable that is labour productivity growth excluding natural resource and agricultural rents. Second, we present the results of the estimation for gross fixed capital formation explained by initial fixed capital stock, schooling, savings rate, GDP growth and oil sector variables including oil price, oil reserves and oil extraction ratio. See Equations 33 and 34, and Table 1 and 2 for more details on the estimation and definitions of the variables.

In Table 3: A-1 includes only the base explanatory variables, A-2 introduces oil price (OP), reserves ratio (OR) and extraction ratio (OE), A-3 adds only time period fixed effects and A-4 only country fixed effects. A-5 includes both time and country fixed effects. A-6 introduces the interaction between oil price and oil reserves ratio (INT). Finally, A-7 adds the interaction of country dummies with INT.

Table 3 – Regression results – Productivity Equation

Dependent Variable	Productivity Growth (Net of natural resource rents and agricultural value added)							
	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-7 Continued INT#Country
Labour Productivity	-0.029***	-0.028***	-0.028***	-0.177***	-0.177***	-0.177***	-0.202***	
	(0.010)	(0.010)	(0.010)	(0.034)	(0.034)	(0.035)	(0.036)	
Fixed Capital Stock	0.009	0.009	0.009	0.061**	0.062**	0.062**	0.070***	
	(0.007)	(0.007)	(0.007)	(0.024)	(0.024)	(0.024)	(0.023)	
Savings Rate	0.042**	0.041*	0.040*	0.036	0.025	0.028	0.037	
	(0.021)	(0.021)	(0.021)	(0.038)	(0.038)	(0.040)	(0.047)	
Schooling	0.006***	0.006***	0.005***	0.011***	0.009***	0.009***	0.011***	
	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)	(0.003)	
Oil Price (OP)		0.004	0.023***	0.011***	0.023***	0.023***	0.018***	
		(0.004)	(0.006)	(0.004)	(0.006)	(0.006)	(0.006)	
Oil Reserves Ratio (OR)		0.000	0.000	0.003	0.002	0.003	0.004	
		(0.001)	(0.001)	(0.003)	(0.003)	(0.004)	(0.004)	
Oil Extraction Ratio (OE)		0.013	0.012	-0.001	-0.006	-0.007	0.035	
		(0.017)	(0.017)	(0.029)	(0.029)	(0.029)	(0.036)	
OP#OR (INT)						0.000	0.005	
						(0.001)	(0.020)	
Bahrain				-0.040**	-0.034*	-0.035*	-0.032	-0.013
				(0.019)	(0.019)	(0.020)	(0.031)	(0.044)
Kuwait				-0.167	-0.134	-0.102	-0.456	-0.004
				(0.149)	(0.148)	(0.159)	(0.394)	(0.020)
Oman				-0.023	-0.027	-0.026	-0.032	-0.005
				(0.031)	(0.031)	(0.031)	(0.108)	(0.022)
Qatar				-0.002	0.006	0.014	0.181*	-0.009
				(0.053)	(0.053)	(0.056)	(0.105)	(0.020)
KSA				-0.090	-0.075	-0.065	-0.070	-0.006
				(0.058)	(0.057)	(0.059)	(0.138)	(0.020)
UAE				-0.035	-0.024	-0.009	0.204	-0.008
				(0.063)	(0.063)	(0.073)	(0.212)	(0.020)
Time period fixed effects	No	No	Yes	No	Yes	Yes	...	Yes
Country Fixed Effect	No	No	No	Yes	Yes	Yes	...	Yes
Root Mean Square Error	0.104	0.104	0.103	0.099	0.099	0.099	...	0.097
Adj.R-squared	0.024	0.023	0.029	0.114	0.120	0.119	...	0.153
Countries	149	149	149	149	149	149		149
Years	23	23	23	23	23	23		23
Observations	3337	3337	3337	3337	3337	3337	...	3337
*** p<0.10, ** p<0.05, *** p<0.01**								

