ECONOMICS

Working Paper Series

No. 08-2019

Wasted windfalls: Inefficiencies in health care spending in oil rich countries

Michael Keller[a]

[a]Department of Economics, University of Sussex, BN1 9SL, Falmer, UK

Michael.Keller.research@gmail.com

Abstract: This paper uses Stochastic Frontier Analysis (SFA) to determine whether oil rents drive inefficiency in the healthcare sector. SFA simultaneously estimates a production function for health outputs and the determinants of inefficiency in production. Using a sample of 119 countries covering the period 2000 to 2015, unexpectedly high oil revenues are shown to increase inefficiency. Oil rents hinder countries in reaching their potential life expectancy. Exploiting exogenous variation in the international oil price reveals that causality runs from oil rents to inefficiency. The effect varies with institutions, sex and age. The effect is more pronounced in democracies, and women and children are affected more. Transparency and inequality are potential mechanisms.

JEL classification: H51, I15, Q33, Q38

Key words: Oil windfalls, health expenditure, stochastic frontier analysis

Wasted windfalls: Inefficiencies in health care spending in oil rich countries

Michael Keller[a,*]

[a] *Department of Economics, University of Sussex, Falmer, United Kingdom*

Abstract

This paper uses Stochastic Frontier Analysis (SFA) to determine whether oil rents drive inefficiency in the health care sector. SFA simultaneously estimates a production function for health outputs and the determinants of inefficiency in production. Using a sample of 119 countries covering the period 2000 to 2015, unexpectedly high oil revenues are shown to increase inefficiency. Oil rents hinder countries in reaching their potential life expectancy. Exploiting exogenous variation in the international oil price reveals that causality runs from oil rents to inefficiency. The effect varies with institutions, sex and age. The effect is more pronounced in democracies, and women and children are affected more. Transparency and inequality are potential mechanisms.

Keywords: Oil windfalls, health expenditure, stochastic frontier analysis

JEL: H51, I15, Q33, Q38

1. Introduction

Oil rich countries often underperform in economic and social development.[1] For example, Gabon, an oil rich upper middle-income country reached merely 64.5 years in terms of life expectancy in 2013. This is 7.5 years below the average life expectancy in upper-middle income countries in the same year. The discrepancy of Gabon is not an exceptional case for oil rich countries. The mediocre performance is also true in Angola (11 years), Chad (7 years), Trinidad and Tobago (7 years) and Saudi Arabia (4 years). This paper explores one possible reason, namely that funds spend on health care are disproportionally wasted in countries with high oil revenues.

The literature about natural resources usually focuses on the effect of oil on economic growth. For a decade or two the common wisdom was that natural resources impede economic growth (Isham, 2005; Sachs and Warner, 2001). Those findings have been challenged lately (Brunnschweiler and Bulte, 2008; Brunnschweiler, 2008; Cotet and Tsui, 2013b). A smaller, but still essential literature is connecting natural resources with social development and analyses the effect of natural resources on non-monetary well-being indicators, such as education or health outcomes (e.g. Arezki and Gylfason (2013); Blanco and Grier (2012); Carmignani (2013); Cotet and Tsui (2013b); Edwards (2016); Gylfason (2001)).

*Corresponding Author
Email address: `Michael.Keller.research@gmail.com` (Michael Keller)

[1] For an overview of this literature see Frankel (2010); van der Ploeg (2011); Ross (1999, 2015)

This paper contributes to the literature connecting oil with social development by estimating the effect of oil rents on inefficiency in the health care sector. Using stochastic frontier analysis (SFA), I construct health production functions for 119 countries for the period 2000-2015 and test whether oil rents are a determinant of inefficiency in the health care sector. SFA estimates a frontier representing the maximum potential outcome a country could have achieved in terms of health output (life expectancy at birth) and compares it with the actual health output, the difference is defined as inefficiency. I find that oil rich countries have on average a lower level of efficiency than oil poor countries and that oil is a significant determinant of this inefficiency partially explaining the underperformance of oil rich countries while controlling for income. For example, Gabon has a technical efficiency estimate of 0.82 and by eradicating inefficiency Gabon could increase life expectancy by 11 years, outperforming the average upper-middle income country by about 3.5 years.

The empirical literature finds mostly a negative effect of natural resources on health outcomes. Edwards (2016) analyses the impact of mining on health and education outcomes in up to 157 countries by instrumenting the size of the mining sector with the geological variation in a country's resource endowment and controlling for income, geography and institutions. He finds a negative effect of the mining sector on life expectancy and infant mortality. His results show that doubling the mining share of an economy increases infant mortality on average by 20% and reduces life expectancy by about 5%. Carmignani and Avom (2010) find a statistically significant negative effect of resource intensity on social development in a sample of 87 countries for the period 1975-2005. Social development is defined as an aggregate measure of life expectancy, immunization rate and average year of schooling. Resource intensity is defined as 'primary commodity exports as percentage of total merchandise exports'. They use the instrumental variable approach and dynamic panel estimators to confirm their hypothesis that primary commodities are negatively correlated with social development. They further provide evidence that the negative effect is due to inequality and macroeconomic volatility. Bulte et al. (2005) find an indirect connection between point-source resources and development indicators. The connection in their model is through institutional quality and they show that point-source resources negatively affect institutional quality which in turn reduces social development indicators such as the Human Development Index, undernourished population share, water access, and life expectancy. Daniele (2011) analyses the relation between resource dependence/abundance and social development (Human development index and child mortality). He finds a negative correlation between resource dependence and social development but finds a positive correlation for his resource abundance measure. The findings are robust particularly in countries with low levels of institutional quality.

There is also evidence that points in the opposite direction. Cotet and Tsui (2013b) find a positive effect of oil on health. Exploiting the timing of oil discoveries and cross-country variation in the size of initial oil endowments they find that oil increases life expectancy and decreases infant mortality in the long run. They also find that the effect is stronger in non-democratic countries.

I depart from the existing literature in several ways. First, I use stochastic frontier analysis (SFA) and to the best of my knowledge this is the first study including oil rents as an inefficiency determinant in SFA. The empirical techniques used in the literature all assume that countries produce efficiently completely ignoring inefficiency. That inefficiency is present in the health care sector is well established (Greene, 2005a; Grigoli and Kapsoli, 2013; Kapsoli and Teodoru, 2017; Ogloblin, 2011). Further, SFA uses inputs -public/private health care expenditure and education- to estimate the production function, apart from education the empirical literature does not control for government preferences in the form of health care expenditure. Second, I exploit exogenous variation in oil rents due to fluctuations in the international oil price to establish causality. Third, I conduct a heterogeneity analysis and test whether the effect is different across institutional quality, sex and age. The latter two dimensions represent new results.

The identification strategy is similar to Smith (2016) and relies on the stochastic, often unpredictable nature of price changes. I compare oil rents in boom, bust and valley years. Boom years are defined as years in which the international oil price increases by at least 10% compared to the previous year and in bust years the oil price decreases by at least 10%. Valley years are years with less than +/- 10% price fluctuation and serve as comparison unit. The plausible exogenous variation of the international oil price can be exploited to analyse unexpected changes in oil income in a country. A decrease in oil income should force the government to save which in turn should increase inefficiency. Hence, a causal relation should show up as greater inefficiency in bust years compared to valley years. The effect in boom years is more ambiguous. An increase in the international oil price should increase the state budget and increase funds available for the health care sector. More investment should improve life expectancy but the effect on inefficiency could go either way, depending on investment quality. Inefficiency could decrease if the additional funds are invested efficiently but inefficiency could also increase if the additional funds are spent in a wasteful or corrupt manner. Identification strategy and methodology are discussed in section 2 and 3.

The results indicate that oil is a significant determinant of inefficiency and explains aside from other factors why life expectancy is lower in oil rich countries compared to oil poor countries. For example, the average technical efficiency estimate of oil rich high-income countries is 0.94 compared to 0.97 in oil poor countries in the same income group. The potential gains in life expectancy from eradicating inefficiency in oil rich high-income countries would be 5 years compared to only 2 years in oil poor high-income countries. The boom-bust-valley year analysis shows that the effect is causal for the full sample running from oil rents to inefficiency. The effect is also heterogeneous and stronger in democratic countries compared to intermediate and autocratic countries and causality could only be established in the democratic sub-sample, but not in the intermediate and autocratic sub-sample. This result seems surprising considering that many scholars attribute adverse effects of natural resources to a low level of institutional quality (e.g. Mehlum et al. (2006); Bhattacharyya and Hodler (2010); Bhattacharyya and Collier (2014); Robinson et al. (2006)). Nevertheless, considering the analysed outcome (health) a good with a wide reach the result is in line with de Mesquita and Smith (2002) selectorate theory. [2] Further, the results are heterogeneous across sex and age. Women's health is more affected by oil than men's and children suffer more than adults. The results for women is in

[2]The selectorate theory states that in countries with a big selectorate and big winning coalition (democracies) it is more cost efficient to use goods with a wider reach (e.g. health care) for the leader to appraise her supporters and stay in office. In countries with a small selectorate and winning coallition (autocracies) it is more cost efficient to use private goods.

line with Ross (2008) theory of an oil driven women impeding effect in oil rich countries. The children results are new.

The results are robust to the exclusion of potential oil price setters, time lags and different definitions of price shocks. The robustness checks are discussed in section 6.

Transparency and inequality are identified as potential channels through which oil rents affect inefficiency in the health care sector. Oil rents incentivize the government to be less transparent, so it is easier to use them for their own purposes, such as patronage spending or stealing (Ross, 2011; Williams, 2011). Lower transparency increases the possibilities for officials to enrich themselves and spend the money with their own aims in mind contributing to inefficiency. Inequality persists in oil rich countries because oil is a point-source resource from which the elite benefits disproportionally more relative to the rest of the population (Karl, 2007). Inequality impedes poor people from accessing health care facilities and promotes the misallocation of funds contributing to inefficiency (Ogloblin, 2011). My analysis confirms that lower transparency and higher inequality lead to higher inefficiency in the health care sector in democratic countries. The two mechanisms are tested and discussed in section 7.

The paper contributes to the literature about the resource curse, social development and health care spending efficiency. Health represents human capital itself and is also an input to produce other forms of human capital (Bleakley, 2010). Human capital contributes to economic growth and an inefficient health care sector triggered by oil could reduce human capital accumulation. Therefore, the analysis shows a way how natural capital in the form of oil reduces human capital and in turn could slow down economic growth. Further, the paper contributes to the literature concerned with the determinants of social development. The SFA analyses how a non-monetary well-being indicator −life expectancy− is affected by oil. Finally, the paper contributes to the literature concerned with efficiency in the health care sector. Health care expenditure contributes between 9-10% to world GDP representing a significant part in most economies (Ortiz-Ospina and Roser, 2018). Therefore, the scarce resources should be used in the most efficient way possible, because waste in this sector does not only affect economic indicators but everyone's life directly.

The paper proceeds as follows: Section 2 outlines the identification strategy used to test for a causal relationship between oil and inefficiency in the health care sector. Section 3 explains the stochastic frontier approach and section 4 describes data and descriptive statistics. Section 5 and 6 presents results and robustness checks. Section 7 discusses possible mechanisms and section 8 concludes.

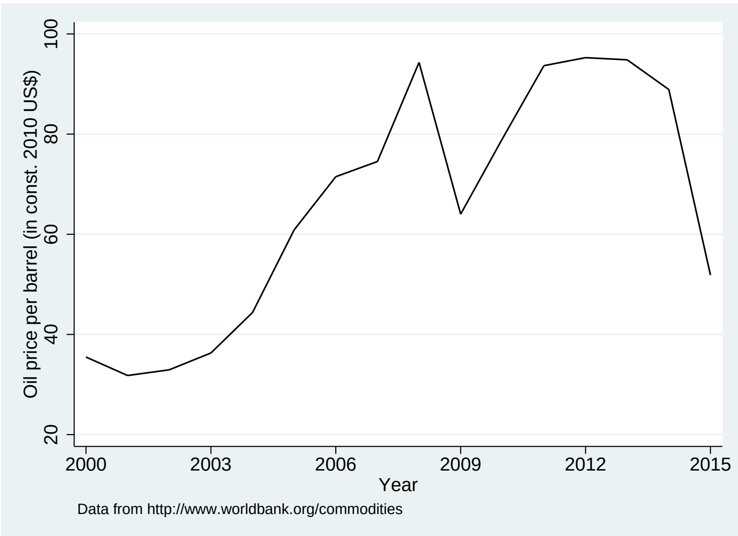
2. Identification Strategy

Identifying causality in an analysis concerned with natural resources is a major challenge. It can be argued that any dependent variable could cause a change in oil production or exploration efforts and is therefore vulnerable to reverse causality. For example, an inefficient health care sector could be the reason to extract more resources to generate more funds which in turn could be invested into the health care sector to improve life expectancy through higher investments or efficiency improving investments.

To establish a causal relation running from oil rents to health care inefficiency it would be necessary to exploit exogenous variation in oil income. Several strategies have been proposed in the literature ranging from the timing of giant resource discoveries (Arezki et al., 2017; Bhattacharyya et al., 2017; Cotet and Tsui, 2013a) over instrumenting past reserves (Edwards, 2016) or price fluctuations due to natural disasters (Ramsay, 2011) to price shocks (Smith, 2016). This study follows a strategy similar to Smith (2016) exploiting price shocks during the 2000-2015 period. This period offers a wide range of oil price changes which are plausibly exogenous. To define the price shocks as exogenous it is necessary to establish that the shocks are orthogonal to country's characteristics, i.e. the oil producers did not influence the oil price shocks and did not anticipate it (Liou and Musgrave, 2014).

From the beginning of the 2000s until 2008 the international oil price increased by 165% (see figure 1). The reasons for this boom are still discussed in the literature. The main arguments include an increase in demand for oil driven by economic growth in China (Hamilton, 2009), low interest rates set by the Federal Reserve resulting in depreciation of the US$ (Carter et al., 2011; Frankel, 2008), and speculative investment (Masters, 2008). In 2009 the oil price plummeted by 32% due to the Great Recession but consistent high demand from China and low interest rates set by the Federal Reserves helped the oil price to recover quickly. After the recovery the oil price stayed at an elevated level till 2013 and between 2013 and 2015 a decrease of the oil price by 45% occurred which is associated with a decline in world economic growth and to a lesser extent to the shale oil revolution in the US (Prest, 2018).

Figure 1: Oil price 2000-2015



Oil producing countries can influence the international oil price only through the supply side. Except for the shale oil revolution in the US, the reasons mentioned in the literature explaining the oil price fluctuation happened on the demand side. This makes the price fluctuations for this period plausible exogenous for oil producers.

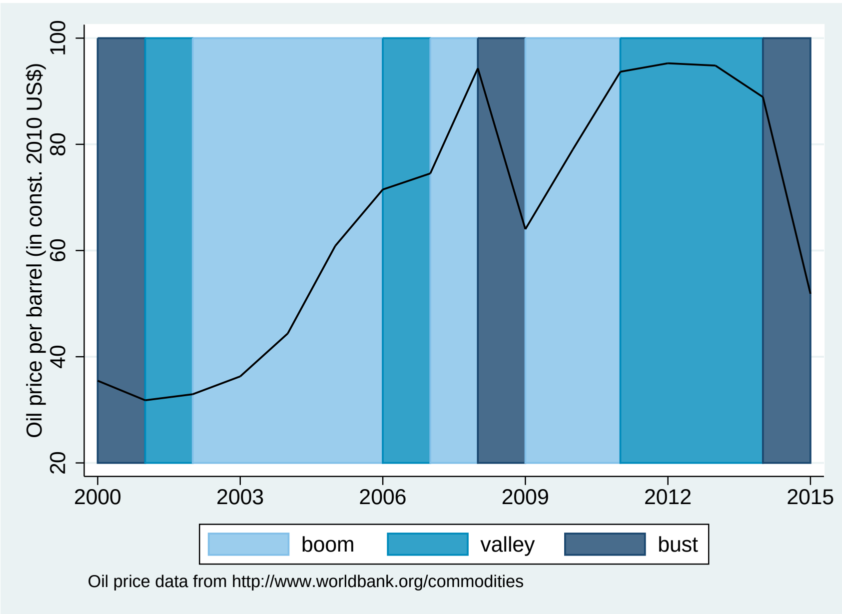
The only country traditionally associated with enough market power to influence the international oil price is Saudi

Arabia (Fattouh and Mahadeva, 2013). Saudi Arabia played for a long time the role of a swing producer to stabilize oil prices. However, in recent years through the shale oil revolution the new big player in the oil market is the USA (Morse, 2018). Saudi Arabia makes its decisions within OPEC and the USA can influence the oil price through shale oil production and its own interest rate. Therefore, both countries could have influenced the oil price between 2000 and 2015. To ensure that Saudi Arabia, the USA and OPEC do not drive the results by influencing the oil price I run robustness checks excluding those countries individually and combined and the results do not alter (robustness checks are shown section 6).

