In this study, we investigate the impact of changes in income on child mortality in oil-rich countries. The health-economics literature does not accept a direct causal effect from income to child health. Therefore, we condition income per capita to shocks from time-series variation in global oil-prices interacted with cross-sectional variation in oil discoveries and a dummy to capture if a country was a European colony during the 16th to 19th-century European colonialism. This strategy helps to isolate a potentially exogenous source of variation in incomes and to broaden the scope of the resource curse while accounting for the enduring effect of European colonial experience. We estimate the causal effect of aggregate GDP per capita on child mortality in 99 heterogeneous, oil-rich countries from 1960 to 2010 with a Fixed Effect (FE) Instrumental variable (IV) estimator. In the first stage, we find a significant correlation between oil-price shock and income, but the experience of colonialism reduces the magnitude. In the second stage and across all specifications, we find a statistically insignificant impact of income on child mortality. Our findings document an aspect of the resource curse; in many resource-rich countries, the expected benefits from resource-wealth hardly translate to significant improvement in child mortality through income. Nevertheless, improving female labour participation helps in reducing child mortality. We suggest improving investments that economically engaged women and improving rent allocation that directly target child welfare as ways of reducing child mortality.

**Keywords:** Oil-Price Shocks, Resource Curse, Child Mortality, Colonial legacies

**JEL Codes:** F54, I15, I38, J13, Q32, Q33

1 **Introduction and Motivation**

In this study, we investigate the income-public health nexus in oil-rich countries. Specifically, we investigate the impact of income per capita, conditional on shocks from oil-price given oil discoveries and the enduring impact of European colonial experience, on child mortality in oil-rich countries. If the positive shock to income (oil-price shocks given oil discoveries) is compromised by the inefficiency in its management, the conditional shocks might not reduce child mortality. An improved understanding of child mortality is

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1 Jubril is a PhD student in Environmental and Resource Economics, Department of Economics, University of Manchester, UK. Phone number: +44(0)7440077279, email: jubril.animashaun@manchester.ac.uk , and a lecturer in the Department of Agricultural Economics, University of Ilorin, Nigeria. Email: Animashaun.jo@unilorin.edu.ng

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particularly useful for improving maternal, perinatal and paediatric healthcare in resource-rich countries with weak institutions and experience of European colonialism\(^2\).

Our work is motivated by the extensive empirical literature in demographics and economics that document mixed findings on the impact of economic shocks on child mortality. In developed countries, evidence suggests that aggregate income shocks and child health outcomes are counter-cyclical: that is, child health improves during economic recessions and deteriorates when the economy improves (Chay and Greenstone 2003, Dehejia and Lleras-Muney 2004). Negative economic shocks could cause a reduction in some health-damaging activities like smoking and unhealthy food eating habits (Ruhm 2000) and lowers the opportunity cost of childcare by making the unemployed parents invest more time for child caring tasks that improve child health (Baird 2011). Another strand of studies shows that in low-income and developing countries, the effect of income shocks is negatively pronounced on child health (Pritchett and Summers 1996, Ferreira and Schady 2009, Baird 2011). Negative income shocks have been shown to have significant implication for child mortality (Cutler et al. 2002, Paxson and Schady 2005, Bhalotra 2010), children's anthropometrics (Rabassa et al. 2012), child investment (Jensen 2000), and child school enrolment (Grimm 2011).

However, these studies have mainly focused on negative economic shocks and they fail to distinguish between positive and negative shocks. We contend that making this distinction is essential as shocks may have an asymmetric effect; for example, on household consumption (Christelis et al. 2019), mental health (Apouey and Clark 2015) and on child care (González 2013). At the macro level, positive income shocks may lead to expansionary monetary policies (i.e., leading to wealth redistribution and reducing income inequality) as opposed to negative income shocks that are contractionary (shocks that increase inequality) (Doepke and Schneider 2006, Emami and Adibpour 2012, Mumtaz and Theophilopoulou 2017, Furceri et al. 2018). Making this distinction is especially important in resource-rich countries where resource wealth is a source of positive shocks on government spending (Arezki et al. 2017, Emami and Adibpour 2012, Van der Ploeg and Poelhekke 2017). If positive income shocks lead to expansionary monetary policies that reduce inequality, then we should expect a reduction in child mortality as child mortality is concentrated among the poor (Flegg 1982, Waldmann 1992, Rodgers 2002). But positive shocks from oil discoveries may not be evident at reducing child mortality, either because of the inefficiency arising from the resource curse and/or because of corruption bequeath from the enduring colonial experience that aggravates rents allocation in resource-rich countries (Ades and Di Tella 1999, Wigley 2017).

The second motivation follows from the mixed evidence on the implication of the enduring legacies of some colonial structures on economic development (Acemoglu et al. 2001, Feyrer and Sacredote 2009). For instance, while the colonial influence on institutional quality and corruption could make government weak at resource allocation (Acemoglu et al. 2001, Angeles 2007, Angeles and Neanidis 2015), the colonial experience could exert countervailing effects through the colonial investment in structures of modernisation that raise post-colonial income per capita (Feyrer and Sacredote 2009). For example, the colonial investment in the human capital (Eynde 2015, Ayesu et al. 2016), the industrial expansion of local processing facilities (Cappelli and Baten 2017, Dell and Olken 2017), and the provision of transportation (railroad, roads) infrastructures (Michalopoulos and Papaioannou, in press)

\(^2\) Data on 2018 estimates of child mortality indicate that all the top 20 countries with the highest child mortality are all European colonised countries and many of them derive a substantial revenue from resource rents (UNICEF 2018).
could be useful for raising post-colonial income per capita given oil discoveries that translate to improvements in child and maternal health.