Note that we first discuss the results of productivity estimation model A-5 indicated in Table 3 based on equation 33. The first result that we observe in above Table 3 is that initial labour productivity is negatively corelated with growth in labour productivity in the modern sector. The coefficient is statistically significant with confidence level of 99%. The standard error is 0.034. A 1% higher initial labour productivity is observed to produce a 0.177 ± 0.034% lower labour productivity growth in the modern sector. The initial capital in the economy is statistically significantly corelated with the growth in labour productivity in the modern sector. Higher initial capital stocks lead to a higher growth of the labour productivity in the modern sector. The coefficient is statistically significant with confidence level of 95%. A 1% increase in initial fixed capital stocks in the economy is observed to increase the labour productivity growth rate in the modern sector by 0.062 ± 0.024%. We observe that a year's increase in schooling is expected to increase the labour productivity growth in the modern sector by 0.009 ± 0.003% *(99% confidence).*

We observe that the coefficient of the oil price variable is positive and statistically significant with a confidence of 99%. An average oil price increase of 1% lead to a 0.023% higher modern sector labour productivity growth rate with a standard error of 0.006. The oil reserves ratio and the oil extraction ratio do not explain the change in labour productivity in the modern sector. The coefficient for all the GCC country dummies except that of Qatar is negative. Excluding Bahrain, the labour productivity growth in the modern sectors of the GCC countries is not statistically different from the reference country (US). Bahrain has the lowest growth in the labour productivity in modern sector among the GCC countries.

The root mean squared error of the estimation is 0.099. The mean of the estimated labour productivity growth in the modern sector is 0.019% with 0.102 as the standard deviation of the residuals. In comparison to this, the real mean of the explained variable is 0.019% with a standard deviation of 0.105.

We observe in A-2 and A-3 that an increase in saving rate leads to higher labour productivity growth in the modern sector. In A-2 (without fixed effects) and A-3 (with time period fixed effects but without country fixed effects), a 1% change in savings rate is expected to yield 0.041 and 0.040 ± 0.021% increase in labour productivity growth in the modern sector, respectively. The relationship is statistically significant with confidence at a level of 90%. However, the relationship between savings rate and the labour productivity growth has a lower confidence and higher standard error when considering country fixed effects. As such cross-country differences are important in explaining the effect of saving rate on labour productivity growth in modern sector.

In A-6 and A-7 we do not observe any statistically significant effect of the interaction (INT) of oil price with oil reserves ratio or the interaction of the country dummies with INT, on the labour productivity in the modern sector. However, in A-7, we observe that including the interaction of INT with country dummies makes the coefficient of the country dummy for Qatar larger and statistically significant with confidence level of 90%. This is indicative that increased labour productivity in the modern sector in Qatar is not driven directly through returns from oil extraction. We will analyse this relationship further in the interpretation of the investment estimation in this section and in the conclusion and discussion section (Section 9).

According to our theoretical model and the associated empirical interpretation, we expect that the effect of oil sector variables on the labour productivity is driven through investments in fixed capital. In the following, the regression output of the empirical model explaining gross fixed capital formation through initial fixed capital stock, savings rate, GDP growth, schooling and oil sector variables is presented.