The remaining oil producing countries in the sample do not have large enough market shares to influence the oil price and cannot anticipate the shocks[3] making the price fluctuations between 2000 and 2015 plausibly exogenous for them.

To exploit the price fluctuations, I define boom and bust years as years in which the oil price increased or decreased by more than 10% respectively compared to the previous year. The remaining years with fluctuation less than 10% are defined as valley years and serve as comparison group. Figure 2 shows the oil price from 2000 to 2015 and indicates the boom, bust and valley years for the sample period.

Figure 2: Boom, bust and valley years



The strategy of this paper is to exploit price fluctuations of the international oil price as exogenous shocks in oil income. Overall, the oil rents coefficients in boom, bust and valley years are expected to be positive and significant, i.e. inefficiency is greater in oil producing countries. Further, a significant difference in the size of the effect in boom

[3]See Keller (2019) chapter 3 for a discussion about oil price anticipation.

and bust years compared to the effect in valley years would imply that changes in oil rents influence inefficiency. If the difference between boom, bust and valley years is according to expectation, then it can be concluded that causality runs from oil rents to inefficiency and not the other way around. The expected changes in boom and bust years will be discussed below.

The effect in boom years is expected to be ambiguous, i.e. inefficiency could increase or decrease due to an increase in oil income. This is because in boom years oil income should increase the state budget and the extra funds can be invested in the health care sector. This should increase the performance in terms of life expectancy by shifting the production function outwards. However, the effect on inefficiency −distance between actual outcome and production function− depends on the quality of the investment. Hiring an additional doctor or a nurse should decrease inefficiency if the doctor or nurse is needed in the hospital. If the doctor or nurse is not needed and the motivation for hiring was to reduce unemployment then the additional doctor or nurse will not improve the performance of a hospital and could increase inefficiency. Similarly, building a new hospital should increase access to health care, increasing life expectancy and decrease inefficiency. However, if the hospital is built in a special location to favour a certain group and gain political support then the impact on efficiency is not clear and depends on the location's initial hospital endowment. It could be that this location already has enough hospitals and it would have been more efficient to build it somewhere else.

The effect in bust years should be unambiguous, showing an inefficiency increase compared to the effect in valley years and is used in this study as the base to establish causality. The unexpected decrease in the international oil price should reduce funds available for investments and should lead to austerity. Austerity comes with an increase in inefficiency, especially in the health care sector. First, unfinished projects which only contributed so far to costs −but benefits have not been harvested yet− are usually the first to be cancelled. Second, necessary updates −like investments in new medical machinery− will be delayed making it necessary to use already out-dated and therefore inefficient machinery for longer. Third, saving in health care personal usually affects first support workers, nurses and junior doctors in that order. Especially nurses and support workers serve complimentary for senior doctors to perform efficiently. Therefore, a decrease in the oil price (bust year) should increase inefficiency.

The exception could be that in bust years unprofitable investments are shut down first which could overall increase efficiency. However, this is unlikely because if an inefficient project started it is likely that the motivation behind it was not purely driven by a social cost-benefit argument but rather by the incentive of personal gains such as in 'white elephant' projects[4] to gain political support (Robinson and Torvik, 2005). Shutting down these projects first would be the same as admitting by the politician that the project was unproductive in the first place and would harm the politician's reputation. To avoid the bad reputation the politician is incentivised to shut down efficient projects before shutting down his/her 'own inefficient projects'.

It could also be argued that spending cuts generate more value per dollar with improvements in terms of efficiency.

[4]White elephants are investments with negative social surplus and can be used by politicians to gain political support in the form of patronage (Robinson and Torvik, 2005).

However, the effect on inefficiency depends on the comparison group and timing. First, even if the value per dollar increases the counterfactual could still be an even greater increase in value per dollar terms. Second, the potential benefits of spending cuts in term of health outcomes or inefficiency usually take time to develop. In the short-run, it is even more likely that inefficiency increases because personal needs time to adjust to the new situation.

Summarizing the identification strategy: fluctuation in the international oil price should increase/decrease oil rents. The effect of oil rents on inefficiency in valley years is used as the baseline effect showing the basic level of inefficiency due to oil. Changes in this baseline effect, i.e. different coefficients in boom and bust years, can be attributed to an increase/decrease in oil price and therefore interpreted as a causal relationship running from oil rents to inefficiency in the health care sector. Because the effect on inefficiency is ambiguous in boom years, the analysis focuses on the difference of the effect between bust and valley years. A confirmation for causality running from oil rents to inefficiency would show up as significant greater inefficiency in bust years compared to valley years.

3. Methodology

In this section, I explain the conceptual framework of efficiency analysis followed by a detailed explanation of the stochastic frontier methodology used to estimate the impact of oil on inefficiency in the health care sector. I start by explaining basic concepts relevant to efficiency analysis.

Production is simply defined as the process transferring inputs into outputs. In this context, inefficiency can be defined in two ways, first as output-oriented and second as input-oriented inefficiency. A production process is efficient if the highest possible output is achieved with given inputs (output-oriented), or that a given output cannot be achieved with fewer inputs (input-oriented) (Kumbhakar et al., 2015). The focus in this study is on output-oriented inefficiency for two reasons. First, the budget allocated to the health care sector is usually fixed for a certain period, hence the health care sector produces outputs with given inputs. Second, the output −life expectancy− is supposedly to be maximised and not set to a given level.

Inefficiency in this paper always refers to technical inefficiency. Contrary to allocative inefficiency, technical inefficiency is only concerned with the fact that given inputs are fully utilized given current technology. Allocative inefficiency would also be concerned with the possible combinations of inputs used to produce the output. However, to estimate allocative inefficiency it would be necessary to use a cost minimization or profit maximization approach, both would need information about the quantity and price of each input (Kumbhakar et al., 2015). Such detailed data is not available and therefore only technical inefficiency is considered.

The methodologies used to estimate technical efficiency can be categorized into parametric and non-parametric approaches. Both have advantages and disadvantages. Parametric approaches for example require several assumptions on the distribution of the error term and the functional form of the model. However, one advantage of parametric approaches is that they assume a stochastic relation between inputs and outputs, which allows to separate inefficiency from measurement errors and noise in the data. The most often used parametric method is the stochastic frontier model (Kapsoli and Teodoru, 2017).

Non-parametric methods, on the other side, do not require assumptions about the shape and form of the inefficiency term because they are based on mathematical programming. However, this advantage of non-parametric methods creates also disadvantages because they do not account for randomness in the data. Each observation is assumed to provide information which ignores measurement errors and noise in the data and makes the approach sensitive to outliers (Grigoli and Kapsoli, 2013). Further, it is difficult to estimate unbiased coefficients for the determinants of inefficiency.

To estimate the impact of oil on inefficiency in the health care sector I use a dataset covering 119 countries. The countries are potentially heterogeneous in several ways and the data could include measurement errors and perhaps outliers. Those reasons are already enough to opt for a parametric approach in the form of stochastic frontier analysis, however, considering that the main aim of this paper is to determine whether oil is a determinant of inefficiency and the non-parametric approaches do not provide a convincing strategy to measure unbiased estimators it becomes necessary to use stochastic frontier analysis in this setting.

The Stochastic Frontier Model

The idea of stochastic frontier analysis (SFA) was initially developed in the seminal papers from Aigner et al. (1977) and Meeusen and van den Broeck (1977). The basic idea consists of estimating an OLS and split the error term into a noise term and an inefficiency term, such that the model to be estimated is of the following form:

$$y_i = \alpha + x_i'\beta + \epsilon_i, \quad i = 1, \ldots, N \tag{1}$$

$$\epsilon_i = v_i - u_i \tag{2}$$

$$v_i \sim \mathcal{N}(0, \sigma_v^2) \tag{3}$$

$$u_i \sim \mathcal{F}(\mu_i, \sigma_u^2) \tag{4}$$

where y_i represents the logarithm of the output and x_i is a vector of inputs in country i. β is the vector of technology parameters showing the impact of an input on the output. The composed error term, ϵ_i, consists of a random component, v_i, representing measurement and specification errors, and a one-sided disturbance component, u_i, representing inefficiency. The distribution of the random component, v_i, is assumed to follow a normal distribution with zero mean and variance σ_v^2. The distribution of the one-sided disturbance component, u_i, must be assumed to make the model estimable. The most common assumptions about the distribution of u_i is the half-normal ($u_i \sim \mathcal{N}^+(0, \sigma_u^2)$), exponential ($u_i \sim \mathcal{E}(\sigma_u)$), gamma ($u_i \sim \mathcal{G}(\Theta, P)$) and truncated-normal ($u_i \sim \mathcal{N}^+(\mu_i, \sigma_u^2)$).

Since Aigner et al. (1977) and Meeusen and van den Broeck (1977) many new models were developed with more desirable characteristics (e.g. Greene (2005b); Schmidt and Sickles (1984); Stevenson (1980); Battese and Coelli (1988); Cornwell et al. (1990); Pitt and Lee (1981); Battese and Coelli (1992, 1995); Kumbhakar (1990); Belotti et al. (2013)). One of the main improvements was the introduction of panel data in SFA. Cross-sectional data allow to estimate the performance of each country at one point in time, while panel data allow to estimate the pattern of inefficiency over time. This is important because there is no reason to believe that inefficiency in the health care sector is constant over time. Further, panel data allow to separate country specific effects that are not related to inefficiency (Battese and Coelli, 1995).

The model chosen in this study is from Battese and Coelli (1995). It allows the use of panel data estimating time variant inefficiency and it also includes the possibility to estimate inefficiency determinants, which is of special interest for this study because the main question is whether oil rents influence inefficiency in the health care sector. The estimated model is of the following form:

$$y_{it} = \alpha + x'_{it}\beta + \epsilon_{it}, \quad i = 1, \ldots, N, \ t = 1, \ldots, T_i \tag{5}$$

$$\epsilon_{it} = v_{it} - u_{it} \tag{6}$$

$$v_{it} \sim \mathcal{N}(0, \sigma_v^2) \tag{7}$$

$$u_{it} \sim \mathcal{F}(\mu_{it}, \sigma_u^2) \tag{8}$$

where everything is defined in the same way as in equation 1 - 4 except for the subscript t indicating that the observations are now for country i in year t. Including the time dimension and comparing the same country over time allows to estimate time variant inefficiency. Further, Battese and Coelli (1995) show that equations 5 - 8 allow to define the mean of the inefficiency distribution, μ_{it}, as a function of explanatory variables. This allows to estimate the production function and the inefficiency determinants simultaneously.

Battese and Coelli (1995) define u_{it} as:

$$u_{it} = z'_{it}\delta + w_{it} \tag{9}$$

where z'_{it} is a vector of inefficiency determinants and δ are the parameters to be estimated. Thus, δ shows how a variable of the z-vector influences the inefficiency term. w_{it} is a random variable defining the truncation of the normal distribution with zero mean and variance σ^2. w_{it} is set such that the point of truncation is $-z'_{it}\delta$. Therefore, u_{it} has the following distribution: $\mathcal{N}^+(z'_{it}, \sigma_u^2)$, i.e. a non-negative truncated normal distribution with mean $z'_{it}\delta$ and variance σ_u^2.

Equations 5 - 9 can be estimated with maximum likelihood (Battese and Coelli, 1995) and technical efficiency in country i in year t is defined by equation 10:

$$TE_{it} = exp(-u_{it}) = exp(-z_{it}\delta - w_{it}) \tag{10}$$

One shortcoming of the Battese and Coelli (1995) model is that the intercept α is the same across countries leading to a potential misspecification bias in the presence of time-invariant unobservable factors, which are unrelated to the production process but affect the output. The time-invariant effect of these factors may be falsely included in the inefficiency term leading to biased results (Greene, 2004). Greene (2005b) developed the 'true fixed effects' model to deal with the potential problem of time-invariant unobservable heterogeneity. The main difference to Battese and Coelli (1995) is that the intercept α in equation 5 becomes α_i, a unit specific intercept. The two models represent two extremes, while Battese and Coelli (1995) include all time-invariant unobserved country differences in the inefficiency term, Greene (2005b) excludes all of them from the inefficiency term. How much of the unobserved country differences should be part of the inefficiency term is debatable and the truth would most likely lie between the two extremes (Greene, 2005c). Hence, the best approach would be to estimate both models and see them as upper and lower bound estimates of the true values. However, my attempt to estimate Greene (2005b) 'true fixed effects' model failed as the regression did not converge. Therefore, I admit the shortcoming of Battese and Coelli (1995) that all time-invariant unobserved heterogeneity is included in the inefficiency term and try to mitigate this issue by including income dummies in the production function to group countries which are more similar than others together which should reduce the problem to a certain extend.

Production function of health (y and x variables)

The outcome variable (y_{it}) is the natural logarithm of *life expectancy at birth* indicating the number of years a newborn infant would live if prevailing patterns of mortality at the time of birth were to stay the same (The World Bank, 2018b).

The following variables are included in the production function as inputs (x):

Publ. exp. Public health care expenditure per capita in international purchasing power parity (PPP) dollars.

Priv. exp. Private health care expenditure per capita in international purchasing power parity (PPP) dollars.

Schooling Mean years of education of the population over 25.

All input variables are converted to their natural logarithm. *Public* and *private expenditure* are the monetary resources a country allocates to the health care sector to pay for doctors, nurses, medicines and medical equipment. The impact on the output should therefore be self-explanatory. Higher spending −public or private− should be positively correlated with *life expectancy*. The monetary values are measured in international purchasing power parity dollars to make them comparable across countries. Note, *public* and *private health expenditure* refer to mandatory and voluntary contributions to the health care sector respectively (OECD/WHO, 2014). Hence, the variables do not measure the performance of private or public health care facilities such as private or public hospitals.[5]

There is also consensus in the literature that educational attainment is an input in the production function of health (Evans et al., 2000; Greene, 2005b; Ogloblin, 2011). *Schooling* is positively correlated with *life expectancy* and is

[5]See section 4 for a detailed definition of the expenditure variables.

likely to be a causal factor in the production of health. Better educated people tend to have healthier life-styles with more exercise, better diet, use of preventive care and a better understanding of medical treatments. Following Evans et al. (2000) and Greene (2005b), a square term of *schooling* is also included in the production function to account for the diminishing effect of education.

A critical point with SFA is that a form of homogeneity in the production function is assumed. The homogeneity assumption is that countries produce with the same technology (Kumbhakar et al., 2015). This creates an issue in an analysis pooling potentially heterogenous countries together. It is likely that low-income countries use different or out-dated technology compared to high-income countries. To control for this issue, income dummies for low-, lower middle-, upper middle- and high-income countries are included in the production function in all regressions.[6] Countries are categorised according to World Bank income categories. The inclusion of the income dummies allows to estimate a production function for each income group and compares therefore only countries with similar income level. The same level of income should reduce the heterogeneity of technology used in the health care sector between countries.

Finally, to control for technological change over time, time dummies are included for each year in the production function in all specifications (Greene, 2004).

Determinants of inefficiency (z-variables)

The inefficiency determinants or z-variables included in equation 9 are the *log of GDP per capita* and *oil rents*.

The literature shows that *GDP per capita* is a significant determinant of *life expectancy* (Edwards, 2016), however, it cannot be included in the production function because it does not represent a health input (Greene, 2005a). On its own *GDP per capita* does not make people healthier (Ogloblin, 2011). The impact of *GDP per capita* on *life expectancy* goes through channels, such as higher spending on health, which is already controlled for in the form of *private* and *public expenditure* or higher educational attainment, which is also controlled for in the *schooling* variable. Apart from *health expenditure* and *schooling*, *GDP per capita* also influences the access to goods and services that enhance health and therefore *life expectancy*, such as nutrition or proxies for general working conditions in the country that can have an effect on health outcomes (Ogloblin, 2011). The fact that the impact of oil on income is still debated in the literature also contributed to the decision to include *GDP per capita* as a z-variable. Assuming that both sides of the resource curse literature are partly correct and oil increases income in some countries and decreases it in others, then any effect of *oil rents* on inefficiency could be cancelled out resulting in insignificant results. As long as there is no agreement about the relation between oil and income I control for it in all specifications. Therefore, the estimates represent the impact of *oil rents* on inefficiency aside from any effect *oil rents* have on income.

Finally, the variable of interest in this study is *oil rents* and measures oil revenues minus the costs of oil extraction as percentage of GDP and is derived from the World Development Indicators.

[6] To avoid multicollinearity the low-income dummy was dropped and represents the base category.