Perhaps a closely related work that motivates this study is Wigley\(^3\) (2017). Wigley (2017) examined whether the so-called resource curse extends to the health of children, as measured by under-five mortality. To analyse the relationship between oil wealth and child mortality, the study uses a measure of oil wealth as the total oil income per capita calculated by deducting extraction costs from the total value of a country's oil and natural gas production. While this measurement represents a better measure of oil rents than oil exports divided by GDP, because it depends on extraction costs, it is also a noisy indicator of resource wealth. Poorer countries with weak institutions and poorly developed financial sector tend to have higher extraction costs than wealthier countries (Bohn and Deacon 2000, Cust and Harding 2014). The health-economics literature does not accept that a direct causal effect runs from income to health (Deaton 2003); therefore, oil rents per capita, income per capita and child health will covary for a variety of reasons and simple correlations would reveal inconsistent estimates (Caldwell 1986, Cutler et al. 2006 Acemoglu et al. 2013).

Our approach is to focus on one specific channel of causation of windfall from oil discoveries on under-five child mortality: the one operating through shocks to income per capita. Income is good for health (Pritchett and Summers 1996), especially among the poor households in developing countries (Deaton 2003). We use a 2-stage Fixed Effect (FE) Instrumental variable (IV) strategy to estimate the causal effect of aggregate GDP per capita on child mortality per 1,000 births in 99 oil-rich countries from 1960 to 2010. We instrument aggregate income per capita with time series variation in global oil prices interacted with cross-sectional variation in the log of new oil discoveries and a dummy to capture if a country was a European colony during the 16th to 19th-century European colonialism. This strategy helps to isolate a potentially exogenous source of variation in income (Acemoglu et al. 2013), and broadens the scope of the resource curse through the enduring implication of colonial legacies that complicate the resource curse (Angeles and Neanidis 2015).

Despite the intuitive appeal, this strategy also implies a limitation: there remains the possibility of unobserved components of health that are correlated with colonialism and shocks from oil discoveries. Nevertheless, as we show that because colonial investments were made a long time ago, they are part of the fixed components of the residual term that explains child mortality and have been plausibly removed from the error term with the fixed effect estimator. Also, we show that because the main source of variation in the value of the log of oil discoveries instrument comes from the time series variation in the global oil price, the value of discoveries per capita is not correlated with another non-income channel. Besides, while countries can choose efforts and investment on exploration, but they cannot choose the amount of discoveries they get which is mainly function geography of oil formation that is independent of countries’ efforts and investment.

We find a statistically insignificant relationship between conditional income shocks and child mortality. A limited analysis where we restrict our analysis to oil-rich countries in the tropics and colonised countries also find similar results. Also, income per capita does not appear to

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\(^3\) Other studies that link oil endowment to health outcomes has focused mainly on adult diseases and have found mixed results (de Soya and Gizelis 2013, Sterck 2016). Child mortality can be considered a more appropriate indicator for studying the effects of the resource curse because it does not involve controlling for the long-run impact of prevention and treatment associated with adults’ disease and health outcomes (Currie and Neidell 2005).
reduce other potential child mortality mechanisms like the reduction of maternal mortality, investment in hospital facilities, basic sanitations and per cent of low birth weights. Our findings document an aspect of the resource curse; in many resource-rich countries, the expected benefits from resource-wealth hardly translate to significant improvement in child mortality through income.

The rest of the paper proceeds as follows. Section 2 conceptualises the study and Section 3 formalises the analytical and identification strategy adopted and describes the data. Section 4 contains the main results of the first and second stage regressions. It also offers a discussion of the main findings and also provides additional robustness. We conclude in Section 5.

2 Conceptual Framework

In this section, we discuss the conceptual framework that underlies our study and use it to develop our analytical strategy. We build on the foundational assumptions of Gary Becker’s theories with respect to the family maximising behaviour at equilibrium and extend to the general equilibrium unit because of the expediency with the analyses of child health at the macro-level. Analysing at the macro instead of the family unit is important because health coverage in developing countries often involved substantial government interventions to improve equity in access to health care that are often not fully captured with household income (Deininger and Mpuga 2005, Meessen et al. 2011, Lagomarsino et al. 2012).

Specifically, we extend the Barro-Becker “altruistic” parent model (Barro and Becker 1989) and the income elasticity and the child quality model of Becker and Lewis (1973). At the family level, these models provide a useful framework for understanding fertility rates, family’s utility and the child’s quantity and quality trade-off. Parents maximise the family’s aggregate utility from their own consumption (i.e., parents’ utility) and by choosing the number of children to have. The more children a family has, the lesser the quality (more costly investment on education), and the lesser the family’s aggregate utility. The implication is that fertility rates decline as families get richer (positive shocks) and as the opportunity cost for having children increases. These well-articulated models have guided the formulation of testable hypotheses, extensions have been provided, and the empirical information required for their verification under a minimal set of restrictions has also been discussed (see for instance; Rosenzweig and Wolpin 1980, Doepke 2005).