Table 4 – Regression results – Investment Equation

Dependent Variable	Fixed Capital Formation							
	B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-7 Continued INT#Country
Fixed Capital Stock	0.902***	0.915***	0.923***	0.734***	0.731***	0.749***	0.739***	
	(0.011)	(0.011)	(0.011)	(0.030)	(0.029)	(0.030)	(0.037)	
Savings Rate	0.858***	0.825***	0.832***	0.595***	0.562***	0.457***	0.509**	
	(0.075)	(0.075)	(0.074)	(0.171)	(0.168)	(0.176)	(0.213)	
Schooling	0.050***	0.041***	0.036***	0.039***	0.012**	0.013**	0.014**	
	(0.003)	(0.003)	(0.004)	(0.005)	(0.006)	(0.006)	(0.006)	
GDP Growth	3.300***	3.251***	3.276***	2.050***	2.059***	2.097***	1.934***	
	(0.296)	(0.294)	(0.295)	(0.192)	(0.189)	(0.186)	(0.182)	
Oil Price (OP)		0.116***	0.051*	0.138***	0.084***	0.077***	0.063***	
		(0.012)	(0.027)	(0.012)	(0.019)	(0.019)	(0.019)	
Oil Reserves Ratio (OR)		0.001	0.001	-0.001	-0.003	-0.026***	-0.023***	
		(0.001)	(0.001)	(0.006)	(0.005)	(0.008)	(0.007)	
Oil Extraction Ratio (OE)		0.091	0.090	0.245*	0.256*	0.276**	0.453**	
		(0.101)	(0.101)	(0.138)	(0.133)	(0.133)	(0.200)	
OP#OR (INT)						0.011***	-0.597***	
						(0.003)	(0.160)	
Bahrain				-0.114	-0.124	-0.104	-0.585***	0.864***
				(0.081)	(0.085)	(0.085)	(0.118)	(0.211)
Kuwait				-0.011	0.043	-0.809**	0.732	0.597***
				(0.279)	(0.263)	(0.326)	(0.472)	(0.160)
Oman				0.108	0.010	-0.021	-0.667***	0.641***
				(0.068)	(0.069)	(0.067)	(0.159)	(0.161)
Qatar				0.634***	0.584***	0.360***	0.225	0.605***
				(0.132)	(0.128)	(0.126)	(0.195)	(0.160)
KSA				-0.073	-0.050	-0.336**	-1.233***	0.617***
				(0.128)	(0.123)	(0.133)	(0.156)	(0.160)
UAE				0.273**	0.240*	-0.184	-1.253***	0.618***
				(0.133)	(0.127)	(0.156)	(0.315)	(0.160)
Time Period Effects	No	No	Yes	No	Yes	Yes	...	Yes
Country Fixed Effect	No	No	No	Yes	Yes	Yes	...	Yes
Root Mean Square Error	0.410	0.405	0.403	0.273	0.269	0.269	...	0.253
Adj.R-squared	0.926	0.928	0.928	0.967	0.968	0.968	...	0.972
Countries	149	149	149	149	149	149		149
Years	149	23	23	23	23	23		23
Observations	149	3337	3337	3337	3337	3337	...	3337
*** p<0.10, ** p<0.05, *** p<0.01**								

In Table 4: B-1 includes only the base explanatory variables, B-2 introduces oil price (OP), reserves ratio (OR) and extraction ratio (OE), B-3 adds only time period fixed effects and B-4 only country fixed effects. B-5 includes both time period and country fixed effects. B-6 introduces the interaction between oil price and oil reserves ratio (INT). Finally, B-7 adds the interaction of country dummies with INT.

Here we discuss the results of the investment estimation model B-5 based on Equation 34 as presented in Table 4. We observe that capital formation in previous period is positively corelated with new capital formation. A 1% higher initial capital stock leads to 0.731% increase in fixed capital formation over a year. The standard error of the coefficient is 0.029 and the result is statistically significant with a confidence of 99%. We also find that the savings rate, schooling and GDP growth are positively and statistically significantly related gross fixed capital formation. A 1% higher savings rate results in a 0.562% higher gross fixed capital formation. The coefficient is statistically significant at confidence level of 99% and the robust standard error is 0.168. A year's increase in initial schooling is expected to increase the fixed capital formation in the final year by 0.012 ± 0.006%. The coefficient is statistically significant at the confidence level of 95%.

We observe that Qatar is able to accumulate highest fixed capital per capita in comparison to its neighbouring GCC countries. The coefficient of the country dummy for Qatar is positive and statistically significant with confidence level of 99%. The coefficient of the country dummy for UAE is also positive and statistically significant (confidence level 90%) showing higher fixed capital formation in comparison to the reference country (US). The fixed capital formation per capita in the remaining GCC countries is not statistically different from the reference country. Bahrain is the lowest performing among the GCC countries in term of fixed capital formation while Saudi Arabia is the second from the last.

We observe that the coefficient of the oil price variable is positive and statistically significant with a confidence level of 99%. An average oil price increase of 1% leads to a 0.084% higher capital formation. The standard error is 0.019. We observe that a higher oil extraction ratio is expected to have a positive effect on the fixed capital investment. The coefficient is observed to be 0.256 with a standard error of 0.133 and a confidence level of 90%.

The root mean squared error of the estimation is 0.269. The mean of the estimated fixed capital formation is 8.039 with 0.387 as the standard deviation of the residuals. In comparison to this, the real mean of the explained variable is 8.026 with a standard deviation of 1.505.