4. Sample, data and descriptive statistics

The data are primarily retrieved from the World Health Organization (WHO) and World Bank databases. Analysis was restricted to 119 countries for which all data are available for the whole period 2000 to 2015. Hence, I am using a balanced dataset. A list of all countries in the sample is provided in Appendix A table A.1. Table 1 shows descriptive statistics of the variables used in the stochastic frontier analysis and for an overview of definitions and sources see table A.2 in Appendix A.

Life expectancy at birth is from the World Development Indicators and measures the years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same (The World Bank, 2018b). *Life expectancy* varies widely in the sample from 39 years in Sierra Leone to 83 years in Italy with a mean of 68 years.

Public and *private health expenditure* data are from WHO and the basic differentiation between the two follows the rule whether payments or contributions are compulsory or not (OECD/WHO, 2014). Therefore, *public* and *private health expenditure* does not measure who provides the health service (e.g. a private or a public hospital), rather they measure how the money is raised (in a mandatory or voluntary scheme). *Public health expenditure* includes transfers from government domestic revenues, social insurance contribution, compulsory prepayment other than social contribution (variable FS1, FS3 and FS4 in the SHA2011 framework). *Private health expenditure* includes voluntary prepayments and other domestic revenues (FS5 and FS6 in the SHA2011 framework).[7] Transfers from government domestic revenues (FS1) are the funds from the state budget allocated to the health care sector and includes income from the oil sector.

Public health expenditure per capita varies widely between countries. The smallest public contribution to health expenditure occurs in the Democratic Republic of the Congo with a small $0.58 per capita in 2000, while Luxembourg provides a staggering $5290 in *public health expenditure per capita* in 2009.[8] Private contributions are highest in the United States with $4350 in 2015, which is almost three times as high as the second highest private contribution made to the health care sector of $1630 per capita in Singapore in the same year.

Table 1: Descriptive statistics

	N	Mean	St.d.	Min	Max
Life expectancy	1904	67.66	9.24	38.70	83.09
Public health exp. p.c.	1904	518.10	848.03	0.58	5,290.82
Private health exp. p.c.	1904	291.52	429.52	3.35	4,355.71
Schooling in years	1904	7.29	3.10	1.10	13.30
Income group	1904	2.55	1.03	1	4
Democracy	1808	1.63	0.79	1	3
GDP per capita	1904	14,903.33	20,479.60	503.83	129,349.92
Oil rent (% of GDP)	1904	5.32	11.15	0.00	60.78

[7] FS2 and FS7 are not included because they have foreign origins, e.g. bilateral or multilateral aid and poor data coverage.
[8] Monetary values are measured in purchasing power parity (constant 2010 international dollars).

The average years of education of the population over 25 is around 7 years. Income groups are defined according to World Bank income groups. The maximum value of *oil rents* occurs in Kuwait in 2011.

Mehlum et al. (2006) argue that the resource curse is conditional on institutional quality and that any adverse effect should be greater or more pronounced in non-democratic countries. To exploit this potential source of heterogeneity I categorized countries according to the Polity2 index which measures the level of democracy on a 21 point scale ranging from -10 to +10 with -10 indicating a fully autocratic country and +10 a fully democratic country (Marshall and Jaggers, 2014). The countries in the sample are defined as democratic (Polity2: +4 to +10), intermediate (Polity2: -3 to +3) and autocratic (Polity2: -4 to -10) countries.[9]

Comparing the average values of *life expectancy*, *public* and *private health expenditure* between income groups shows significant differences (see table 2). The mean of each variable is significantly different from the mean of the other income groups and underlines the necessity to control for income in the production function. As discussed in section 3, lower income should also lead to cheaper or out-dated technology, which is usually less efficient. Hospitals with limited funds are more likely to acquire the out-dated cheap version of medical equipment than a hospital with more funds.

[9] Table A.1 in Appendix A lists all countries and the corresponding institutional category.

Table 2: Differences in life expectancy, public and private health expenditure
by income group

Panel A: Life expectancy				
	Low income	Lower middle inc.	Upper middle inc.	High income
Low income	0			
	–			
Lower middle inc.	9.5	0		
	(0.000)	–		
Upper middle inc.	14.5	4.9	0	
	(0.000)	(0.000)	–	
High income	21.3	11.7	6.8	0
	(0.000)	(0.000)	(0.000)	–

Panel B: Public health expenditure				
	Low income	Lower middle inc.	Upper middle inc.	High income
Low income	0			
	–			
Lower middle inc.	79.86	0		
	(0.000)	–		
Upper middle inc.	331.14	251.27	0	
	(0.000)	(0.000)	–	
High income	1745.40	1665.53	1414.26	0
	(0.000)	(0.000)	(0.000)	–

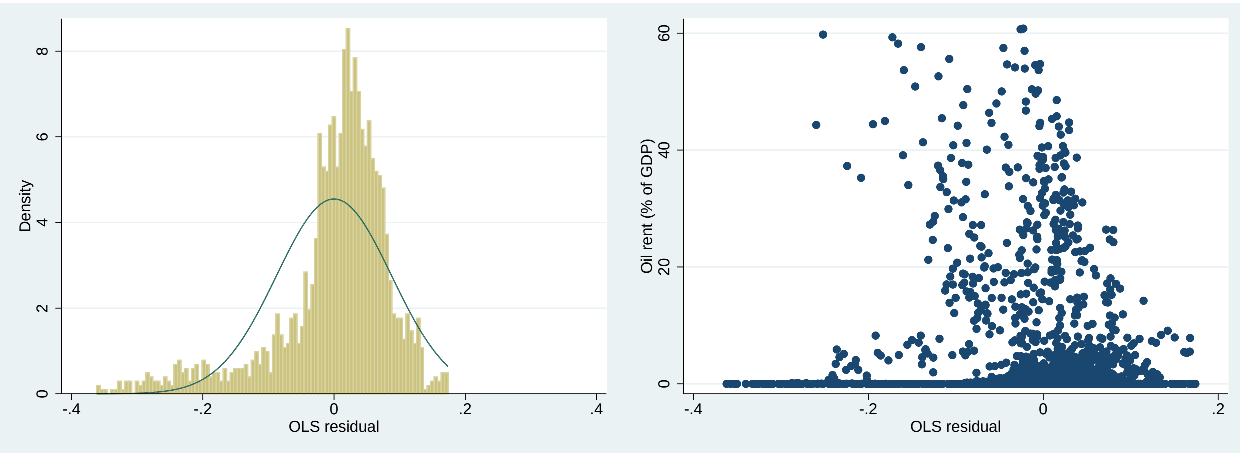
Panel C: Private health expenditure				
	Low income	Lower middle inc.	Upper middle inc.	High income
Low income	0			
	–			
Lower middle inc.	81.96	0		
	(0.000)	–		
Upper middle inc.	247.23	165.28	0	
	(0.000)	(0.000)	–	
High income	743.46	661.50	496.23	0
	(0.000)	(0.000)	(0.000)	–

Notes: The table shows the mean difference of *life expectancy*, *public* and *private health expenditure per capita* between income groups. P-values from Wald tests, testing for significant differences between the means, are shown in parenthesis.

Before discussing the results, I perform a test for the existence of inefficiency in the sample. By estimating the production function shown in equation 5 as a simple OLS without inefficiency term to test if the distribution of the residuals is skewed. Left skewness of the residual distribution indicates that inefficiency is present in the sample (Schmidt and Sickles, 1984). The left panel of figure 3 shows the distribution of the residuals compared to a normal distribution. The left skewness is visible in the figure and confirmed by a skewness test for normality following D'Agostino et al. (1990) (skewness: -1.443; p-value: 0.000).

The skewness so far only shows that inefficiency is present in the sample but says nothing about any determinants. A scatterplot of the residuals and *oil rents*, right panel of figure 3 indicates that the skewness of the residual distribution is at least partly related to the level of *oil rents* in an economy.

Figure 3: Residual distribution



5. Results

Oil rents and inefficiency in the health care sector

Before testing for the causal relationship between *oil rents* and inefficiency in the health care sector, I estimate the stochastic frontier with the plain *oil rents* variable to see if the production function coefficients are according to expectation.[10]

Column (1) in table 3 shows the baseline specification with all 119 countries and coefficients for the production function and mean inefficiency terms. The coefficients of the frontier function are in line with the literature.

[10]The *production function* part of the tables shows the coefficients for the x-variables and their impact on *life expectancy*. The *mean inefficiency* part shows the coefficients for the z-variables which measures the impact on inefficiency.

Table 3: SFA: Inefficiency in the health care sector

	(1)	(2)	(3) Democracy	(4) Intermediate	(5) Autocracy
Prod. function					
Constant	3.8***	3.8095***	3.8504***	3.7678***	3.6995***
	(0.0373)	(0.0378)	(0.037)	(0.0708)	(0.1177)
Public exp.	0.014***	0.014***	0.0238***	0.0201	−0.0042
	(0.0013)	(0.0013)	(0.002)	(0.0226)	(0.0058)
Private exp.	0.0157***	0.0162***	0.0048*	0.012	0.0048
	(0.002)	(0.002)	(0.0028)	(0.0361)	(0.0045)
Schooling	0.3103***	0.2989***	0.2583***	0.3236**	0.5996***
	(0.0372)	(0.0382)	(0.0434)	(0.1419)	(0.1232)
Schooling^2	−0.0681***	−0.0656***	−0.0558***	−0.0668*	−0.1494***
	(0.0088)	(0.009)	(0.0103)	(0.0369)	(0.031)
LM income	0.0212***	0.0223***	0.0264***	0.0193	0.0083
	(0.0062)	(0.0063)	(0.0077)	(0.0439)	(0.022)
UM income	0.0133	0.015*	0.0388***	−0.0163	0.0186
	(0.0079)	(0.0078)	(0.0098)	(0.084)	(0.0229)
High income	0.0302***	0.0314***	0.0409***	0.0226	0.0532**
	(0.0095)	(0.0092)	(0.0127)	(0.0724)	(0.0266)
Mean inefficiency					
Constant	1.5717***	1.6087***	2.5087***	1.2496***	1.9382***
	(0.1326)	(0.1575)	(0.5276)	(0.1746)	(0.1269)
Oil rents	0.0083***		0.0295***	0.0073***	0.0021*
	(0.0011)		(0.0098)	(0.0008)	(0.0012)
Low oil dep.		0.016			
		(0.0189)			
Medium oil dep.		0.1526***			
		(0.0339)			
High oil dep.		0.3291***			
		(0.0489)			
GDP p.c.	−0.2141***	−0.2192***	−0.3577***	−0.1613***	−0.2334***
	(0.0222)	(0.0254)	(0.0845)	(0.0291)	(0.0156)
Distribution					
σ^2	0.034***	0.0345***	0.0618***	0.0136*	0.0237***
	(0.0046)	(0.0046)	(0.0173)	(0.0079)	(0.0013)
λ	0.9952***	0.9953***	0.9996***	0.9811***	0.9997***
	(0.001)	(0.0009)	(0.0002)	(0.1044)	(0.0001)
LL	2591.366	2589.115	1525.359	535.1794	522.2409

Notes: Production functions include time dummies. Public, private health care expenditure, schooling, schooling^2 and GDP per capita are converted to their natural logarithm. Low, medium and high oil dependent are dummies for countries producing between 1-10%, 11-20% and more than 20% of *oil rents* as percentage of GDP, respectively. *, ** and *** stand for significant at the 10%, 5% and 1% level.

Private and *public health expenditure* are positively correlated with *life expectancy*. A one percentage point increase in *public health expenditure* increases *life expectancy* by 0.014 percentage points. At the sample mean, a one percentage point increase in *public health expenditure* is equivalent to US$ 5 per capita and would increase *life expectancy* by 0.0095 years or around 3.5 days. *Private health expenditure* also has a positive correlation with *life expectancy*. The coefficient is slightly bigger compared to *public health expenditure*.

Educational attainment, *schooling*, shows a bigger effect than *health care expenditure*. The *schooling* coefficient of 0.3103 and -0.0681 of the square term indicate that an additional year of schooling at the sample mean of 7 years increases *life expectancy* by around 0.34% or 0.23 years (83 days). The maximum effect of *schooling* on *life expectancy* occurs at 10 years with 0.35% after which the effect slowly diminishes.

To interpret the income dummies, remember that low-income countries are the base category and therefore the positive significant coefficient of 0.0212 for lower middle-income countries indicates that *life expectancy* is 2.1% or 1.1 years higher in lower middle-income countries. Considering that the mean difference in *life expectancy* between low-income and lower middle-income countries is around 9.5 years it seems that 8.4 years are explained by differences in *private* and *public health care expenditure, schooling* and the z-variables (*oil rents* and *GDP per capita*). The upper middle-income dummy is insignificant on the other hand, which means that any difference in *life expectancy* is captured by the controlled variables. The high-income dummy shows a positive significant coefficient of 0.0302 indicating that *life expectancy* is around 3% or 1.7 years higher in high-income countries compared to low-income countries. Hence, 19.6 years of the difference in *life expectancy* between low- and high-income countries is explained by the control variables included in the specification.[11]

Now, I am turning to the determinants of inefficiency. In the Battese and Coelli (1995) model a positive coefficient of a z-variable indicates an inefficiency increasing effect while a negative coefficient is inefficiency decreasing.[12] The z-variables, *oil rents* and *GDP per capita* are both significant but point in opposite directions. The *oil rents* coefficient is positive indicating that more *oil rents* in an economy is positively correlated with inefficiency and explains partly why oil rich countries underperform in terms of *life expectancy*. The opposite is true for *GDP per capita* which seems to decrease inefficiency.

In column (2) of table 3, I test whether the correlation of *oil rents* and inefficiency is non-linear by introducing dummy variables for low, medium, and high oil dependent countries into the regression instead of *oil rents*.[13] The coefficient for low oil dependent countries is insignificant indicating that a low level of oil dependency does not necessarily affect inefficiency. Medium and high oil dependent countries on the other hand have highly significant

[11] Mean difference in *life expectancy* between low-income and high-income countries is 21.3 years, see table 2.

[12] Note, to interpret the magnitude of a z-coefficient it is necessary to calculate the marginal effects which require the calculation of an adjustment term. The adjustment term or marginal effects are not part of the output in Frontier4.1, the software developed by Coelli (1996) and used in this paper. Therefore, I am restricted here to interpret signs and compare coefficient size relative to each other. However, the adjustment term in this setting is always positive, because the z-variables are only included in the mean of u_{it} but not in the variance of u_{it} or v_{it} (Wang, 2002). Hence, the sign of the z-coefficients unambiguously indicates the direction of the effect.

[13] Low oil dependent countries are defined as countries with *oil rents* between 1 and 10% of GDP, medium oil dependent countries produce *oil rents* between 11 and 20% of GDP and high oil dependent countries produce more than 20% of GDP in *oil rents*. The omitted category are countries with less than 1% *oil rents* in GDP.

coefficients, both positive indicating that more oil dependency leads to higher inefficiency with the coefficient for high oil dependent countries double the size of the coefficient for medium oil dependent countries. Hence, higher oil dependency increases inefficiency whereas at low levels there seems to be no effect. This is in line with other findings of the resource curse literature that oil can be beneficial in a more developed and diversified economy but can be harmful in a less developed and more concentrated economy (Ross, 2017).

Next, I split the sample according to institutional quality to exploit potential heterogeneity. Mehlum et al. (2006) argue that the resource curse is conditional on institutional quality and that any adverse effect should be greater in autocratic countries. The countries are defined as democratic, intermediate and autocratic countries according to Marshall and Jaggers (2014) Polity2 index as explained in section 4.

Columns (3)-(5) show the results for the democratic, intermediate and autocratic sub-sample respectively. Surprisingly, the results are inverse of what Mehlum et al. (2006) predicted. The inefficiency increasing effect of *oil rents* is around 4 and 14 times bigger in democracies as it is in intermediate and autocratic countries respectively. This result is perhaps surprising but not entirely new. Cotet and Tsui (2013b) also find that oil rich autocracies are better performing with respect to *life expectancy* than their democratic counterparts.

A further explanation for this result lies in the characteristic of the health care sector. Health care can be provided as a public good with universal access and reaches therefore a wide range of the population. This is in particular important for policy makers in democratic countries but less so in autocratic countries. de Mesquita and Smith (2002)'s selectorate theory implies that in countries with a big selectorate and big winning coalition (democracies) it is more cost efficient to use goods with a wider reach (e.g. health care) for the leader to appraise her supporters and stay in office. In countries with a small selectorate and winning coallition (autocracies) it is more cost efficient to use private goods.

The results reported in table 3, so far confirm the hypothesis that there is a correlation between *oil rents* and inefficiency in the health care sector.