These models, despite their comprehensiveness, do not ascribe any significant influence on child mortality (Doepke 2005). Because of the “pension motive” for having children; i.e., having more children is security for parents at old age (Neher 1971), high mortality rate could reduce the family’s aggregate utility in the long term and the decision on the number of children to have. Child’s mortality disrupts the family's utility by affecting parents’ health; e.g., more hospital admissions (Li et al. 2005), morbidity, e.g., some forms of cancer (Levav et al. 2000), and by affecting their general well-being during and over extended periods of bereavement (Song et al. 2010). More importantly, child mortality has a significant consequence at the macro-economic level; e.g., productivity-related losses from the economic and psychosocial consequence of the bereaved parents (Schultz 1993, Fox et al. 2014, Heazell et al. 2016). Therefore, exploring child mortality as a significant component of the family’s utility model is an aspect that can offer a suitable template for developing our analytical strategy at the macro-economic level.
We consider a simple extension that treats child mortality as an important component of the aggregate family utility. We assume that the family derives utility \( U_i \) from own consumption \( (c_i) \) (i.e., parents’ medical and non-medical) and from the utility of the child’s survival \( (d_i) \). Like Barro and Becker (1989), we assume that parents are “altruistic” \( (\beta) \): i.e., they care about the child’s survival and are willing to take actions that satisfy the child’s wellbeing even if a more rewarding and self-interested alternative exists.\(^4\)

Assuming linearity of each of the utility components, the aggregate utility of the \( i \)th family can be written as (Barro and Becker 1989):

\[
U_i = v(c_i) + \beta F(d_i)
\]

Where \( (U_i) \) is that the sum of the family’s utility, \( c_i \) is parents’ own consumption and \( v(c_i) \) is the utility from this consumption. \( d_i \) is the probability of the child’s survival and \( F(d_i) \) is the utility from this child’s survival. \( \beta \) is the degree of parents’ altruism toward their child. We define the altruism parameter \( (\beta) \) as less than one but greater than zero (Barro and Becker 1989) but relax on the assumption of the functional form it takes.

\[
0 < \beta < 1
\]

Parents’ utility function \( v(c_i) \) is associated with the price \( (p) \) and the quantity of medical \( (m_i) \) and non-medical \( (nm_i) \) consumption (Eqn. 3.3). Also, the child’s survival function\(^5\) \( F(d_i) \) is associated with the mother’s prenatal and postnatal consumption \( (b_i) \) e.g., hospital visits and medical care for the child from conception till birth, and the child’s consumption of other goods \( (q_i) \) at price \( (p) \) during the early stage of development that improves the child’s survival (Eqn. 4).

\[
c_i = p(m_i) + p(nm_i)
\]

\[
d_i = p(b_i) + p(q_i)
\]

Expenditures on parents’ utility (Eqn. 3.3) and the infant’s survival (Eqn. 3.4) are constrained by the available budget (income) denoted by \( w_i \). In Eqn (3.5), we re-arrange Eqns. 3 and 4 and introduce income \( (w_i) \) to specify the budget constraint model:

\[
p(m_i + nm_i) + p(b_i + q_i) \leq w_i
\]

Where the first term \( p(m_i + nm_i) \) is the expenditure on parents’ own medical and non-medical consumption, and the second term \( p(b_i + q_i) \), is the expenditure for improving the child’s survival \( (d_i) \) up to a certain age. Income \( (w_i) \) and the cost parameter \( (p) \) satisfy the necessary conditions i.e., \( w_i > 0 \) and \( p \geq 0 \). At equilibrium, positive shocks to income would increase the aggregate family utility by improving parents’ consumption \( (c_i) \) and by improving child’s survival \( (d_i) \).

\(^4\) An example in this regards could be when a parent avoids certain actions that are not beneficial for the foetus or the child e.g. smoking, or foregoes a higher paying job to focus on the commitment to nursing and raising the child.

\(^5\) Child birth and child rearing are nonmarket activities so the transaction prices used to illustrate the costs associated with the child’s survival cannot provide full information on the full range of costs with the child care (Willis 1973).
To make our model analytically tractable and testable with data, we assume that parents’ consumption component \((m_i + nm_t)\) is less sensitive to income and to the budget constraint; i.e., parents can smoothen consumption in times of temporary negative income shocks (West 1988). But the child’s is more vulnerable to income shocks; negative economic conditions early in life could have a significant impact on their survival and such shocks can reflect the decline in the aggregate family utility and wellbeing (Thomas 1994, Huck 1995, Van den Berg 2006). Besides, child mortality is an outcome that can also serve as an index of parents’ living standards and utility (Thomas 1994, Huck 1995, Van Poppel 2000, Semba et al. 2008). Using this intuition, we extend Eqn 5 by relaxing the parents’ consumption component; i.e., \(p(m_i + nm_t) = 0\), include time dimension \(t\) and consider variation at the family \(i\) and community \(j\) levels to build our analytical model of income shocks and the child mortality.

We define a reduced form relationship of the income-child mortality as:

\[ d_{i,j,t} = \delta(\text{Income}_{ijt}) + \mu_{i,j,t} \]  

(6)

Where \(d\) is the rate of child mortality in the \(i\)th family, community \(j\) and year \(t\). \(\text{Income}\) denotes exogenous income shock at the household level at time \(t\) and reflects the marginal elasticity of household income on the probability of the child’s survival. The error term is assumed to take the form; \(\mu_{i,j,t} = e_{i,j,t} + \gamma_j + \phi_t\) where the two latter terms capture the systematic differences in the infant survival rates fixed across households and communities over time. \(e_{ijt}\) is the idiosyncratic error component which reflects maternal genetic factors, differences in altruism that could affect parents’ investment on child’s survival, other omitted variables, and the approximation errors associated with income and child mortality measurements.