In order to delve further into the mechanism through which oil reserves and oil prices affect capital formation, we test the interaction of oil price and oil reserves ratio (INT) in B-6. Also, we interact the interaction – INT – with all country dummies and discuss the results for the six GCC countries in B-7. In B-6 we observe that OP#OR (INT) is positively corelated with fixed capital formation with a coefficient of 0.011 and standard error of 0.003 (confidence level 99%). In B-7 we observe through the interaction of country dummies with INT that all GCC countries are able to exploit high oil prices for increased capital formation, owing to their large oil reserves ratio (See column for B-7 Continued INT#Country in Table 4).

It is noteworthy that the coefficient of the country dummy of Qatar has a smaller magnitude in B-7 in comparison to B-6. We discussed a similar comparison for Qatar between A-7 and A-6 for the productivity estimation. There, we observed that the revenues generated from oil extraction in terms of labour productivity are not the direct drivers of Qatar's modern sector labour productivity growth. In the investment estimation it become clear that the revenues from oil extraction have a positive impact on the fixed capital formation in Qatar. This trend is most clearly observed from the coefficients for Qatar in both estimations and the relationship is the same for all the GCC countries except Kuwait. All in all, the ability of all GCC countries to divert their natural resource profits to higher fixed capital formation is evident.

8. Postestimation tests and robustness

In relation to the countries with very low oil extraction ratios (discussed in section presenting the Data Reliability) we repeated the estimation of both equation 33 and 34 excluding the country group. The exclusion of countries with very low oil extraction ratios did not affect the outcome of the estimations with the coefficients and standard errors not changed to any considerable extent. The estimation results in Table 3 and 4 include these countries. The regressions result for equation 33 and 34 were also estimated excluding the outliers identified by calculating dfbetas. The standard error, significance and coefficients of the variables in the estimation model based on equations 33 and 34 were not meaningfully different when estimated excluding the outliers identified. The estimation results in Table 3 and 4 do not exclude the outliers identified by calculating the dfbetas.

We find that the standard errors of oil price variable are robust to changes in selection of time dummy periods as well as when no time dummies are used. While the oil extraction ratio standard errors are robust to selection of time dummy periods and also when no time dummies are used. Note that we have selected the time dummy periods to be based on the business cycles as reported by NBER with the addition of the Asian Financial Crises. However, we tested by using random six years periods and did not observe any substantial changes in the results of the estimation. The oil reserves per capita as a ratio of world oil reserves per capita coefficient and the oil extraction ratio are robust to these changes.

9. Discussion and Conclusion

Our theoretical model predicts that the change in fixed capital formation per capita is a function of the initial stock of fixed capital, the savings rate, the productive efficiency of the economy, and output of the oil sector. The output of the oil sector is a function of the oil sector variables – oil price, oil reserves per capita, and the ratio of oil reserves extracted from the total oil reserves. The change in productivity of the modern sector is a function of the initial labour productivity, initial fixed capital stock, productive efficiency of the economy and gross fixed capital formation.

In our estimation we test the theoretical model for 149 countries including 85 countries with commercially extractable oil reserves and do no find any evidence of an "Oil Curse". We find that higher oil prices affect the labour productivity in modern sector as well as the fixed capital formation. The oil reserves and the oil extraction ratio do not affect labour productivity growth directly. Also, we find that the oil reserves variable on its own does not have a statistically significant effect on fixed capital formation. However, countries with high oil reserves benefit from high oil prices in order to form new fixed capital. The oil extraction ratio has a positive effect on the fixed capital formation.

The mechanism for increase of labour productivity in the modern sectors of countries with and without an active oil sector can be assumed to be different to a certain extent. The similarity between the two types of countries may be related to foreign direct investments (FDI). Countries without an oil sector may be benefiting from FDIs from the sovereign funds oil rich nations. Firms in rich countries may be offsetting higher energy costs by moving production to lower income countries thus increasing productivity in the modern sectors and fixed capital investment there. Oil rich countries may also become more attractive FDI destinations for international firms during high oil price periods because of liquidity and availability of finance. For countries without an active oil sector the increase in labour productivity in the modern sector may also be driven by demand for capital and consumption goods (and services) from oil rich countries that have surplus wealth available to consume as well as to invest during high oil price periods. Another possibility is that higher oil prices reduce the marginal returns for producing consumption goods due to high cost of energy per unit, this leads to innovation for improving profitability, that in turn leads to higher productivity in the modern sector of non-oil-extracting countries. However, we expect that a mechanism whereby higher energy prices drive innovation would exhibit itself in the longer run, rather than one-year periods that we use in this chapter. It is recommended that further research is undertaken to further disentangle the mechanisms of the relationship between labour productivity growth in the modern sectors of countries with and without an oil sector.