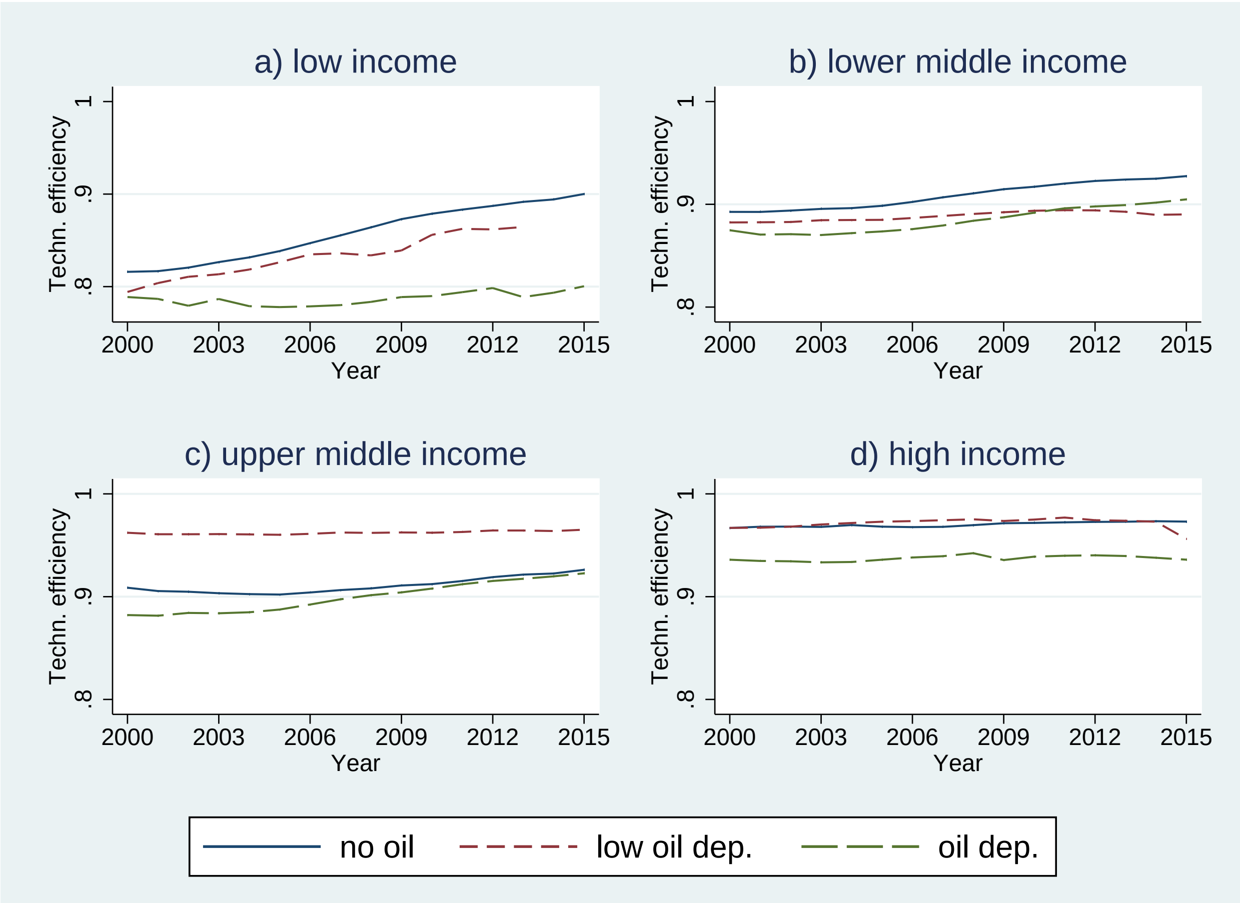
Technical efficiency over time

Next, I analyse how efficiency developed over time. Note that the efficiency estimates in this section do not show the impact of *oil rents* alone. They also incorporate the effects of *GDP per capita* and the constant term. It is a way of showing by how much a country could improve *life expectancy* if it could eradicate inefficiency completely. To bring the oil dimension back into the analysis all the results are shown according to oil dependency.[14] The average efficiency estimates for each individual country are shown in table A.3 in Appendix A.

Figure 4 shows average efficiency estimates by income group and oil dependency. The efficiency estimate can be interpreted as percentage term showing the actual performance of a country in terms of *life expectancy* as percentage of the maximum possible *life expectancy*.

[14] The oil dependency categories are: 'no oil' countries, defined as countries producing less than 1% of GDP in *oil rents*; 'low oil dependent' are countries with 1-10% *oil rents* of GDP; and 'oil dependent' countries include all countries with *oil rents* more than 10% of GDP.

Figure 4: Technical efficiency by income groups



Notes:'No oil' countries are defined as countries producing less than 1% of GDP in *oil rents* (blue line), 'low oil dependent' countries are countries with 1-10% *oil rents* of GDP (red line) and 'oil dependent' countries include all countries with *oil rents* more than 10% of GDP (green line).

In the low and lower middle-income group, 'no oil' countries have the highest efficiency score and 'low oil dependent' countries generally perform better than 'oil dependent' countries (Graph a) and b)). The sub-sample of upper middle-income countries shows that 'low oil' dependency can be beneficial with higher efficiency scores compared to 'no oil' and 'oil dependent' countries (Graph c)). In high-income countries 'no oil' and 'low oil dependent' countries are almost identical (Graph d)). The worst performing countries in the upper middle-income and high-income group are 'oil dependent' countries (Graph c) and d)).

The results previously derived from table 3 –*oil rents* increase inefficiency– seem to be driven by low- and high-income countries. To illustrate this, table 4 lists the mean efficiency score and *life expectancy* for each income group and compares them according to oil dependency. Potential gains in table 4 shows the number of years *life expectancy* would increase if inefficiency could be eradicated completely.

Table 4: Average efficiency, life expectancy and potential gains
by income groups and oil dependency

		no oil	**low oil dep.**	**oil dep.**
Low income	efficiency	0.86	0.83	0.79
	life expectancy	56.22	54.50	49.45
	potential gain	9.32	10.96	13.38
LM income	efficiency	0.91	0.89	0.88
	life expectancy	66.60	64.59	62.72
	potential gain	6.68	8.11	8.20
UM income	efficiency	0.91	0.96	0.90
	life expectancy	69.20	73.04	67.88
	potential gain	6.77	2.86	7.57
High income	efficiency	0.97	0.97	0.94
	life expectancy	77.91	78.10	74.38
	potential gain	2.40	2.32	4.98

Notes: 'No oil' countries are defined as countries producing less than 1% of GDP in *oil rents*, 'low oil dependent' countries are countries with 1-10% *oil rents* of GDP and 'oil dependent' countries include all countries with *oil rents* more than 10% of GDP. Income groups are defined according to World Bank income groups.

Comparing 'no oil' countries with 'low oil dependent' countries in table 4, there seems to be only minor differences in efficiency, *life expectancy* and potential gains in most income groups. The exception is the sub-sample of upper middle-income countries where 'low oil dependent' countries outperform 'no oil' countries and 'oil dependent' countries. Efficiency is as high as 96% in 'low oil dependent' upper middle-income countries, whereas it is only 91% and 90% in 'no oil' and 'oil dependent' countries, respectively.

'Oil dependent' countries underperform significantly in the sub-sample of low- and high-income countries. The potential gains of eradicating inefficiency in *life expectancy* amounts to 13 years in 'oil dependent' low-income countries which is two and five years more than in 'no oil' and 'low oil dependent' countries respectively. The gap is smaller in high-income countries, nevertheless, 'oil dependent' countries could still gain five years in terms of *life expectancy* compared to two years in 'no oil' and 'low oil dependent' countries.

Oil rents and inefficiency in boom and bust years

So far, the analysis used simply *oil rents* to establish the relationship between oil and inefficiency in the health care sector. This measure is easily marked as endogenous because an underperforming government could increase oil extraction and use the funds to close the gap and produce more efficiently in the health care sector. This would make inefficiency the reason for higher *oil rents* and not *oil rents* the reason for inefficiency.

Therefore, in this section I test for a causal relationship between *oil rents* and inefficiency in the health care sector by exploiting price fluctuations of the international oil price as exogenous income shocks. The *oil rents* variable is divided into boom, bust and valley years, whereas boom and bust years are defined as years in which the international oil price fluctuated by more than 10% compared to the previous year. The remaining years with fluctuation less than

10% are considered as valley years and serve as comparison group. The basic idea is that a significantly greater coefficient of the *oil rents* variable in bust years compared to the coefficient in valley years is an indication of causality from *oil rents* to inefficiency. See section 2 for a detailed discussion.

Table 5 shows the results with the *oil rents* variable divided into boom, bust and valley years. Overall, the coefficients for the production function are similar to those in table 3. Column (1) shows the result for the full sample, all three coefficients of the *oil rents* variable are positive and significant indicating that *oil rents* increase inefficiency in the health care sector in boom, bust and valley years. Comparing the *oil rents* coefficient in boom and valley years shows a smaller coefficient in boom years by around 9%. The difference between the two coefficients, however, is insignificant.[15]

[15] Any statement claiming a 'significant' difference between two coefficients have been tested with a Wald-test $\left(\sqrt{\frac{(A-B)^2}{var(A)+var(B)-2cov(A,B)}}\right)$.

Table 5: SFA: Inefficiency in boom, bust and valley years

Variable	(1)	(2) Democracy	(3) Intermediate	(4) Autocracy
Production function				
Constant	3.8004***	3.8506***	3.8184***	3.5827***
	(0.0365)	(0.0363)	(0.0589)	(0.1066)
Public exp.	0.014***	0.0238***	0.0132	−0.0039
	(0.0013)	(0.0018)	(0.0089)	(0.0039)
Private exp.	0.0157***	0.0048	0.0106**	0.0067**
	(0.0021)	(0.003)	(0.0051)	(0.0033)
Schooling	0.31***	0.258***	0.3227***	0.6859***
	(0.0365)	(0.042)	(0.0491)	(0.1252)
Schooling^2	−0.0681***	−0.0557***	−0.0693***	−0.1653***
	(0.0087)	(0.01)	(0.0106)	(0.0338)
LM income	0.0213***	0.0264***	0.0151	0.0133
	(0.0062)	(0.0076)	(0.01)	(0.1067)
UM income	0.0134*	0.0388***	−0.0101	0.0037
	(0.0078)	(0.0093)	(0.0062)	(0.1216)
High income	0.0305***	0.0409***	0.0444***	0.0414
	(0.0095)	(0.0118)	(0.0042)	(0.1436)
Mean inefficiency				
Constant	1.5706***	2.5077***	1.5341***	1.8264***
	(0.1557)	(0.517)	(0.0552)	(0.3155)
Oil rents boom	0.0078***	0.0278***	0.0075***	0.0033***
	(0.001)	(0.0094)	(0.0008)	(0.0012)
Oil rents bust	0.0111***	0.0426***	0.0087***	0.0025
	(0.0017)	(0.0113)	(0.0013)	(0.002)
Oil rents valley	0.0085***	0.0285***	0.0083***	0.0027***
	(0.0014)	(0.0101)	(0.0013)	(0.0003)
GDP per capita	−0.2138***	−0.3574***	−0.1963***	−0.2204***
	(0.0249)	(0.0827)	(0.0056)	(0.0452)
Distribution				
σ^2	0.0339***	0.0617***	0.0152***	0.0216***
	(0.0049)	(0.0168)	(0.0009)	(0.0075)
λ	0.9952***	0.9996***	0.9991***	0.9998***
	(0.001)	(0.0002)	(0.0016)	(0.0013)
LL	2592.348	1525.586	560.5318	518.0747

Notes:Production functions include time dummies. Public, private health care expenditure, schooling, schooling^2 and GDP per capita are converted to their natural logarithm. *, ** and *** stand for significant at the 10%, 5% and 1% level.

Comparing the coefficient in bust and valley years yields the expected result. The coefficient in bust years is significantly larger by around 30% compared to the coefficient in valley years indicating that inefficiency increases when the international oil price decreases. This result shows that the causal relationship between *oil rents* and inefficiency moves from *oil rents* to inefficiency. An exogenous decrease in oil income due to a negative price shock increases inefficiency in the health care sector.

Columns (2)-(4) in table 5 show the results for the democratic, intermediate and autocratic sub-samples. In democracies the direction of the effect and the causal relationship is the same as in the full sample with a significant difference between bust and valley years. The inefficiency increasing effect becomes larger by about 50% in bust years when the international oil price decreases.

The coefficients in the intermediate sub-sample have the same pattern as the democratic sub-sample with smaller coefficient in boom years and larger coefficient in bust years compared to valley years. However, the Wald test reveals that the differences between the coefficients are not significantly different from zero, i.e. causality cannot be established in the intermediate sub-sample. Furthermore, the causal relation does not hold in autocratic countries. The result indicates that autocratic countries are wasteful with their funds in boom years but not in bust years. Hence, causality running from *oil rents* to inefficiency present in the full sample is purely driven by the democratic sub-sample. The results for the intermediate and autocratic sub-samples do not show signs of a causal relationship between *oil rents* and inefficiency.

Oil rents and inefficiency in the health care sector by sex

Next, I analyse whether the *oil rents* driven inefficiency effect in the health care sector is heterogenous across sexes. Ross (2008) argues that oil leads to lower female labour participation and lower female representation in parliament. The sex discrepancy could also occur in the health care sector. Lower labour market participation of women reduces their income and could decrease private health investments and fewer women in parliament could lead to lower public health care spending for women.

Panel A of table 6 shows the results using *life expectancy, male* as dependent variable. The overall causal relationship is the same as before with *life expectancy, both sexes* (shown in Table 5). In the democratic sub-sample, the *oil rents* coefficient is significantly greater in bust years compared to valley years, showing a causal relation. Again, this is not the case for the intermediate sub-sample. While the coefficients point in the same direction, the differences are not significant. The sub-sample of autocratic countries does not show any significant effect of *oil rents* on inefficiency in boom, bust or valley years, i.e. inefficiency in the health care sector is not affected by *oil rents* for men in autocratic countries.

Table 6: SFA: Inefficiency by sex

	(1)	(2) Democracy	(3) Intermediate	(4) Autocracy
Panel A: Life expectancy, male				
Constant	1.2358***	1.4179***	1.3575***	0.931***
	(0.0992)	(0.1154)	(0.085)	(0.1942)
Oil rents boom	0.0058***	0.0192***	0.0068***	0.0007
	(0.0007)	(0.0032)	(0.0007)	(0.0017)
Oil renst bust	0.0081***	0.0291***	0.0095***	0.0032
	(0.0016)	(0.0065)	(0.002)	(0.0025)
Oil renst valley	0.0061***	0.0175***	0.0083***	−0.0012
	(0.001)	(0.004)	(0.0014)	(0.0026)
GDP per capita	−0.159***	−0.1896***	−0.1683***	−0.1018***
	(0.0153)	(0.0166)	(0.0121)	(0.0214)
Panel B: Life expectancy, female				
Constant	1.9417***	3.3678***	1.1668***	2.0609***
	(0.2244)	(0.4252)	(0.1014)	(0.1284)
Oil rents boom	0.01***	0.0243***	0.0051***	0.0039***
	(0.0014)	(0.006)	(0.0009)	(0.0012)
Oil rents bust	0.0141***	0.0346*	0.0087***	0.0054**
	(0.0025)	(0.0183)	(0.002)	(0.0023)
Oil rents valley	0.0112***	0.0223***	0.0066***	0.0033**
	(0.0017)	(0.0052)	(0.0014)	(0.0015)
GDP per capita	−0.2723***	−0.4746***	−0.1458***	−0.252***
	(0.0363)	(0.0692)	(0.0145)	(0.0156)

Notes: Production functions (not shown) include public, private health care expenditure, schooling, schooling^2 (converted all to their natural logarithm), income dummies and time dummies. GDP per capita is converted to natural logarithm. *, ** and *** stand for significant at the 10%, 5% and 1% level.

Panel B shows the results for *life expectancy, female* and while all the *oil rents* coefficients are positive and significant, the differences between boom, bust and valley years are not significant. There is no evidence for causality for female health production, only a strong correlation.

Nevertheless, comparing the coefficients between men and women shows that the inefficiency increasing effect of *oil rents* is generally greater for women. For example, in the full sample the boom, bust and valley coefficients are 72, 74, and 83% greater for *life expectancy, female* respectively compared to *life expectancy, male*. The same is true in the sub-samples of democratic and autocratic countries with greater coefficients in Panel B. For intermediate countries the opposite is the case. *Oil rents* coefficients are greater for men's health outcome compared to women's. For democratic and autocratic countries the results are in line with Ross (2008) argument and point towards a potential consequence of lower labour market participation and representation in parliament of women due to oil.