Equation (6) represents the equilibrium at the family and community level \((j)\). However, income shocks at this level could hardly explain the variation in child mortality. Investment and interventions at improving the child’s survival and health, e.g. the provision of vaccinations and immunisation against infectious disease, are usually done by the government at the macro-level. Also, the government provides subsidies that cater to the health needs of pregnant women and children, especially in many developing countries where out-of-pocket medical expenses are usually low. So a more-informed analysis of Eqn (6) will focus on analysing the effects of income shocks on child mortality (CMR) at the macro-level \((k)\).

For the general equilibrium, we take the national averages by countries for equation (6) and weigh by population:

\[ CMR_{k,t} = \delta(\text{Income per capita}_{k,t}) + \mu_{k,t} \]  

(7)

where \(CMR\) is the number of child death before age five per 1,000 live births in country \(k\) and for a given year \(t\).
3 Analytical strategy

To estimate the parameters of interest, we re-write equation (7), include controls for time-non
varying covariates and use the country ($\lambda$) and time ($\Omega$) fixed effects to control for omitted
variables in eqn (8).

$$CMR_{k,t+1} = \delta_1(\text{Log } GDP_{k,t}) + \delta_2(F_{k,t}) + \delta_3(R_{k,t}) + \lambda_k + \Omega_t + \varepsilon_{k,t}$$ (8)

In Eqn. (8), $CMR_{k,t+1}$ represents the child mortality rate per 1,000 live births before reaching
age five in country $k$ and a year ahead of the income shock. $\text{Log } GDP_{k,t}$ is the income per
capita 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. $F_{k,t}$ is the
percentage of female of the total work force and $R_{k,t}$ is the percentage of the population
within the active age range of 15 to 64 years. The country ($\lambda$) and time ($\Omega$) fixed effects
measure any other time-invariant differences across the different oil rich countries and the
year fixed effects capture any common changes in disease outcomes each year.

Fixed Effects (FE) estimates in Eqn (8) are likely to be biased. Income per capita and child
health co-vary at the national level for a variety of reasons; therefore, simple correlations
would unlikely reveal the causal effect of income on health (Acemoglu et al. 2013). First,
there could be an external source of shock to income per capita which could increase the
affordability of expensive medical technology and improved nutrition and lead to a decline in
child mortality (Schofield et al. 1991, Easterlin 1999). Second, it is possible that
improvements in health are a consequence of the efficient use of public health technology,
improvements in the education of women, maternal and child health services, and changes in
 genetic diversity which may be correlated with higher income (Caldwell 1986, Venter et al.

To consistently estimate the income elasticity on child mortality, first; we relate our approach
to the one used in Acemoglu et al. (2013), Michael (2007) and Black et al. (2005) where the
stock value of the natural resource is employed as an instrumental variable to obtain a
consistent estimate of the impact of income on health outcomes. Specifically, we identify
income per capita with the time series variation in global oil prices given that a country has a
discovery of oil and gas. We call this instrumental variable the log of the value of discoveries.
This variable is sourced from the replication dataset of Cotet and Tsui (2013). Although these
discoveries are not exclusively giant oil fields, they also represent a potential source of
shocks on the government’s current account and other key macroeconomic variables. At a
reasonable global oil price, the effects could plausibly be directly observable national income
and government spending (Arezki et al. 2017).

As our second instrumental variable, we interact with the values of the discoveries a dummy
variable that represents the experience of European colonialism. The intuition for this is to
understand how specific institutional barriers constitute inefficiencies that reduce the shocks
from the discoveries on income. The extent to which oil-price shocks given discoveries will
translate to improvement in income per capita that will reduce child mortality depends on the
presence of a socially efficient rent allocation mechanism that makes the government
accountable in revenue allocation. For instance, if corruption and clientelism are high, the
government will be less concerned at having an efficient allocation (Ades and Di Tella 1999),
and such positive price shocks may not translate into an improvement in child mortality. The
interaction of these two variables will give the true value of the income shocks and can aid in
providing a true impact of income shocks on child mortality.
Corruption has been shown to have a deep historical origin associated with the enduring legacies of some of the 16th-19th European colonisation practices (Mulinge and Lesetedi 1998, Treisman 2000, Angeles and Neanidis 2015). In several ways, colonial could have inadvertently birthed corruption that makes the benefits from oil price shocks to not translate into a significant economic improvement in many oil-rich countries. For instance, to consolidate foreign rule and encouraged low-cost extraction of resources in many colonies, colonial authorities often modified apparatuses of governance and designated authority to selected individuals which created a gap in access to privilege and created an elitist group (Igbafe 1979, Dell 2010, Aldrich and McCreery 2016). These elites were not directly responsible to the people, and the position created limited accountability, an increase in the abuse of offices and the use of the position to divert public resources for private use (Leonard 1991, Mulinge and Lesetedi 1998). If this abuse of office and poor accountability associated with colonial experience is passed on and inherited, it could inform the decision of the indigenous post-colonial elite on how to allocate rent that would be socially efficient and supportive of inclusive shared prosperity.