We observe that all the GCC Countries are able to generate higher amounts of fixed capital during high oil price periods owing to their large oil reserves per capita. We observe that Qatar has been able to generate higher fixed capital per capita in comparison to the reference country (US), as well as in comparison to all other GCC countries. The UAE's investments in fixed capital are higher in comparison to the reference country and other GCC countries, but lower than Qatar. We find that for Saudi Arabia and UAE, the formation of fixed capital is highly associated with their ability to benefit from high oil prices owing to their high oil reserves. A similar effect is observed for Oman and Bahrain but the association is of a lesser magnitude than that of Saudi Arabia and UAE. Unlike other GCC countries, Kuwait and Qatar appear to have positive relationship of their individual country dummies with fixed capital formation even when the interaction of oil price, oil reserves and country dummies is introduced. As such, it appears that oil income during high oil price periods is not the only source for fixed capital formation in these two countries. As far as the effect of the oil variables is concerned, it may well be that oil reserves offer countries a type of collateral or warranty inducing financial influx through financial intermediation or as mentioned earlier through FDIs. These can lead to an increase of fixed capital investments. However, future research may be carried out to focus on this aspect of the oil sector's contribution to overall fixed capital formation.

We observe that schooling has a positive effect on labour productivity growth in the modern sector as well as fixed capital formation. The relationship between labour productivity and productive efficiency and/or education is well known. We propose that the relationship between schooling and fixed capital formation is driven by the countries' ability to invest in modern or highly technology because of higher skill level of the population. Simply stated, improving capital stocks without relevant education and skill is not expected to have analogous returns. As such countries only invest in fixed capital that is matching the productive efficiency level of the economy proxied here by schooling. Further research into the relationship between productive efficiency and/or schooling and fixed capital formation is recommended. All in all, we find that natural resources offer an important means for investing into the modern sector, diversify the economy and ensure economic sustainability. This is evident in the case of GCC countries investing in fixed capital using their oil wealth.

References

Amuzegar, J., 1982. Oil Wealth: a Very Mixed Blessing. *Foreign Affairs,* Spring, 60(4), pp. 814-835.

Anshasy, A. A. E. & Katsaiti, M.-S., 2013. Natural resources and fiscal performance: Does good governance matter?. *Journal of Macroeconomics,* 37(C), pp. 285-298.

Auty, R. M., 2001. The Political Economy of Resource-Driven Growth. *European Economic Review,* Volume 45, pp. 839-846.

Auty, R. M., 2007. Natural resources, capital accumulation and the resource curse. *Ecological Economics,* 61(4), pp. 627-634.

Barro, R. J. & Salai-i-Martin, X., 2004. Growth Models with Exogenous Savings Rates (the Solow-Swan Model). In: R. J. Barro & X. Salai-i-Martin, eds. *Economic Growth.* Massachusetts: Massachusetts Institute of Technology, pp. 23-84.

Boschini, A. D., Pettersson, J. & Roine, J., 2007. Resource Curse or Not: A Question of Appropriability. *The Scandinavian Journal of Economics,* 109(3), p. 593–617.

Canuto, O. & Cavallari, M., 2012. *Natural Capital and the Resource Curse,* Washington, D.C.: World Bank - Povert Reduction and Economic Managment Network - Economic Premise Notes.

Cumby, R. E. & Huizinga, J., 1992. Testing the Autocorrelation Structure of Disturbances in Ordinary Least Squares and Instrumental Variables Regressions. *Econometrica,* 60(1), pp. 185-195.

Davis, G. A., 1995. Learning to Love the Dutch Disease: Evidence from the Mineral Economies. *World Development,* 23(10), pp. 1765-1779.

EIA, 2019. *International Energy Statistics.* [Online] Available at: https://www.eia.gov/beta/international/data/browser/ [Accessed 03 06 2019].