Oil rents and inefficiency in the health care sector by sub-population

Certain sub-groups of the population are more vulnerable than others, especially children and older people need more medical care than adults. To explore this potential source of heterogeneity in the effect of *oil rents* on inefficiency

I test whether mortality rates of certain sub-groups of the population are affected in a different way by *oil rents*.

The dependent variable in this setting is *mortality rate* instead of *life expectancy*. The reason for this change is that *life expectancy* is generally defined as the numbers of years a person would live if prevailing patterns of mortality were to stay the same (The World Bank, 2018a). Because of this definition a government investment aiming to improve health and therefore *life expectancy* of older people affects the 'prevailing pattern of mortality' for everyone younger than the older people. *Life expectancy* at birth would be affected in the same way as *life expectancy* for a 10-, 20-, 30- or 40-year-old person. Therefore, using *life expectancy* for different age groups would not be comparable. *Mortality rate* on the other side is specific for each age group or sub-sample of the population and a change in the *mortality rate* between 60 and 70 years does not affect the *mortality rate* between 10 and 20 year old people.

Mortality rates measure the number of the population in a sub-group dying before reaching a certain age and the available categories are neonatal, infant, child, adult (both sexes), adult (male), adult (female), and maternal mortality rate. Neonatal, infant and child mortality rates measure the number of dying newborns before reaching the age of 28 days, 1 year and 5 years, respectively. Adult mortality corresponds to the probability of dying between the age 15 and 60 years and maternal mortality measures the number of women dying because of pregnancy related reasons up to 48 days after pregnancy termination. Except for maternal mortality the data are measured as the number of deaths per 1000 people of the specific sub-population, maternal mortality measures the number of deaths per 100,000 live births.

All the mortality rates are rescaled by dividing the minimum number of deaths in year i by the actual number of deaths in year i and was multiplied by 100. The new scale is equal 100 for the best performing country, i.e. lowest mortality rate in year i and the measure decreases with higher mortality rate. Hence, the direction of the variable is the same as for *life expectancy* (higher values equal better outcomes) and a production function can be used again to estimate inefficiency.

Table 7: SFA: Inefficiency by age-groups

Mortality rate	(1) Neonatal	(2) Infant	(3) Child	(4) Adult
Mean inefficiency				
Constant	0.4002***	4.1171***	4.8574***	-0.1775
	(0.0927)	(0.2404)	(0.4631)	(0.538)
Oil rents boom	0.0086***	0.0152***	0.0161***	0.01**
	(0.001)	(0.0011)	(0.001)	(0.0043)
Oil rents bust	0.0145***	0.0221***	0.0235***	0.0129
	(0.0024)	(0.0019)	(0.0024)	(0.0077)
Oil rents valley	0.0101***	0.0173***	0.0185***	0.0072*
	(0.0014)	(0.0016)	(0.0014)	(0.0041)
GDP per capita	−0.0355***	−0.3864***	−0.39***	-0.0952**
	(0.0094)	(0.0246)	(0.0285)	(0.0396)

Mortality rate	(5) Adult, male	(6) Adult, female	(7) Maternal
Mean inefficiency			
Constant	−0.8783	−0.5664	0.0293*
	(0.6697)	(1.8459)	(0.0162)
Oil rents boom	−0.0005	0.0502**	0.0042***
	(0.0031)	(0.0221)	(0.0003)
Oil rents bust	−0.0016	0.0682	0.0054*
	(0.007)	(0.0515)	(0.0028)
Oil rents valley	−0.0049	0.047**	0.0032
	(0.0052)	(0.0193)	(0.0023)
GDP per capita	0.0383	−0.5753**	−0.0242***
	(0.0399)	(0.2506)	(0.0051)

Notes: Neonatal are newborn babies between 0 and 28 days. Infants are children between 0 and 1 years. Children are between 0 and 5 years old. Adults are between 15 and 60 years old. Maternal mortality measures pregnancy-related deaths. Production functions (not shown) include public, private health care expenditure, schooling, schooling^2 (all converted to their natural logarithm), income dummies and time dummies. GDP per capita is converted to natural logarithm. *, ** and *** stand for significant at the 10%, 5% and 1% level.

Table 7 shows the results for the full sample and table A.4 in Appendix A shows estimates for the democratic, intermediate and autocratic sub-samples. Neonatal, infant and child mortality rates do all look similar with highly significant *oil rents* coefficients, significantly greater coefficient in bust years and insignificantly smaller coefficients in boom years compared to valley years, showing a causal relation. The pattern is the same in democratic, intermediate and autocratic countries (see table A.4 in Appendix A).

The results for the different groups of adult mortality rates show a weaker effect and sometimes even no effect for the full sample. For example, all coefficients for male adults are insignificant and for females and both sexes only the *oil rents* coefficients in valley and boom years are significant at the 5 or 10% level. A look at the institutional sub-samples shows that the weak effects for the full sample is driven by insignificant coefficients in autocracies and sometimes democracies. Inefficiency in the adult health care sector is only influenced in intermediate countries and to a smaller extent in democratic countries due to *oil rents*.

The significant results for adults in intermediate countries could be driven by the fact that the polity score categorizes countries 'interregnum' and in transition as 0 on the Polity2 index. A period of interregnum are years with total collapse of political authority and include internal wars and periods of anarchy (Marshall and Jaggers, 2014). Periods of civil unrest are accompanied by higher mortality rates and because the conflict parties consist of adults, the adult mortality rate should be affected. A huge literature exists analysing the relation between natural resources and civil war (e.g. Arezki et al. (2015); Bell and Wolford (2015); Cotet and Tsui (2013a); Lei and Michaels (2014); Ross (2015); De Soysa and Neumayer (2007); Wegenast (2013). However, scholars concerned with the question have not delivered a clear answer yet (e.g. Lei and Michaels (2014) find a positive effect while Cotet and Tsui (2013a) find no effect with similar data and slightly different strategies). However, if natural resources led to periods of interregnum and civil unrest with higher mortality rates, this could explain the significant results for intermediate countries. To test if this is the driving factor I re-run the specifications, excluding countries with interregnum years from the sample. The results are the same as before, hence this possibility does not drive the results.

In summary, the analysis concerned with different age-groups reveals that the inefficiency increasing effect of *oil rents* is strong for the most vulnerable part of the population (newborns, infants, and children) while the effect for adults is weaker and only significant in intermediate countries.

6. Robustness checks

In this section, I conduct robustness checks concerned with potential oil price setters, time lags of the effect and different definitions of price shocks.

Excluding Saudi Arabia and the US

I start by testing whether the causal relationship found in the data is driven by the inclusion of OPEC, Saudi Arabia and the United States. As discussed in section 2, Saudi Arabia was the traditional swing producer collaborating with OPEC and the United States have the potential to be the new swing producer today due to the shale oil revolution. The US can also influence the oil price through monetary policy. These countries or group of countries −in the case of OPEC− could have influenced the international oil price rendering the oil rents boom, bust and valley variable as endogenous which would reduce the identification strategy as invalid.

Table A.5 in the appendix shows the main specifications excluding one country at a time and combined. Significance and signs of the oil rents boom, bust, and valley coefficients do not change and changes in the magnitude of any coefficient are minor. Hence, I conclude that the results concerned with causality are robust and not driven by the inclusion of potential oil price setters.

Time lags of the effect

The next robustness check is concerned with potential time lags of the effect of *oil rents* on inefficiency. Grigoli and Kapsoli (2013) argue that health expenditure needs time to affect *life expectancy* and inefficiency. The same could be argued for *oil rents* and an additional concern for the identification strategy is that a country could smooth out consumption through borrowing in bust years.

However, this does not seem to be the case here. Table A.6 in the appendix shows the results with lagged values of *life expectancy* by 1, 2, 3, 4, and 5 years to test if the effect of *oil rents* on inefficiency this year is different in 1, 2, 3, 4 or 5 years. The *oil rents* coefficients in boom, bust and valley years slightly decrease with increasing lags, hence the effect can be seen as immediate and diminishing over time but does not take a certain lagged number of years to develop.

Different definitions of boom, bust and valley years

A further robustness check is concerned with the definition of boom and bust years. So far, the definition was a more than 10% change in the international oil price. The chosen 10% benchmark is arbitrary and for this reason I re-run the main specification with different benchmarks.

Table A.7 in the appendix shows the results using 5, 10, 15 and 20% price fluctuation as benchmark. The results are almost identical in all specifications; hence my main results are robust to different definitions of price shocks.

7. Two potential mechanisms

In this section, I discuss two mechanisms through which *oil rents* potentially influence inefficiency in the health care sector. The first mechanism is that oil increases inequality, which in turn increases inefficiency and the second mechanism is that oil reduces transparency, which in turn increases inefficiency.

The spoils of oil are often unevenly distributed in the population benefiting the elite proportionally more than the rest. This is because oil is a capital intensive industry with only few linkages to the rest of the economy, therefore creating little employment (Karl, 2007). The result is that oil rich countries are plagued with high inequality (Mallaye et al., 2015). In turn, high inequality influences inefficiency in the health care sector (Herrera and Pang, 2005; Ogloblin, 2011; Ravallion, 2003). Inequality can create a barrier for the poor to access health care services and generally reflects unhealthy working conditions. Further, unequal societies tend to misallocate resources more in favour of the population that can afford them and away from the part of the population who actually needs them (Ogloblin, 2011).

The enclave characteristic and high profitability of oil makes it also lucrative for governments to be less transparent allowing them to use the spoils of oil for their own purposes (Karl, 2007). Williams (2011) confirms this argument empirically finding that point-source resources, such as oil, decrease transparency. Less transparency should increase inefficiency due to missing ways of holding the government accountable for their decisions.

Both −inequality and transparency− should lead to more inefficiency in the health care sector, because an unequal income distribution is seen as obstacle for many to access health care services and lower transparency could lead to the wrong kind of public health investments. Therefore, I test here the two following hypotheses:

Hypothesis 1. (H_1) : *oil rents decrease transparency, which in turn increases inefficiency*

Hypothesis 2. (H_2) : *oil rents increase inequality, which in turn increases inefficiency*

To test the hypotheses I follow Carmignani and Avom (2010) and include a variable measuring inequality and transparency in addition to the *oil rents* variable in the model. If the hypotheses are correct then the *oil rents* coefficients should lose in magnitude and significance after including inequality or transparency. This is because any effect of *oil rents* on inefficiency should be accounted for by the estimated coefficient of inequality or transparency. Further, the inequality and transparency coefficient should be significant.

I am using Gini from the World Income Inequality database provided by UNU-WIDER (2017) to capture inequality and to measure transparency I use the Release of Information Index compiled by Williams (2009). The inclusion of the two variables creates some data issues due to lower data coverage in terms of countries and years. To include the maximum amount of countries the time dimension of the panel was shortened to 2000-2010. Even with this adjustment some countries were lost completely. In the case of inequality the number of countries drops from 119 to 96. Because of this, I first estimate the model with the smaller sample to see whether the results still hold and then I include the transparency and inequality variables to see whether they affect the *oil rents* coefficients.

Table 8 shows the results testing H_1 (oil rents decrease transparency, which in turn increases inefficiency). The odd columns re-estimate the specifications without transparency for the new smaller sample. The results are overall in line with the main results.

Column (2) of table 8 shows the results for the full sample including *transparency*. The *transparency* coefficient is insignificant and has no influence on the *oil rents* coefficients. Hence, H_1 cannot be confirmed. However, the situation changes for the democratic sub-sample in column (4) where *transparency* is significant, and the *oil rents* coefficient lose in magnitude and significance as it would be expected if H_1 is true. The situation changes again for the intermediate and autocratic sub-samples (columns (6) and (8)). Whereas the sub-sample of intermediate countries is not affected by *transparency* (insignificant *transparency* coefficient and no changes in *oil rents* coefficients), the autocratic sub-sample surprisingly shows a significant and this time positive *transparency* coefficient. The *transparency* coefficient indicates that more transparency increases inefficiency in autocratic countries.

Concluding the *transparency* results: the inefficiency increasing effect due to *oil rents* is partly driven by lower *transparency* in democratic countries, but *transparency* does not seem to be the driving force in intermediate or autocratic countries.

Table 8: Transparency mechanism

	(1) All countries	(2) All countries	(3) Democratic	(4) Democratic
Mean inefficiency				
Constant	1.6283***	1.6308***	1.6835***	1.7651***
	(0.1684)	(0.1729)	(0.1227)	(0.1251)
Oil rents boom	0.0079***	0.0082***	0.0138***	0.0085**
	(0.0012)	(0.0013)	(0.0036)	(0.0043)
Oil rents bust	0.011***	0.0113***	0.0206***	0.0108
	(0.002)	(0.0022)	(0.007)	(0.0083)
Oil rents valley	0.0092***	0.0094***	0.0161**	0.0094
	(0.0018)	(0.0019)	(0.007)	(0.0072)
Transparency		0.0007		−0.0155***
		(0.0012)		(0.0022)
GDP per capita	−0.2193***	−0.2238***	−0.2159***	−0.1279***
	(0.0267)	(0.0293)	(0.0159)	(0.0215)

	(5) Intermediate	(6) Intermediate	(7) Autocracy	(8) Autocracy
Mean inefficiency				
Constant	1.3163***	1.5386***	3.3746***	1.4454***
	(0.1233)	(0.0964)	(0.1683)	(0.0978)
Oil rents boom	0.0061***	0.0073***	0.0037***	0.0029***
	(0.0009)	(0.0006)	(0.0008)	(0.0005)
Oil rents bust	0.0089***	0.0106***	0.0048***	0.0048***
	(0.002)	(0.0022)	(0.0015)	(0.0015)
Oil rents valley	0.0067 * **	0.0082***	0.0059***	0.0044***
	(0.0018)	(0.0018)	(0.0014)	(0.001)
Transparency		0.0039		0.0091***
		(0.0025)		(0.0018)
GDP per capita	−0.166***	−0.2161***	−0.434***	−0.2073***
	(0.016)	(0.016)	(0.0235)	(0.0048)

Notes: Production functions (not shown) include public, private health care expenditure, schooling, schooling^2 (all converted to their natural logarithm), income dummies and time dummies. GDP per capita is converted to natural logarithm. *, ** and *** stand for significant at the 10%, 5% and 1% level.

Table 9 shows the results testing H_2 (oil rents increase inequality, which in turn increases inefficiency). *Inequality* data are rare and Papyrakis (2016) even shows that resource rich countries tend to under-report or not report *inequality* at all. The sample is reduced to 96 countries and the list of excluded countries consists mainly of resource rich countries.[16] Replicating the main specifications for the smaller *inequality* sample resulted in insignificant results for intermediate and autocratic countries. Therefore, it is not possible to test the *inequality* mechanism for intermediate and autocratic countries and only the results for the full sample and democratic samples are discussed.

[16]The countries with missing inequality data are: Azerbaijan, Bahamas, Bahrain, Benin, Brunei, Central African Republic, Chad, Rep. of Congo, Democratic Republic of Congo, Gabon, Guyana, Jamaica, Kenya, Kuwait, Liberia, Myanmar, Oman, Samoa, Saudi Arabia, Togo, Trinidad and Tobago, United Arab Emirates, and Uzbekistan.

Table 9 shows the results for the full sample and the democratic sub-sample. In column (1) and (3) the main specifications are re-estimated for the smaller samples without *inequality*. Both show similar effects of *oil rents* in boom, bust and valley years as before. Column (2) and (4) include *inequality* and the coefficients are positive and significant in both samples, i.e. more *inequality* increases inefficiency. The *oil rents* coefficients for the full sample lose in magnitude, but not in significance. The *oil rents* coefficients for the democratic sub-sample again lose in magnitude and this time they also lose significance. Not being able to test H_2 for intermediate and autocratic countries leaves the conclusion that *inequality* drives the *oil rents* effect on inefficiency to some degree in democratic countries.

Table 9: Inequality mechanism

	(1) All countries	(2) All countries	(3) Democratic	(4) Democratic
Mean inefficiency				
Constant	2.762***	0.9804***	2.4606***	0.6021***
	(0.5777)	(0.0772)	(0.1261)	(0.0932)
Oil rents boom	0.0114***	0.0068***	0.0163***	0.0042
	(0.0036)	(0.0011)	(0.0054)	(0.005)
Oil rents bust	0.0157***	0.0097***	0.0273***	0.0153*
	(0.005)	(0.0025)	(0.0105)	(0.0085)
Oil rents valley	0.0136***	0.0085***	0.0212***	0.0042
	(0.004)	(0.0023)	(0.0079)	(0.0069)
Inequality		2.8942***		3.1154***
		(0.1752)		(0.1799)
GDP per capita	−0.4007***	−0.2904***	−0.349***	−0.2499***
	(0.0943)	(0.0123)	(0.019)	(0.0147)

Notes: Production functions (not shown) include public, private health care expenditure, schooling, schooling^2 (all converted to their natural logarithm), income dummies and time dummies. GDP per capita is converted to natural logarithm. *, ** and *** stand for significant at the 10%, 5% and 1% level.