Building on these insights, we instrument the log of income per capita in Eqn(8) with the time series variation in global oil prices given discoveries and a colonial dummy that represent the enduring impact of the colonial legacy. Equation (3.9) is the first-stage regression:

First Stage Regression:

\[
\log Y_{k,t} = \varphi_1 \left( Price \times Discoveries_{k,t} \right) + \varphi_2 \left( Price \times Discoveries_{k,t} \times Colony_k \right) + \sum_{j=3}^{4} \varphi_j Z_{k,t} + \lambda_k + \Omega_t + \mu_{k,t} \tag{9}
\]

where \( \log Y_{k,t} \) is the endogenous regressor (income per capita). \( Price \times Discoveries \) measures the log of the value of the new oil discoveries in terms of millions of barrels per capita multiplied by the price of crude oil per barrel expressed on 1990 USD (cross-sectional variation in oil discoveries and time-series variation in global oil-price). Because a significant variation comes from the time series variation in global oil price, the value of the new discoveries is plausibly exogenous to income shocks. \( Colony \) is a dummy variable equal to 1 if country \( k \) is a former European colony (with available data on settlers’ mortality and the use of European colonial language as official language) and 0 otherwise. Other time-varying variables (\( Z_{k,t} \) in eqn 8) are controlled for by accounting for the country’s socio-demographics by including a female participation in labour and the proportion of the population within the active working age 15-64 ages.

Our approach leverages on the assumption that changes in global oil price, discoveries and European colonial history have no direct effect on aggregate child mortality except through the income per capita. However, areas with different amount of oil discoveries and colonial experience may differ in other ways that could affect health outcomes. For example, the overseas investment in modernisation via industrial expansion (Dell and Olken 2017), the human capital (Eynde 2015, Ayesu et al. 2016), and the provision of transportation infrastructures (Michalopoulos and Papaioannou, in press) could help in raising current income per capita and reducing child mortality. However, since these investments are likely to be fixed, therefore time-invariant, they have been absorbed by the country fixed effects. Furthermore, exogenous changes in government policy and global innovation in the treatment and care of children and pregnant mothers are all likely to be accounted for by the time fixed effects (Acemoglu et al. 2013). We conduct a series of validity test to confirm the strength of
our identification strategy in Section 4. The schematic framework for the analytical strategy is illustrated in Figure 1.

![Figure 1: Schematic Illustration of the Conceptual and Analytical Strategy](image)

### 3.1 Data and Variable Description

**GDP per capita (constant 2010 US$).** GDP per capita is gross domestic product divided by midyear population. GDP 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 depletion and degradation of natural resources. Log of GDP per capita in 2000 constant dollars (multiplied by a 100).

**Child mortality rate child (per 1,000 live births and multiplied by a 100)** Child mortality rate is the number of a child dying before reaching five years of age, per 1,000 live births in a given year. Estimates developed by the UN Inter-agency Group for Child Mortality Estimation (UNICEF, WHO, World Bank, UN DESA Population Division) at www.childmortality.org. Log of child mortality rate is taken from Acemoglu et al. 2019.
Log (Value of Oil Discoveries per capita) is (the log of) cross-sectional variation in oil discovery per capita multiplied by the time series variation in the price of crude oil expressed on 1990 USD. The data is secured from the replication data of Cotet and Tsui (2013). For countries with no oil discovery, the authors imputed the zeroes by dividing the smallest observed positive value of the variable oil discovery per capita and crude oil price by 1000. The link to the online appendix where the data is exhaustively described is formed https://www.aeaweb.org/aej/mac/app/2010-0022_app.pdf
**Colony** is defined as countries with data on the log of settler mortality as identified in Acemoglu et al. (2001) paper, or with the presence of European colonisation at a certain point in their history. Also, we match our description with colonised countries listed in Comin et al. (2010).

**Labour force, female (% of the total labour force)** is the share of the female labour force that is with work. The data is taken from Ross (2008) and can be assessed from https://doi.org/10.7910/DVN/BHU6SP

![Figure 4: Child Mortality per 1000 birth and Female labour force participation](image)

**Log (Oil Rents per capita)** is taken from the replication data of Cotet and Tsui (2013). The variable is the log of cross-sectional variation in oil production per capita multiplied by the time series variation in the price of crude oil expressed in 1990 USD. These are for countries that are already actively producing oil and have started receiving rents. For years with no oil production, the authors imputed the zeroes by dividing the smallest observed positive value of the variable oil production per capita and crude oil price by 1000. The data is from Cotet and Tsui (2013) and can be assessed from https://www.aeaweb.org/aej/mac/data/2010-0022_data.zip
Figure 5: Correlation between (mean) Child mortality rate and (mean) Oil rent per capita

Per cent of total population ages 15-64 (WDI Ross 2008) Total population between the ages 15 to 64 as a percentage of the total population. The population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The data is original from the World Bank Development Index, but we use the replication provided in Ross 2008 and assessed from [https://doi.org/10.7910/DVN/BHU6SP](https://doi.org/10.7910/DVN/BHU6SP)

4 Results and discussion

This section presents and discusses the results, and the section is divided into three parts. In the first part (Section 4.1), we establish the relationship between oil rents per capita and child mortality to explore whether countries with revenue from oil and gas are susceptible to more child mortality (Table 1). In the first part, it is not our aim to imply causality as the direction of impact is hard to establish. Instead, we aim to establish a preliminary justification for our study. If countries with more oil revenue cannot reduce child mortality, then it is important to causally identify the direction through which oil price shocks and discoveries relates to child mortality.