Feenstra, R. C., Inklaar, R. & Timmer, M. P., 2015. The Next Generation of the Penn World Table. *American Economic Review,* 105(10), pp. 3150-3182.

Ferranti, D. d., Perry, G. E., Ledeman, D. & Maloney, W. F., 2002. Chapter 1 - Introduction and Summary. In: *From Natural Resources to the Knowledge Economy: Trade and Job Quality.* Washington DC.: The World Bank, pp. 1-10.

Gelb, A. & Associates, 1988. *Oil Windfalls: Blessing or Curse?.* Washington DC: Oxford University Press for The World Bank.

GEM Commodities, World Bank Group, 2019. *World Bank Commodity Price Data,* New York: World Bank.

Gupta, S., Kangur, A., Papageorgiou, C. & Wane, A., 2006. Efficiency-Adjusted Public Capital and Growth. *World Development,* Volume 57, pp. 164-178.

Hoel, M., 2015. *Optimal control theory with applications to resource and environmental economics,* Oslo: University of Oslo.

Kamps, C., 2004. New Estimates of Government Net Capital Stocks for 22 OECD Countries 1960-2001. *IMF Working Papers*, 1 April, p. Working Paper No. 04/67.

Lederman, D. & Maloney, W. F., 2007. *Natural Resources: Neither Curse nor Destiny,* Washington DC.: The World Bank.

Lederman, D. & Maloney, W. F., 2008. In Search of the Missing Resource Curse. *World Bank Policy Research Working Paper,* Working Paper Number (4766).

Levy, W. J., 1978. the Years That the Locust Hath Eaten: Oil Policy and OPEN Development Prospect. *Foreign Affairs,* Winter, 57(2), pp. 287-305.

Maddison, A., 1994. Explaining the Economic Performance of Nations, 1820-1989. In: *Convergence of Productivity: Cross National Studies and Historical Evidence.* New York: Oxford University Press, pp. 20-60.

Maloney, W. F., Manzano, O. & Warner, A., 2002. Missed Opportunities - Innovation and Resource-Based Growth in Latin America. *Economia,* 3(1), pp. 111-167.

Mehlum, H., Moene, K. & Torvik, R., 2006. Institutions and the Resource Curse. *The Economic Journal,* 116(508), pp. 1-20.

NBER, 2019. *US Business Cycle Expansions and Contractions.* [Online] Available at: https://www.nber.org/cycles.html [Accessed 20 05 2019].

Newey, W. K. & West, K. D., 1987. A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix. *Econometrica,* 55(3), pp. 703-708.

Papyrakis, E., 2017. The resource curse - What have we learned from two decades of intensive research: Introduction to the special issue. *The Journal of development studies,* 53(2), pp. 175-185.

Prebisch, R., 1959. Commercial Policy in the Underdeveloped Countries. *The American Economic Review,* May, 49(2), pp. 251-273.

Sachs, J. D. & Warner, A. M., 1995. Natural Resource Abundance and Economic Growth. *NBER Working Paper,* Working Paper Number (5398).

Sachs, J. D. & Warner, A. M., 2001. The curse of natural resources. *European Economic Review,* Volume 45, pp. 827-838.

Sarmidi, T., Law, S. H. & Jafari, Y., 2014. Resource Curse: New Evidence on the Role of Institutions. *International Economic Journal,* 28(1), pp. 191-206.

Singer, H. W., 1950. The Distribution of Gains between Investing and Borrowing Countries. *The American Economic Review,* May, 40(2), pp. 473-485.

Stijns, J.-P. C., 2005. Natural resource abundance and economic growth revisited. *Resources Policy,* Volume 30, pp. 107-130.

Thompson, H., 2012. Economic growth with a nonrenewable resource. *Journal of Energy and Development,* Volume 38.

UNESCO, 2018. *UIS.Stat.* Montreal: UNESCO Institute for Statistics.

van der Ploeg, F., 2011. Natural Resources: Curse or Blessing?. *Journal of Economic Literature,* 49(2), pp. 366-420.

World Bank, 2019. *World Development Indicators.* [Online] Available at: http://data.worldbank.org/data-catalog/world-development-indicators [Accessed 23 May 2019].

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