8. Conclusion

This study uses stochastic frontier analysis (SFA) to estimate inefficiency in the health care sector and focuses in particular on the question whether unexpected changes in oil rents have an impact on inefficiency. The SFA estimates show that oil dependent countries could increase life expectancy between 5 and 13 years by eradicating inefficiency in health care spending. Further, the results confirm that oil rent is a significant determinant of inefficiency in the health care sector, i.e. higher oil dependency leads to more inefficiency. Exploiting exogenous fluctuations in the international oil price also shows that the effect can be considered as causal for democratic countries.

The inefficiency increasing effect is heterogenous in several dimensions. First, the effect is stronger in democratic countries compared to intermediate and autocratic countries. Second, women's health is affected by higher inefficiency compared to men's and finally, vulnerable parts of the population, such as infants and children, are affected by higher inefficiency compared to adults.

Two mechanisms that could drive the effect have been postulated and tested. The identified mechanisms are transparency and inequality. The results show that both mechanisms are responsible for the effect in democracies, but not in intermediate and autocratic countries. Hence, policy implications for democratic oil rich countries would be to invest the oil dividends into poverty reducing policies to battle inequality and reform institutions to increase transparency.

Two caveats accompany the analysis and could not have been resolved yet. The first is that the applied SFA model from Battese and Coelli (1995) includes all time-invariant unobserved country heterogeneity in the inefficiency term and therefore represent upper bound estimates. Other models, such as Greene (2005b) 'true fixed effects' model would be capable to exclude time-invariant unobserved heterogeneity from the inefficiency term. However, it is debatable how much of the unobserved heterogeneity should be included or excluded in the inefficiency term and −as was noted by Greene himself− the true estimates should be somewhere in between. The results in this paper are derived completely from Battese and Coelli (1995) model, because the Greene (2005b) model did not converge. Therefore, the results should be seen as upper bound estimates of the real effect.

The second caveat is concerned with the quantification of the z-variables. The analysis would benefit from the calculation of the marginal effects of *oil rents* and *GDP per capita*. Wang (2002) shows that the marginal effects in this setting would be the slope coefficient of the z-variables multiplied by an adjustment function. Using the Frontier4.1 software from Coelli (1996) I was unable to calculate the adjustment function and therefore cannot make a statement by how much inefficiency increases if *oil rents* increases by one percent. However, because *oil rents* and *GDP per capita* are included only in the mean of u_{it} the direction of the effect (inefficiency increasing or decreasing) is still valid because the adjustment function would be positive Wang (2002).

Future research could focus on allocative inefficiency. The analysis here is restricted to technical inefficiency due to missing data measuring input quantity and prices in the health care sector. However, with time comes data and an analysis taking the allocation of inputs into account would be of interest because resource curse theories predict that oil rents increase the misallocation of resources which could be detected with allocative inefficiency. Further, the analysis is not limited to the health care sector and stochastic frontier analysis could analyse whether oil influences inefficiency in other areas as well, such as education or infrastructure.

References

Aigner, D., Lovell, C.A.K., Schmidt, P., 1977. Formulation and estimation of stochastic frontier production functions. Journal of Econometrics 6, 21–37. URL: https://doi.org/10.1016/0304-4076(77)90052-5.

Arezki, R., Bhattacharyya, S., Mamo, N., 2015. Resource Discovery and Conflict in Africa: What Do the Data Show? CSAE Working Paper Series 2015-14. Centre for the Study of African Economies. University of Oxford.

Arezki, R., Gylfason, T., 2013. Resource rents, democracy, corruption and conflict: Evidence from Sub-Saharan Africa. Journal of African Economies 22, 552–569. doi:10.1093/jae/ejs036.

Arezki, R., Ramey, V.A., Sheng, L., 2017. News Shocks in Open Economies: Evidence from Giant Oil Discoveries. The Quarterly Journal of Economics 132, 103–155. doi:10.1093/qje/qjw030.Advance.

Battese, G.E., Coelli, T., 1995. A model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data. Empirical Economics 20, 325–332. doi:10.1007/BF01205442, arXiv:arXiv:1011.1669v3.

Battese, G.E., Coelli, T.J., 1988. Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data. Journal of Econometrics 38, 387–399. doi:10.1016/0304-4076(88)90053-X.

Battese, G.E., Coelli, T.J., 1992. Frontier production functions, technical efficiency and panel data: With application to paddy farmers in India. Journal of Productivity Analysis 3, 153–169. doi:10.1007/BF00158774, arXiv:1407.2593.

Bell, C., Wolford, S., 2015. Oil Discoveries, Shifting Power, and Civil Conflict. International Studies Quarterly 59, 517–530. doi:10.1111/isqu.12150.

Belotti, F., Daidone, S., Ilardi, G., Atella, V., 2013. Stochastic frontier analysis using Stata. The Stata Journal 13, 719–758. URL: http://www.stata-journal.com/sjpdf.html?articlenum=st0315, doi:TheStataJournal, arXiv:The Stata Journal.

Bhattacharyya, S., Collier, P., 2014. Public capital in resource rich economies: is there a curse? Oxford Economic Papers 66, 1–24.

Bhattacharyya, S., Conradie, L., Arezki, R., 2017. Resource discovery and the politics of fiscal decentralization. Journal of Comparative Economics 45, 366–382. URL: https://www.sciencedirect.com/science/article/pii/S0147596717300215, doi:10.1016/J.JCE.2017.02.003.

Bhattacharyya, S., Hodler, R., 2010. Natural resources, democracy and corruption. European Economic Review 54, 608–621.

Blanco, L., Grier, R., 2012. Natural resource dependence and the accumulation of physical and human capital in Latin America. Resources Policy 37, 281–295. URL: http://dx.doi.org/10.1016/j.resourpol.2012.01.005, doi:10.1016/j.resourpol.2012.01.005.

Bleakley, H., 2010. Health, Human Capital, and Development. Annual Review Economics 2, 283–310. doi:10.1146/annurev.economics.102308.124436.Health.

Brunnschweiler, C.N., 2008. Cursing the Blessings? Natural Resource Abundance, Institutions, and Economic Growth. World Development 36, 399–419. doi:10.1016/j.worlddev.2007.03.004.

Brunnschweiler, C.N., Bulte, E.H., 2008. The resource curse revisited and revised: A tale of paradoxes and red herrings. Journal of Environmental Economics and Management 55, 248–264. URL: http://linkinghub.elsevier.com/retrieve/pii/S0095069608000193, doi:10.1016/j.jeem.2007.08.004.

Bulte, E.H., Damania, R., Deacon, R.T., 2005. Resource intensity, institutions, and development. World Development 33, 1029–1044. doi:10.1016/j.worlddev.2005.04.004.

Carmignani, F., 2013. Development outcomes, resource abundance, and the transmission through inequality. Resource and Energy Economics 35, 412–428. URL: http://dx.doi.org/10.1016/j.reseneeco.2013.04.007, doi:10.1016/j.reseneeco.2013.04.007.

Carmignani, F., Avom, D., 2010. The social development effects of primary commodity export dependence. Ecological Economics 70, 317–330. URL: http://dx.doi.org/10.1016/j.ecolecon.2010.09.003, doi:10.1016/j.ecolecon.2010.09.003.

Carter, C.A., Rausser, G.C., Smith, A., 2011. Commodity Booms and Busts. Annual Review of Resource Economics 3, 87–118. URL: http://www.annualreviews.org/doi/10.1146/annurev.resource.012809.104220, doi:10.1146/annurev.resource.012809.104220.

Coelli, T.T.J., 1996. A Guide to FRONTIER Version 4.1: A Computer Program for Stochastic Frontier Production and Cost Function Estimation. CEPA Working Paper series 96/07. Centre for Efficiency and Productivity Analysis. URL: https://absalon.itslearning.com/data/ku/103018/publications/coelli96.pdf{%}5Cnhttp://scholar.google.com/scholar?hl=en{&}btnG=Search{&}q=intitle:A+guide+to+Frontier+Version+4.1{#}1, doi:10.1007/BF00158774, arXiv:1407.2593.

Cornwell, C., Schmidt, P., Sickles, R.C., 1990. Production frontiers with cross-sectional and time-series variation in efficiency levels. Journal of Econometrics 46, 185–200. doi:10.1016/0304-4076(90)90054-W.

Cotet, A.M., Tsui, K.K., 2013a. Oil and Conflict: What Does the Cross Country Evidence Realy Show? American Economic Journal: Economic Policy 5, 49–80.

Cotet, A.M., Tsui, K.K., 2013b. Oil, Growth, and Health: What Does the Cross-Country Evidence Really Show? Scandinavian Journal of Economics 115, 1107–1137. doi:10.1111/sjoe.12027.

D'Agostino, R.B., Belanger, A., D'Agostino Jr., R.B., 1990. A Suggestion for Using Powerful and Informative Tests of Normality. The American Statistician 44, 316–321.

Daniele, V., 2011. Natural Resources and the 'Quality' of Economic Development. Journal of Development Studies 47, 545–573. doi:10.1080/00220388.2010.506915.

De Soysa, I., Neumayer, E., 2007. Resource Wealth and the Risk of Civil War Onset: Results from a New Dataset of Natural Resource Rents, 1970-1999. Conflict Management and Peace Science 24, 201–218. URL: http://cmp.sagepub.com/cgi/doi/10.1080/07388940701468468, doi:10.1080/07388940701468468.

Edwards, R.B., 2016. Mining away the Preston curve. World Development 78, 22–36. doi:10.1016/j.worlddev.2015.10.013.

Evans, D.B., Tandon, A., Murray, C.J.L., Lauer, J.A., 2000. The Comparative Efficiency of National Health Systems in producing health: An analysis of 191 countries. GPE Discussion Paper Series 29. EIP/GPE/EQC World Health Organization. Geneva. URL: www.who.int/healthinfo/paper29.pdf.

Fattouh, B., Mahadeva, L., 2013. OPEC: What Difference Has It Made? Annual Review of Resource Economics 5, 427–443. URL: http://www.annualreviews.org/doi/10.1146/annurev-resource-091912-151901, doi:10.1146/annurev-resource-091912-151901.

Frankel, J., 2010. The Natural Resource Curse: A Survey. CID Working Papers 195. Center for International Development at Harvard.

Frankel, J.A., 2008. The Effect of Monetary Policy on Real Commodity Prices, in: Campbell, J.Y. (Ed.), Asset Prices and Monetary Policy. University of Chicago Press.

Greene, W.H., 2004. Distinguishing between heterogeneity and inefficiency: Stochastic frontier analysis of the World Health Organization's panel data on national health care systems. Health Economics 13, 959–980.

Greene, W.H., 2005a. Efficiency of public spending in developing countries: a stochastic frontier approach. World Bank, available at: http://go.worldbank.org/M0SS97QVV0.

Greene, W.H., 2005b. Fixed and Random Effects in Stochastic Frontier Models. Journal of Productivity Analysis 23, 7–32.

Greene, W.H., 2005c. Reconsidering heterogeneity in panel data estimators of the stochastic frontier model. Journal of Econometrics 126, 269–303.

Grigoli, F., Kapsoli, J., 2013. Waste Not, Want Not: The Efficiency of Health Expenditure in Emerging and Developing Economies. IMF Working Papers 13, 1. URL: http://elibrary.imf.org/view/IMF001/20773-9781484364260/20773-9781484364260/20773-9781484364260.xml, doi:10.5089/9781484364260.001.

Gylfason, T., 2001. Natural resources, education, and economic development. European Economic Review 45, 847–859. URL: https://www.sciencedirect.com/science/article/pii/S0014292101001271, doi:10.1016/S0014-2921(01)00127-1.

Hamilton, J.D., 2009. Causes and Consequences of the Oil Shock of 2007-08. Brookings Papers on Economic Activity 2009, 215–261. URL: http://muse.jhu.edu/content/crossref/journals/brookings{_}papers{_}on{_}economic{_}activity/v2009/2009.

1.hamilton.html, doi:10.1353/eca.0.0047, arXiv:arXiv:1011.1669v3.

Herrera, S., Pang, G., 2005. Efficiency of Public Spending in Developing Countries: An Efficiency Frontier Approach. World Bank Policy Research Working Paper No. (2005). World Bank. Washington, D.C. URL: http://econ.worldbank.org.

Isham, J., 2005. The Varieties of Resource Experience: Natural Resource Export Structures and the Political Economy of Economic Growth. The World Bank Economic Review 19, 141–174. URL: https://academic.oup.com/wber/article-lookup/doi/10.1093/wber/lhi010, doi:10.1093/wber/lhi010.

Kapsoli, J., Teodoru, I.R., 2017. Benchmarking Social Spending Using Efficiency Frontiers. IMF Working Paper No. WP/17/197. International Monetary Fund. Washington, D.C.

Karl, T.L., 2007. Oil-Led Development: Social, Political, and Economic Consequences. CDDRL Working Papers No. 80. Center on Democracy, Development and the Rule of Law. Stanford. URL: http://doi.wiley.com/10.1111/j.1475-4932.1989.tb00684.x.

Keller, M., 2019. Gold-diggers and Where to Find Them - The Political Economy of Natural Resources. Doctoral Thesis, PhD URL: http://sro.sussex.ac.uk/id/eprint/82836.

Kumbhakar, S.C., 1990. Production frontiers, panel data, and time-varying technical inefficiency. Journal of Econometrics 46, 201–211. doi:10.1016/0304-4076(90)90055-X.

Kumbhakar, S.C., Wang, J.H., Horncastle, A.P., 2015. A practioner's guideto stochastic frontier analysis using Stata. Cambridge University Press, New York.

Lei, Y.H., Michaels, G., 2014. Do giant oilfield discoveries fuel internal armed conflicts? Journal of Development Economics 110, 139–157. URL: http://linkinghub.elsevier.com/retrieve/pii/S0304387814000789, doi:10.1016/j.jdeveco.2014.06.003.

Liou, Y.M., Musgrave, P., 2014. Refining the Oil Curse. Comparative Political Studies 47, 1584–1610. URL: http://journals.sagepub.com/doi/10.1177/0010414013512607, doi:10.1177/0010414013512607.

Mallaye, D., Yogo, T.U., Timba, G.T., 2015. Oil Rent and Income Inequality in Developing Economies: Are They Friends or Foes? Working Papers 201502. CERDI. URL: http://cerdi.org/production/show/id/1644/.

Marshall, M.G., Jaggers, K., 2014. Polity IV Project: Political Regime Characteristics and Transitions, 1800-2013. URL: http://www.systemicpeace.org/polity/polity4.htm.

Masters, M.W., 2008. Testimony of Michael W. Masters, Managing Member / Portfolio Manager, Masters Capital Management, LLC, in: Testimony before the U.S. Senate Committee on Homeland Security and Governmental Affairs. URL: http://www.hsgac.senate.gov//imo/media/doc/052008Masters.pdf?attempt=2.

Meeusen, W., van den Broeck, J., 1977. Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error. International Economic Review 18, 435–444. URL: https://www.jstor.org/stable/2525757, doi:10.2307/2525757.

Mehlum, H., Moene, K., Torvik, R., 2006. Institutions and the Resource Curse. The Economic Journal 116, 1–20.

de Mesquita, B.B., Smith, A., 2002. The Logic of Political Survival .

Morse, E., 2018. US set to become swing oil supplier. https://www.ft.com/content/49354866-117d-11e8-8cb6-b9ccc4c4dbbb.

OECD/WHO, 2014. Guidelines for the Implementation of the SHA 2011 Framework for Accounting Health Care Financing. Technical Report.

Ogloblin, C., 2011. Health care efficiency across countries: A stochastic frontier analysis. Applied Econometrics and International Development 11, 5–14.

Ortiz-Ospina, E., Roser, M., 2018. Financing Healthcare. https://ourworldindata.org/financing-healthcare.

Papyrakis, E., 2016. The Resource Curse - What Have We Learned from Two Decades of Intensive Research: Introduction to the Special Issue. Journal of Development Studies 53, 1–11. URL: http://www.tandfonline.com/doi/full/10.1080/00220388.2016.1160070, doi:10.1080/00220388.2016.1160070.

Pitt, M.M., Lee, L.F., 1981. The measurement and sources of technical inefficiency in the Indonesian weaving industry. Journal of Development Economics 9, 43–64. doi:10.1016/0304-3878(81)90004-3.

van der Ploeg, F., 2011. Natural Resources: Curse or Blessing? Journal of Economic Literature 49, 366–420.