In the second part (Section 4.2), which is the main result section, we document the conditional relationship of shocks to income per capita (from time series variation in global oil prices given cross-sectional variation in discoveries and colonial experience) on child mortality from 1960-2010. This is important because it enables us to understand the direction of causality and help us to identify the impact of income on child mortality. The main results are presented in Tables 2 and 3. Also, we present statistical tests to validate the strength of our instruments (Table 4).
In the third part (Section 4.3), we carried out some sensitivity analysis; first, we consider the heterogeneous impact based on ecological zones by restricting our sample to countries in the tropical zones, colonised countries, and consider countries that were colonised and also fall in the tropics. We also consider other outcomes, e.g., maternal mortality, use of basic sanitation, per cent of low birth weight and hospital bed per 1000 population. These are recognised channels that are important for reducing child mortality, and we test if income shocks have any significant impact on these outcomes.

4.1 Cross-Country Correlation: Oil Endowment per Capita, Income and Child Mortality

In this section, we establish a preliminary link between a country’s oil rents per capita (Log (Oil production in a million barrels per 1000 person x by crude oil price)) and child mortality (Table 1). The approach is similar to the results from Wigley (2017) on the effect if oil-wealth per capita on child mortality.

Establishing this link is important to justify our subsequent analysis. The intuition behind this preliminary analysis is that if oil rents per is used efficiently, it could lead to a reduction in child mortality. In essence, absent the resource curse and all things being equal, countries with more rents should have less child mortality. This motivating hypothesis is empirically analysed in Eqn. 10 and the results are presented in Table 1.

\[ Y_{j,t} = \beta_1(Oil \ rents_{j,t}) + \beta_2(GDP \ per \ capita_{j,t}) + \lambda_j + \Omega_t + \varepsilon_{j,t} \]  

(10)

Where \( Y \) is the dependent variable and it is the Log of child mortality per 1000 live birth. The main variable of interest in Table 1 is \( Oil \ rents \) and it is the log of oil production per capita multiplied by the price of crude oil expressed on 1990 USD. The oil rents per capita variable represents the revenue from oil production for countries that are already oil exporters. This variable is different from log of value of new discoveries (countries with new discoveries might not be earning rents since there is usually a time lag between discoveries and subsequent production).

Consistent across all Models in Table 1 is the significant positive correlation between oil rents per capita and child mortality and a negative correlation between income per capita and child mortality. Model, I reports the results without any other control and Model II reports with additional controls for Income per capita, per cent of the working population (15-64 ages) of the population and per cent of the female labour force of the total labour force. In Model III we account for non-linearity between income and child mortality as an income may not have the same effect on child mortality reduction between rich and developing countries; increasing income will reduce child mortality more among the developing countries than among rich countries. Model IV restrict our sampled countries to just African countries. More oil rents should lead to more revenue for the government, and such additional revenue could translate into an improvement in the medical and non-medical household consumption. However, a positive correlation between child mortality and oil rents could indicate an aspect of the resource curse that deserves further enquiry.
## Table 1: Oil rents per capita, GDP per capita and Child Mortality per 1000 birth

<table>
<thead>
<tr>
<th>Dependent Variable: Log of child mortality per 1000 birth (multiplied by a 100)</th>
<th>Model I</th>
<th>Model II</th>
<th>Model III</th>
<th>Model IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log Oil Rents per capita</td>
<td>0.43***</td>
<td>2.53***</td>
<td>3.36***</td>
<td>22.51*</td>
</tr>
<tr>
<td></td>
<td>(0.06)</td>
<td>(0.68)</td>
<td>(0.69)</td>
<td>(12.08)</td>
</tr>
<tr>
<td>Log GDP/capita</td>
<td>-0.27***</td>
<td>-0.33***</td>
<td>-0.30*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.06)</td>
<td>(0.057)</td>
<td>(0.15)</td>
<td></td>
</tr>
<tr>
<td>Log GDP/capita (squared)</td>
<td>-0.0006***</td>
<td>-0.0003</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0002)</td>
<td>(0.0004)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per cent of total population ages 15-64</td>
<td>-1.93**</td>
<td>-2.09**</td>
<td>-1.09</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.75)</td>
<td>(0.71)</td>
<td>(1.53)</td>
<td></td>
</tr>
<tr>
<td>Female Labour force (% of the total labour force)</td>
<td>-3.52***</td>
<td>-2.7***</td>
<td>-5.88***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.58)</td>
<td>(0.65)</td>
<td>(1.23)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>320.78***</td>
<td>774***</td>
<td>567.5***</td>
<td>690.5***</td>
</tr>
<tr>
<td></td>
<td>(3.0)</td>
<td>(50.2)</td>
<td>(36.3)</td>
<td>(79.16)</td>
</tr>
</tbody>
</table>

### Notes:
- Table 1 is the Fixed Effect OLS regression of log rents per capita, Log GDP per capita on child mortality. Log Oil Rents per capita is Oil production in countries already producing oil (million barrel per 1000 person \(\times\) by crude oil price). The data is from Cotet, and Tsui (2013) accessed from [https://www.aeaweb.org/aej/mac/data/2010-0022_data.zip](https://www.aeaweb.org/aej/mac/data/2010-0022_data.zip), and it covers from 1960-2010.
- Income per capita is in 2000 constant dollars (multiplied by a 100).
- Models I-III include all countries described in Cotet and Tsui with oil reserves (2013)
- Model IV include only countries from Africa.
- All models control for Country and Time FE. The robust standard errors are in parenthesis and are clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.