Prest, B.C., 2018. Explanations for the 2014 Oil Price Decline: Supply or Demand? Energy Economics 74, 63–75. URL: http://linkinghub.

elsevier.com/retrieve/pii/S0140988318302020, doi:10.1016/j.eneco.2018.05.029.

Ramsay, K.W., 2011. Revisiting the Resource Curse: Natural Disasters, the Price of Oil, and Democracy. International Organization 65, 507–529. doi:10.1017/S002081831100018X.

Ravallion, M., 2003. On Measuring Aggregate "Social Efficiency". Policy Research Working Paper WPS3166. World Bank. Washington DC.

Robinson, J., Torvik, R., 2005. White elephants. Journal of Public Economics 89, 197–210. doi:10.1016/j.jpubeco.2004.05.004.

Robinson, J., Torvik, R., Verdier, T., 2006. Political foundations of the resource curse. Journal of Development Economics 79, 447–468. URL: http://linkinghub.elsevier.com/retrieve/pii/S0304387806000137, doi:10.1016/j.jdeveco.2006.01.008.

Ross, M.L., 1999. The political economy of the resource curse. World Politics 51, 297–322. URL: http://muse.jhu.edu/journals/world{_}politics/v051/51.2er{_}karl.html.

Ross, M.L., 2008. Oil, Islam, and women. American Political Science Review 102, 107–123. doi:10.1017/S0003055408080040.

Ross, M.L., 2011. Mineral Wealth and Budget Transparency. IBP working paper 2. International Budget Partnership. Washington.

Ross, M.L., 2015. What Have We Learned about the Resource Curse? Annual Review of Political Science 18, 239–259. URL: http://dx.doi.org/10.1146/annurev-polisci-052213-040359, doi:10.1146/annurev-polisci-052213-040359.

Ross, M.L., 2017. What Do We Know About Economic Diversification in Oil-Producing Countries? Technical Report. Available at SSRN: https://ssrn.com/abstract=3048585 or http://dx.doi.org/10.2139/ssrn.3048585.

Sachs, J., Warner, A., 2001. The curse of natural resources. European Economic Review 45, 827–838.

Schmidt, P., Sickles, R.C.R.C., 1984. Production Frontiers and Panel Data. Journal of Business & Economic Statistics 2, 367–374. URL: http://www.jstor.org/stable/1391278.

Smith, B., 2016. Dutch Disease and the Oil and Boom and Bust. OxCarre Working Papers 133. Oxford Centre for the Analysis of Resource Rich Economies. Oxford.

Stevenson, R., 1980. Likelihood Functions for Generalized Stochastic Frontier Estimation. Journal of Econometrics 13, 57–66. doi:10.1016/0304-4076(80)90042-1.

The World Bank, 2018a. The Pink Sheet: Price forecasts. Available at: http://www.worldbank.org/en/research/commodity-markets.

The World Bank, 2018b. World Development Indicators. Available at: https://data.worldbank.org/indicator.

UNU-WIDER, 2017. World Income Inequality Database (WIID3.4). Available at: https://www.wider.unu.edu/project/wiid-world-income-inequality-database.

Wang, H.j.J., 2002. Heteroscedasticity and Non-Monotonic Effciency Effects of a Stochastic Frontier Model. Journal of Productivity Analysis 18, 241–253.

Wegenast, T., 2013. Opening Pandora's box? Inclusive institutions and the onset of internal conflict in oil-rich countries. International Political Science Review 34, 392–410. URL: http://ips.sagepub.com/cgi/doi/10.1177/0192512112467214, doi:10.1177/0192512112467214.

Williams, A., 2009. On the release of information by governments: Causes and consequences. Journal of Development Economics 89, 124–138. URL: http://dx.doi.org/10.1016/j.jdeveco.2008.08.001, doi:10.1016/j.jdeveco.2008.08.001.

Williams, A., 2011. Shining a Light on the Resource Curse: An Empirical Analysis of the Relationship Between Natural Resources, Transparency, and Economic Growth. World Development 39, 490–505. URL: http://dx.doi.org/10.1016/j.worlddev.2010.08.015, doi:10.1016/j.worlddev.2010.08.015.

Appendix A. Tables

Table A.1: List of countries in the sample

#	Country	Oil rent	Income group	Institution
1	Albania	1.47	Upper Middle Income	Democracy
2	Algeria	19.69	Upper Middle Income	Intermediate
3	Angola	41.67	Upper Middle Income	Intermediate
4	Argentina	3.21	Upper Middle Income	Democracy
5	Armenia	0.00	Lower Middle Income	Democracy
6	Azerbaijan	30.72	Upper Middle Income	Autocratic
7	Bahamas	0.00	High Income	
8	Bahrain	6.00	High Income	Autocratic
9	Bangladesh	0.95	Lower Middle Income	Intermediate
10	Belarus	1.10	Upper Middle Income	Autocratic
11	Belize	2.33	Upper Middle Income	
12	Benin	0.04	Low Income	Democracy
13	Bolivia	6.76	Lower Middle Income	Democracy
14	Botswana	0.00	Upper Middle Income	Democracy
15	Brazil	1.71	Upper Middle Income	Democracy
16	Brunei	21.79	High Income	
17	Bulgaria	0.07	Upper Middle Income	Democracy
18	Burundi	0.00	Low Income	Intermediate
19	Cambodia	0.00	Lower Middle Income	Intermediate
20	Cameroon	5.51	Lower Middle Income	Autocratic
21	Canada	2.73	High Income	Democracy
22	Cape Verde	0.00	Lower Middle Income	Democracy
23	Central Afr. Rep.	0.00	Low Income	Intermediate
24	Chad	18.80	Low Income	Intermediate
25	Chile	0.07	High Income	Democracy
26	China	1.43	Upper Middle Income	Autocratic
27	Colombia	4.39	Upper Middle Income	Democracy
28	Congo	44.43	Lower Middle Income	Autocratic
29	Costa Rica	0.00	Upper Middle Income	Democracy

Continued on next page

Table A.1 – continued from previous page

#	Country	Oil rent	Income group	Institution
30	Cote d'Ivoire	2.55	Lower Middle Income	Intermediate
31	Croatia	0.65	High Income	Democracy
32	Cyprus	0.00	High Income	Democracy
33	DR of Congo	1.72	Low Income	Intermediate
34	Denmark	1.37	High Income	Democracy
35	Dominican Rep.	0.00	Upper Middle Income	Democracy
36	Ecuador	11.61	Upper Middle Income	Democracy
37	Egypt	9.17	Lower Middle Income	Autocratic
38	El Salvador	0.00	Lower Middle Income	Democracy
39	Ethiopia	0.00	Low Income	
40	Finland	0.00	High Income	Democracy
41	Gabon	30.82	Upper Middle Income	Intermediate
42	Gambia	0.00	Low Income	Autocratic
43	Georgia	0.26	Upper Middle Income	Democracy
44	Germany	0.05	High Income	Democracy
45	Ghana	1.52	Lower Middle Income	Democracy
46	Guatemala	0.56	Lower Middle Income	Democracy
47	Guinea	0.00	Low Income	Intermediate
48	Guyana	0.00	Upper Middle Income	Democracy
49	Honduras	0.00	Lower Middle Income	Democracy
50	India	1.23	Lower Middle Income	Democracy
51	Indonesia	3.61	Lower Middle Income	Democracy
52	Iran	24.14	Upper Middle Income	Autocratic
53	Italy	0.11	High Income	Democracy
54	Jamaica	0.00	Upper Middle Income	Democracy
55	Jordan	0.04	Upper Middle Income	Intermediate
56	Kazakhstan	18.77	Upper Middle Income	Autocratic
57	Kenya	0.00	Lower Middle Income	Democracy
58	Kuwait	47.87	High Income	Autocratic
59	Kyrgyz Republic	0.52	Lower Middle Income	Intermediate
60	Laos	0.00	Lower Middle Income	Autocratic

Continued on next page

Table A.1 – continued from previous page

#	Country	Oil rent	Income group	Institution
61	Latvia	0.00	High Income	Democracy
62	Lesotho	0.00	Lower Middle Income	Democracy
63	Liberia	0.00	Low Income	Intermediate
64	Lithuania	0.16	High Income	Democracy
65	Luxembourg	0.00	High Income	Democracy
66	Madagascar	0.00	Low Income	Democracy
67	Malawi	0.00	Low Income	Democracy
68	Malaysia	5.67	Upper Middle Income	Intermediate
69	Mali	0.00	Low Income	Democracy
70	Malta	0.00	High Income	
71	Mauritania	3.16	Lower Middle Income	Intermediate
72	Mauritius	0.00	Upper Middle Income	Democracy
73	Moldova	0.04	Lower Middle Income	Democracy
74	Mongolia	1.08	Lower Middle Income	Democracy
75	Morocco	0.01	Lower Middle Income	Autocratic
76	Mozambique	0.93	Low Income	Democracy
77	Myanmar	2.68	Lower Middle Income	Autocratic
78	Namibia	0.00	Upper Middle Income	Democracy
79	Nepal	0.00	Low Income	Intermediate
80	Nicaragua	0.00	Lower Middle Income	Democracy
81	Niger	0.88	Low Income	Democracy
82	Oman	38.59	High Income	Autocratic
83	Pakistan	1.83	Lower Middle Income	Intermediate
84	Panama	0.00	Upper Middle Income	Democracy
85	Papua New G.	7.25	Lower Middle Income	Intermediate
86	Paraguay	0.00	Upper Middle Income	Democracy
87	Peru	1.67	Upper Middle Income	Democracy
88	Philippines	0.20	Lower Middle Income	Democracy
89	Portugal	0.00	High Income	Democracy
90	Qatar	32.88	High Income	Autocratic
91	Romania	1.77	Upper Middle Income	Democracy

Continued on next page

Table A.1 – continued from previous page

#	Country	Oil rent	Income group	Institution
92	Russia	14.42	Upper Middle Income	Democracy
93	Rwanda	0.00	Low Income	Intermediate
94	Samoa	0.00	Lower Middle Income	
95	Saudi Arabia	40.94	High Income	Autocratic
96	Senegal	0.01	Low Income	Democracy
97	Sierra Leone	0.00	Low Income	Democracy
98	Singapore	0.00	High Income	Intermediate
99	South Africa	0.07	Upper Middle Income	Democracy
100	South Korea	0.00	High Income	Democracy
101	Sri Lanka	0.00	Lower Middle Income	Democracy
102	Sudan	10.90	Lower Middle Income	Autocratic
103	Swaziland	0.00	Lower Middle Income	Autocratic
104	Tajikistan	0.15	Lower Middle Income	Intermediate
105	Tanzania	0.07	Low Income	Intermediate
106	Thailand	1.42	Upper Middle Income	Democracy
107	Togo	0.00	Low Income	Intermediate
108	Trin. and Tobago	14.66	High Income	Democracy
109	Tunisia	3.95	Lower Middle Income	Intermediate
110	Uganda	0.00	Low Income	Intermediate
111	Ukraine	1.95	Lower Middle Income	Democracy
112	UAE	21.19	High Income	Autocratic
113	United Kingdom	0.84	High Income	Democracy
114	United States	0.63	High Income	Democracy
115	Uruguay	0.00	High Income	Democracy
116	Uzbekistan	19.62	Lower Middle Income	Autocratic
117	Vietnam	5.92	Lower Middle Income	Autocratic
118	Yemen	26.05	Lower Middle Income	Intermediate
119	Zambia	0.00	Lower Middle Income	Democracy

Table A.2: Definition and source of variables used in the analysis

Variable	**Definition**	**Source**
Life expectancy at birth, total, male, female (years)	Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same.	World Development Indicators
Oil rents (% of GDP)	Is the sum of oil and gas rents from WDI. Oil and gas rents are the difference between the value of crude oil and gas production at world prices and total costs of production.	World Development Indicators
Oil price	Crude oil, average spot price of Brent, Dubai and West Texas Intermediate, equally weighed in real 2010 US$	World Bank Commodity Price Data (The Pink Sheet)
GDP per capita	GDP per capita based on purchasing power parity (PPP). PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States. GDP at purchasers prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2011 international dollars.	World Development Indicators
Schooling (years)	Mean years of education of population over 25	Human Development Indicators

Continued on next page

Table A.2 – continued from previous page

Variable	Defintion	Source
Mortality rate, adult (per 1,000 live births)	Adult mortality rate is the probability of dying between 15 and 60 years per 1000 population	World Health Organization
Mortality rate, child (per 1,000 live births)	Under-five mortality rate is the probability per 1,000 that a newborn baby will die before reaching age five, if subject to age-specific mortality rates of the specified year.	World Development Indicators
Mortality rate, infant (per 1,000 live births)	Infant mortality rate is the number of infants dying before reaching one year of age, per 1,000 live births in a given year.	World Development Indicators
Maternal mortality ratio (per 100,000 live births)	Maternal mortality ratio is the number of women who die from pregnancy-related causes while pregnant or within 42 days of pregnancy termination per 100,000 live births. The data are estimated with a regression model using information on the proportion of maternal deaths among non-AIDS deaths in women ages 15-49, fertility, birth attendants, and GDP.	World Development Indicators
Mortality rate, neonatal (per 1,000 live births)	Neonatal mortality rate is the number of neonates dying before reaching 28 days of age, per 1,000 live births in a given year.	World Development Indicators
Polity2	Combined Polity Score; measuring on a scale from -10 to +10 the polity of a country.	Centre of Systematic Peace
Public health expenditure per capita	Mandatory payments or contributions to the health care sector including transfers from government domestic revenues, social insurance contribution and compulsory prepayment other than social contribution (variable FS1, FS2 and FS4 in the SHA2011 framework)	World Health Organization

Continued on next page

Table A.2 – continued from previous page

Variable	**Defintion**	**Source**
Private health expenditure per capita	Voluntary contributions to the health care sector including voluntary prepayments and other domestic revenues (FS5 and FS6 in the SHA2011 framework)	World Health Organization
Transparency	Transparency is measured as the Release of Information index and is based on the quantity of reported socio- economic data contained in the World Development Indicators and the International Finance Statistics databases.	(Williams 2015)
Inequality	Inequality is measured as the Gini index. The Gini index is defined as the deviation of the income distribution from a perfectly equal distribution.	World Income Inequality Dataset

Table A.3: Technical efficiency ranking by income groups

Low income			Lower middle income			Upper middle income			High income		
#	**Country**	**Eff.**	**#**	**Country**	**Eff.**	**#**	**Country**	**Eff.**	**#**	**Country**	**Eff.**
1	Nepal	0.9880	1	Vietnam	0.9927	1	Costa Rica	0.9946	1	Italy	0.9920
2	Senegal	0.9460	2	Morocco	0.9866	2	Albania	0.9911	2	Singapore	0.9909
3	Ethiopia	0.9360	3	Cape Verde	0.9859	3	China	0.9887	3	UK	0.9891
4	Niger	0.9058	4	Sri Lanka	0.9841	4	Panama	0.9863	4	Canada	0.9885
5	Gambia	0.8974	5	Bangladesh	0.9834	5	Jamaica	0.9814	5	South Korea	0.9882
6	Madagascar	0.8973	6	Nicaragua	0.9799	6	Ecuador	0.9802	6	Malta	0.9880
7	Guinea	0.8883	7	Tunisia	0.9779	7	Thailand	0.9754	7	Cyprus	0.9849
8	Rwanda	0.8848	8	Samoa	0.9747	8	Algeria	0.9736	8	Chile	0.9840
9	Benin	0.8839	9	Honduras	0.9743	9	Georgia	0.9727	9	Finland	0.9814
10	Liberia	0.8687	10	Armenia	0.9727	10	Argentina	0.9725	10	Germany	0.9810
11	Mali	0.8487	11	Guatemala	0.9565	11	Peru	0.9686	11	Luxembourg	0.9775
12	Tanzania	0.8469	12	Tajikistan	0.9472	12	Malaysia	0.9684	12	Portugal	0.9771
13	Burundi	0.8404	13	El Salvador	0.9404	13	Colombia	0.9633	13	Denmark	0.9738
14	DRC	0.8345	14	PNG	0.9388	14	Mauritius	0.9605	14	Brunei	0.9675
15	Mozambique	0.8333	15	Myanmar	0.9366	15	Romania	0.9590	15	Croatia	0.9658
16	Togo	0.8293	16	Kyrgyz Rep.	0.9349	16	Dominican Rep.	0.9577	16	Uruguay	0.9621
17	Malawi	0.8163	17	Uzbekistan	0.9334	17	Jordan	0.9561	17	Qatar	0.9589
18	Chad	0.7871	18	Egypt	0.9294	18	Paraguay	0.9556	18	Oman	0.9582
19	Uganda	0.7844	19	Yemen	0.9251	19	Bulgaria	0.9504	19	Bahrain	0.9551
20	Centr. Afr. Rep.	0.7113	20	Philippines	0.9192	20	Iran	0.9488	20	UAE	0.9443
21	Sierra Leone	0.6911	21	Moldova	0.9178	21	Brazil	0.9450	21	United States	0.9424
			22	Ukraine	0.9142	22	Belize	0.9275	22	Bahamas	0.9340
			23	Cambodia	0.9139	23	Belarus	0.9256	23	Kuwait	0.9297
			24	Indonesia	0.9125	24	Azerbaijan	0.9254	24	Lithuania	0.9275
			25	Pakistan	0.9099	25	Kazakhstan	0.8939	25	Latvia	0.9258
			26	India	0.9095	26	Guyana	0.8933	26	Saudi Arabia	0.9234
			27	Laos	0.8880	27	Russia	0.8832	27	Trinidad and Tobago	0.8789
			28	Mongolia	0.8865	28	Gabon	0.8214			
			29	Sudan	0.8776	29	Angola	0.7709			
			30	Mauritania	0.8771	30	Namibia	0.7567			
			31	Bolivia	0.8720	31	Botswana	0.7438			
			32	Kenya	0.8215	32	South Africa	0.7318			
			33	Ghana	0.8177						
			34	Congo	0.8015						
			35	Cameroon	0.7559						
			36	Zambia	0.7367						
			37	Cote d'Ivoire	0.7022						
			38	Lesotho	0.6870						
			39	Swaziland	0.6710						