After establishing that countries with more rents have higher child mortality, it is also important to identify the main medium which is responsible for the relationship. One channel we suspect is through income. To consistently estimate this channel, we need another variable that is not directly correlated with child mortality but serves as a shock to income. Positive shocks from oil discoveries could help in raising income, and through income, we can understand the direction of mechanism. Because these discoveries are new oil-fields have not started producing oil, we can use shocks from their announcement to partial out the exogenous variation in child mortality through income.
4.2 Impact of Income per capita on Child Mortality in Oil-rich Countries

In this section, we examine the resource curse in oil-rich countries with respect to child mortality by conditioning the relationship between income and child mortality with the time series variation in global oil prices given new oil discoveries and the experience of the 16th to 19th-century European colonialism. Using a 2-stage IV regression, we estimate in the first stage, the correlation between the logs of the value of discoveries interacted with the colonial experience dummy and income per capita. At a reasonable price, more oil discoveries could make countries potentially richer, and this can improve government spending and more income for citizens (Arezki et al. 2017). However, if anticipated benefits do not transmit to better income because of poor management and an allocation problem, the positive shocks from oil price on income would be immaterial at helping to reduce the number of child mortality.

The instrumental variables help to account for the remaining omitted variables that account for heterogeneity between the income and child mortality. The colonial experience dummy identifies institutional corruption that mediates why shocks from oil discoveries may not translate into a positive impact on child mortality through income per capita. We account for a year lag to allow for income shock to take effect on child mortality gave that vulnerability to mortality might not be immediate as a household may smoothen consumption within a short window of shock. All the models control for country and time fixed effects. The result of the second stage is presented in Table 2, and the reduced first-stage result is in Table 3.

The FE-IV models in Table 2 show a departure from estimates of the impact of income per capita on infant mortality presented in Table 1. Specifically, we find in Model V, a statistically weak 0.022 decline in a number of deaths per 1,000 births in oil rich countries with a 10% increase in Log GDP per capita. Richer countries tend to have higher education levels, better public health policies for child health and more importantly, well-developed employment policies that engage and accommodate the female into the workforce. These additional factors can contribute to child mortality independent of income and make the results in Model V biased (Cutler et al. 2006, Baird et al. 2011). In Model VI, we include additional control for Female Labour force participation (% of the total labour force) and the percentage of the active population (ages 15-64) of the total population and find no significant impact of income per capita on child mortality. In Model VII, we also find that similar result after accounting for plausible non-linearity between income and child mortality. In Model VIII, we restrict our sample to only African countries, and in Model IX, we restrict our sampled countries only to oil-producing countries who have been earning rents from the production of oil and gas. In both of these latter cases, we find no significant impact of income on child mortality.

Across all models, we find a weak and statistically insignificant impact of conditional income shocks on child mortality. The evidence of no significant impact of income shocks on child mortality in Table 2 lies between findings of the positive effect income shock has on improving child health (Summers and Pritchett 1996, Bhalotra 2010, Baird et al. 2011) and findings that document negative effect (e.g., Waldmann 1992, Ruhm 2000, Chay and Greenstone 2003). Several explanations have been proposed in the literature to explain why positive income shocks might not lead to child mortality and why economic recession might be good for reducing infant mortality (Chay and Greenstone 2003, Dehejia and Lleras-Muney 2004). For one, if positive income growth comes from economic activity that increases air pollution, then slower growth might be good for child health and make them less vulnerable.
to mortality (Chay and Greenstone 2003, Dehejia and Lleras-Muney 2004, Currie and Neidell 2005). Also, positive income shocks might increase the probability of health-damaging behaviours among pregnant mothers, such as smoking and drinking, which may contribute to the higher vulnerability of child mortality. Furthermore, aggregate negative shocks can depress wages and imply a lower opportunity cost (Baird et al. 2011). The implication of this is that mothers and caregivers now value the time spent on looking after the wellbeing and care of the child; e.g., taking children for preventive health visits, breastfeeding, cooking healthy meals, and collecting clean water than the time spent on working for wages (Baird et al. 2011).

The year effects absorb aggregate trends in income and infant mortality that are associated with a change in government or breakthrough in the cure of infectious disease outbreaks. Country FE controls for time-nonvarying geographical effects that may be associated with prevalence and susceptibility of child to mortality.

Another explanation for no significant impact of income on child mortality can be deduced from historical accounts of mortality and income. For instance, in England from 1750 to 1820, mortality had nothing to do with increased income per head6 (Cutler et al. 2006). Indeed, the 16th to 18th century English aristocrats with better income and higher nutrition had no life expectancy advantage over the rest of the population and mortality was also not lower in other well-fed populations such as in the United States. Perhaps, the proof behind the non-significant impact of income on child health is that significant improvements in public health policies played an important channel for the reduction of mortality and not income (Cutler et al. 2006). Taking a cue from mortality estimates of the general population, people, irrespective of income levels live longer today because of the improvement in sanitation rather than income than they did several years back. The argument here is that public health improvement and not income is the sole driver of a reduction in mortality.