Table A.4: SFA: Inefficiency by age-groups and institutions

Neonatal mortality	(1)	(2) Democracy	(3) Intermediate	(4) Autocracy
Mean inefficiency				
Constant	0.4002***	−3.7839***	−1.6531***	2.2471***
	(0.0927)	(0.9926)	(0.347)	(0.5486)
Oil rent boom	0.0086***	0.0405***	0.0193***	0.0136***
	(0.001)	(0.0097)	(0.0022)	(0.0016)
Oil rent bust	0.0145 * **	0.0537 * **	0.0309***	0.0189***
	(0.0024)	(0.0189)	(0.0047)	(0.0032)
Oil rent valley	0.0101***	0.0526***	0.025***	0.015***
	(0.0014)	(0.012)	(0.0031)	(0.0019)
GDP per capita	−0.0355***	0.3849***	0.158***	−0.2322***
	(0.0094)	(0.0856)	(0.0364)	(0.0614)

Infant mortality	(1)	(2) Democracy	(3) Intermediate	(4) Autocracy
Mean inefficiency				
Constant	4.1171***	−3.7998***	−0.8486***	3.2416
	(0.2404)	(1.1158)	(0.1066)	(9.042)
Oil rent boom	0.0152***	0.0613***	0.0231***	0.0106***
	(0.0011)	(0.017)	(0.0019)	(0.0016)
Oil rent bust	0.0221***	0.0832***	0.0363***	0.0152***
	(0.0019)	(0.0288)	(0.0052)	(0.0034)
Oil rent valley	0.0173***	0.0808***	0.0283***	0.012***
	(0.0016)	(0.0208)	(0.0029)	(0.0021)
GDP per capita	−0.3864***	0.3224***	0.068***	−0.1946***
	(0.0246)	(0.0862)	(0.0127)	(0.0697)

Child mortality	(1)	(2) Democracy	(3) Intermediate	(4) Autocracy
Mean inefficiency				
Constant	4.8574***	−3.2242**	−1.5642***	8.441***
	(0.4631)	(1.5055)	(0.573)	(0.8466)
Oil rent boom	0.0161***	0.0779***	0.0302***	0.0119**
	(0.001)	(0.0248)	(0.0032)	(0.0049)
Oil rent bust	0.0235***	0.1068**	0.0461***	0.0197***
	(0.0024)	(0.0481)	(0.0064)	(0.0053)
Oil rent valley	0.0185***	0.1074***	0.0368***	0.0176***
	(0.0014)	(0.0353)	(0.0048)	(0.0042)
GDP per capita	−0.39***	0.1897*	0.1271**	−0.8078***
	(0.0285)	(0.0971)	(0.0636)	(0.1231)

Table A.4 - continued from previous page

Adult mortality	(1)	(2) Democracy	(3) Intermediate	(4) Autocracy
Mean inefficiency				
Constant	−0.1775	−2.2541	1.4332***	0.0035
	(0.538)	(2.096)	(0.2422)	(0.9455)
Oil rent boom	0.01**	0.1196*	0.0135***	0.0066
	(0.0043)	(0.0691)	(0.0028)	(0.0093)
Oil rent bust	0.0129	0.1883*	0.0228***	0.0083
	(0.0077)	(0.0997)	(0.0066)	(0.0247)
Oil rent valley	0.0072*	0.1317*	0.0175***	0.006
	(0.0041)	(0.0673)	(0.0045)	(0.0424)
GDP per capita	−0.0952**	−0.0796	−0.1769***	−0.0216
	(0.0396)	(0.1161)	(0.0352)	(0.084)

Adult mort., male	(1)	(2) Democracy	(3) Intermediate	(4) Autocracy
Mean inefficiency				
Constant	−0.8783	−1.3159*	1.3232***	−0.0619
	(0.6697)	(0.6984)	(0.3297)	(0.976)
Oil rent boom	−0.0005	0.0451***	0.0111***	0.0068**
	(0.0031)	(0.0141)	(0.0025)	(0.0032)
Oil rent bust	−0.0016	0.0772***	0.0223***	0.0085
	(0.007)	(0.0271)	(0.0065)	(0.0285)
Oil rent valley	−0.0049	0.0481***	0.0151***	0.0054
	(0.0052)	(0.0175)	(0.0044)	(0.0072)
GDP per capita	0.0383	0.0835	−0.1368***	−0.0139
	(0.0399)	(0.0557)	(0.0425)	(0.0611)

Adult mort., female	(1)	(2) Democracy	(3) Intermediate	(4) Autocracy
Mean inefficiency				
Constant	−0.5664	−4.22	2.0047	0.0167
	(1.8459)	(7.6279)	(2.9722)	(0.9912)
Oil rent boom	0.0502**	0.3226	0.0142***	0.0077
	(0.0221)	(0.3024)	(0.0025)	(0.0086)
Oil rent bust	0.0682	0.4867	0.0217***	0.0103
	(0.0515)	(0.4196)	(0.0066)	(0.0436)
Oil rent valley	0.047**	0.3756	0.0183***	0.0076
	(0.0193)	(0.2845)	(0.0044)	(0.0296)
GDP per capita	−0.5753**	−0.7615	−0.2617	−0.024
	(0.2506)	(0.5435)	(0.2748)	(0.1218)

Table A.4 - continued from previous page

Maternal mortality	(1)	(2) Democracy	(3) Intermediate	(4) Autocracy
Mean inefficiency				
Constant	0.0293*	−2.2496**	−0.7823***	0.5746
	(0.0162)	(1.0926)	(0.2453)	(0.7361)
Oil rent boom	0.0042***	0.0339**	0.0086***	0.0112
	(0.0003)	(0.0138)	(0.002)	(0.0091)
Oil rent bust	0.0054*	0.0788***	0.0164***	0.0113
	(0.0028)	(0.0202)	(0.005)	(0.0134)
Oil rent valley	0.0032	0.0529***	0.0116***	0.0081
	(0.0023)	(0.0176)	(0.0031)	(0.0111)
GDP per capita	−0.0242***	0.2217*	0.1216***	−0.0947
	(0.0051)	(0.1136)	(0.0296)	(0.1179)

Notes: Neonatal are newborn babies between 0 and 28 days. Infants are children between 0 and 1 years. Children are between 0 and 5 years old. Adults are between 15 and 60 years old. Maternal mortality measures pregnancy-related deaths. Production functions (not shown) includes public, private health care expenditure, schooling, schooling2 (measured all in natural logarithm), income dummies and time dummies. GDP per capita is converted to natural logarithm. *, ** and *** stand for signifcant at the 10%, 5% and 1% level.

Table A.5: Robustness check: Excluding potential oil price setters

	(1)	(2)	(3)	(4)	(5)
Excluded countries:	Saudi Arabia	USA	Saudi Arabia + USA	OPEC	OPEC + USA
Prod. function					
Constant	3.7926***	3.805***	3.797***	3.7473***	3.7495***
	(0.0369)	(0.0366)	(0.0354)	(0.0358)	(0.0361)
Public exp.	0.0141***	0.0141***	0.0141***	0.0147***	0.0147***
	(0.0013)	(0.0013)	(0.0013)	(0.0012)	(0.0013)
Private exp.	0.0154***	0.0179***	0.0177***	0.0157***	0.0182***
	(0.002)	(0.002)	(0.002)	(0.0021)	(0.0021)
Schooling	0.3197***	0.2958***	0.3055***	0.3656***	0.3526***
	(0.0367)	(0.0364)	(0.0356)	(0.0363)	(0.0366)
Schooling^2	−0.0706***	−0.0645***	−0.067***	−0.0823***	−0.079***
	(0.0087)	(0.0087)	(0.0084)	(0.0087)	(0.0087)
LM income	0.021***	0.0209***	0.0206***	0.0192***	0.0187***
	(0.0062)	(0.0062)	(0.0062)	(0.006)	(0.006)
UM income	0.0135*	0.011	0.011	0.0114	0.0084
	(0.008)	(0.0079)	(0.0078)	(0.0079)	(0.0078)
High income	0.0315***	0.0256***	0.0266***	0.0299***	0.0245***
	(0.0097)	(0.0095)	(0.0094)	(0.0096)	(0.0094)
Mean inefficiency					
Constant	1.5914***	1.5865***	1.6082***	1.6573***	1.6945***
	(0.1627)	(0.1458)	(0.1594)	(0.2008)	(0.21)
Oil boom	0.0079***	0.0079***	0.008***	0.008***	0.0083***
	(0.0011)	(0.0012)	(0.0012)	(0.0014)	(0.0018)
Oil bust	0.0111***	0.0112***	0.0112***	0.0107***	0.011***
	(0.0018)	(0.0017)	(0.0017)	(0.0024)	(0.0033)
Oil valley	0.0085***	0.0086***	0.0086***	0.0096***	0.0098***
	(0.0013)	(0.0012)	(0.0012)	(0.0017)	(0.0022)
GDP pc	−0.2173***	−0.2166***	−0.2202***	−0.2322***	−0.2387***
	(0.0262)	(0.0235)	(0.0255)	(0.033)	(0.0347)
Distribution					
σ^2	0.0347***	0.0343***	0.0352***	0.0413***	0.0425***
	(0.0051)	(0.0048)	(0.0051)	(0.0071)	(0.0074)
λ	0.9954***	0.9952***	0.9954***	0.9966***	0.9965***
	(0.001)	(0.001)	(0.0009)	(0.0008)	(0.0008)
LL	2567.409	2565.406	2540.294	2362.162	2335.029

Notes: Production functions include time dummies. Public, private health care expenditure, schooling, schooling^2 and GDP per capita are converted to natural logarithm. *, ** and *** stand for significant at the 10%, 5% and 1% level.

Table A.6: Robustness check: Lagged outcome variable

	(1)	(2)	(3)	(4)	(5)
Outcome in:	t+1	t+2	t+3	t+4	t+5
Prod. function					
Constant	3.8196***	3.8349***	3.8499***	3.8646***	3.8817***
	(0.0374)	(0.0375)	(0.039)	(0.0399)	(0.043)
Public exp.	0.0135***	0.0129***	0.0122***	0.0115***	0.0107***
	(0.0013)	(0.0015)	(0.0015)	(0.0014)	(0.0016)
Private exp.	0.0152***	0.0149***	0.0147***	0.0144***	0.0139***
	(0.0021)	(0.0022)	(0.0022)	(0.0023)	(0.0024)
Schooling	0.3022***	0.2965***	0.291***	0.2874***	0.2801***
	(0.0375)	(0.0379)	(0.0396)	(0.0407)	(0.0435)
Schooling^2	−0.0667***	−0.0657***	−0.0648***	−0.0645***	−0.0632***
	(0.009)	(0.009)	(0.0095)	(0.0098)	(0.0105)
LM income	0.0211***	0.0207***	0.0206***	0.0206***	0.0215***
	(0.0064)	(0.0065)	(0.0071)	(0.007)	(0.0076)
UM income	0.0144*	0.0148*	0.0154*	0.0166*	0.0188*
	(0.0082)	(0.0083)	(0.0091)	(0.0091)	(0.0098)
High income	0.0325***	0.0337***	0.0355***	0.0383***	0.0423***
	(0.01)	(0.0102)	(0.0111)	(0.0112)	(0.012)
Mean inefficiency					
Constant	1.5236***	1.4667***	1.4003***	1.323***	1.2423***
	(0.15)	(0.1444)	(0.146)	(0.1371)	(0.1344)
Oil rent boom	0.0075***	0.0072***	0.0068***	0.0065***	0.0061***
	(0.0011)	(0.0011)	(0.001)	(0.0009)	(0.0009)
Oil rent bust	0.0103***	0.0099***	0.0095***	0.009***	0.0084***
	(0.0019)	(0.0019)	(0.0018)	(0.0018)	(0.0018)
Oil rent valley	0.0082***	0.0078***	0.0074***	0.0073***	0.0068***
	(0.0014)	(0.0014)	(0.0014)	(0.0015)	(0.0015)
GDP per capita	−0.2071***	−0.199***	−0.1895***	−0.1782***	−0.1664***
	(0.0243)	(0.0234)	(0.0234)	(0.0218)	(0.0214)
Distribution					
σ^2	0.0328***	0.0315***	0.0299***	0.0281***	0.026***
	(0.0048)	(0.0047)	(0.0043)	(0.0041)	(0.0041)
λ	0.9952***	0.9953***	0.9952***	0.9952***	0.995***
	(0.001)	(0.001)	(0.001)	(0.0011)	(0.0014)
LL	2437.355	2283.78	2131.401	1979.129	1825.46

Notes: Production functions include time dummies. Public, private health care expenditure, schooling, schooling^2 and GDP per capita are converted to natural logarithm. *, ** and *** significant at the 10%, 5% and 1% level.

Table A.7: Robustness check: Different definition of price shocks

	(1)	(2)	(3)	(4)
Price shock:	5%	10%	15%	20%
Production function				
Constant	3.8001***	3.8004***	3.8002***	3.8002***
	(0.037)	(0.0365)	(0.0364)	(0.0366)
Public exp.	0.0141***	0.014***	0.014***	0.014***
	(0.0013)	(0.0013)	(0.0013)	(0.0013)
Private exp.	0.0156***	0.0157***	0.0156***	0.0157***
	(0.002)	(0.0021)	(0.0021)	(0.002)
Schooling	0.3105***	0.31***	0.3104***	0.3104***
	(0.0371)	(0.0365)	(0.0368)	(0.0365)
Schooling^2	−0.0682***	−0.0681***	−0.0682***	−0.0682***
	(0.0089)	(0.0087)	(0.0088)	(0.0087)
LM income	0.0212***	0.0213***	0.0213***	0.0213***
	(0.0063)	(0.0062)	(0.0063)	(0.0062)
UM income	0.0135*	0.0134*	0.0136*	0.0135*
	(0.0079)	(0.0078)	(0.0078)	(0.0079)
High income	0.0305***	0.0305***	0.0307***	0.0306***
	(0.0096)	(0.0095)	(0.0094)	(0.0094)
Mean inefficiency				
Constant	1.5734***	1.5706***	1.5781***	1.5768***
	(0.1524)	(0.1557)	(0.1559)	(0.1557)
Oil rent boom	0.0078***	0.0078***	0.0077***	0.0079***
	(0.0012)	(0.001)	(0.001)	(0.0012)
Oil rent bust	0.0107***	0.0111***	0.0133***	0.0133***
	(0.0016)	(0.0017)	(0.0024)	(0.0026)
Oil rent valley	0.0084***	0.0085***	0.009***	0.0084***
	(0.0012)	(0.0014)	(0.0014)	(0.0011)
GDP per capita	−0.2142***	−0.2138***	−0.2149***	−0.2147***
	(0.0247)	(0.0249)	(0.025)	(0.025)
Distribution				
σ^2	0.0339***	0.0339***	0.0339***	0.0339***
	(0.0048)	(0.0049)	(0.0049)	(0.0048)
λ	0.9952***	0.9952***	0.9952***	0.9952***
	(0.001)	(0.001)	(0.001)	(0.001)
LL	2592.331	2592.348	2592.727	2592.358

Notes: Production functions include time dummies. Public, private health care expenditure, schooling, schooling^2 and GDP per capita are converted to natural logarithm. *, ** and *** stand for significant at the 10%, 5% and 1% level.