While there is truth in these positions, however, these explanations obscure other aspects of the problems with resource-rich and colonised countries where suggestions attribute the generally poor economic development to corruption and mismanagement of resources. For one, the previous literature has focused on negative shocks arising from macroeconomic crises and drought. However, positive shocks to income could reduce constraints household face in terms of spending on goods that help to lower child mortality. More importantly, the identified problem in oil-rich countries suggests that if institutions in place discourage an efficient rents allocation, the positive oil-price shocks will not be fully felt on income (Table 3), and this might cause a weak and non-significant reduction in child mortality (Table 2). Therefore, a contribution to these explanations in respect of resource rich countries could be to use to understand and broaden the scope of the resource curse and to understand the priority of institutional settings (i.e. colonial experience) at explaining the income shocks to lead to a positive outcome.

Cross-section variation in oil discoveries at a reasonably modest price (time series variation) would likely stimulate economic activities that improve income, which could increase investment and improvement in the consumption of medical and non-medical goods. Such positive income shocks might increase household consumption and contribute to better access to inputs that help in determining child health. However, the extent of how expected benefits

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6 Indeed, Wrigley and Schofield (1981) estimate that life expectancy in 1600 was the same as in 1820, with 1750 being the low point of a two-century swing.
from oil wealth translate into significant improvement is premised on government commitment. Particularly, strong institutions that reduce corruption and ensure a socially efficient rent distribution, the investment in health facilities and health policies that make medical care and treatment available for every pregnant mother and child up to a certain age.

Table 2: Instrumental Variable Estimates of Income Shocks and Child Mortality

<table>
<thead>
<tr>
<th>Dependent Variable: Log of child mortality per 1000 births (multiplied by a 100)</th>
<th>Model V</th>
<th>Model VI</th>
<th>Model VII</th>
<th>Model VIII</th>
<th>Model IX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log GDP/capita</td>
<td>-0.23*</td>
<td>0.32</td>
<td>0.34</td>
<td>0.17</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td>(0.13)</td>
<td>(0.22)</td>
<td>(0.21)</td>
<td>(0.14)</td>
<td>(0.27)</td>
</tr>
<tr>
<td>Log GDP/capita (squared)</td>
<td></td>
<td></td>
<td>-0.0002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per cent of population ages 15-64</td>
<td>-5.56***</td>
<td>-5.91***</td>
<td>-5.06***</td>
<td>-5.11***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.21)</td>
<td>(1.19)</td>
<td>(1.18)</td>
<td>(0.91)</td>
<td></td>
</tr>
<tr>
<td>Female Labour force (% of the total labour force)</td>
<td>-3.17***</td>
<td>-2.79***</td>
<td>-3.68***</td>
<td>-0.67</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.21)</td>
<td>(0.52)</td>
<td>(0.922)</td>
<td>(0.45)</td>
<td></td>
</tr>
<tr>
<td>Endogenous regressors</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Instruments</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Under-identification test</td>
<td>36.85</td>
<td>23.62</td>
<td>30.2</td>
<td>14.34</td>
<td>15.92</td>
</tr>
<tr>
<td>Cragg-Donald Wald F statistic</td>
<td>17.65</td>
<td>12.84</td>
<td>10.79</td>
<td>10.83</td>
<td>10.94</td>
</tr>
<tr>
<td>Kleibergen-Paap rk Wald F-stat</td>
<td>20.56</td>
<td>12.55</td>
<td>15.7</td>
<td>13.6</td>
<td>8.11</td>
</tr>
<tr>
<td>Over-identification test</td>
<td>8.58</td>
<td>0.55</td>
<td>0.00</td>
<td>0.00</td>
<td>0.01</td>
</tr>
<tr>
<td>Number of Countries</td>
<td>97</td>
<td>97</td>
<td>97</td>
<td>33</td>
<td>52</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>3,401</td>
<td>3,396</td>
<td>3,396</td>
<td>1,200</td>
<td>1,772</td>
</tr>
</tbody>
</table>

Notes: Table 2 is the Second stage (IV) Fixed Effect regression of Log GDP per capita on child mortality. Original data for Oil population per 1000 person is from Cotet, and Tsui (2013) accessed from https://www.aeaweb.org/aej/mac/data/2010-0022_data.zip, and it covers from 1960-2010. The dependent variable is the World Bank estimates of the Log Child Mortality taken from Acemoglu et al. (2019): https://www.journals.uchicago.edu/doi/suppl/10.1086/700936/suppl_file/2014340data.zip. Income per capita is in 2000 constant dollars (multiplied by a 100). Models V-VII include all countries described in Cotet and Tsui with oil reserves (2013), Model VIII includes only oil-rich countries from Africa, and Model IX includes only countries with reported earnings from oil production (rents). The robust standard errors are in parenthesis and are clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.

Institutions matter for mediating the translation of oil-price and discoveries shocks on income per capita that will have a significant impact of reducing child mortality. For instance, institutions that disallow corruption might enable governments in oil-rich countries to make the price shocks meaningfully translate into better income and reduced child mortality. Additionally, the presence of such institutional might matter for governments commitments in the design of public health projects, e.g., providing treated water, sanitation systems,
draining swamps for safer environments and undertaking mass vaccination campaigns; as well as providing incentives at the micro level that encourage individuals and households to participate and utilise these projects.

Table 3: First Stage Regressions for Models IV-IX in Table 2

<table>
<thead>
<tr>
<th>Endogenous regressors</th>
<th>First stages for:</th>
<th>Instrumental Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>^aModel V</td>
<td>^bModel VI</td>
</tr>
<tr>
<td></td>
<td>Log GDP/capita</td>
<td>Log GDP/capita</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log (Value of Oil Discoveries per capita)</td>
<td>87.21***</td>
<td>63.53***</td>
</tr>
<tr>
<td>Log (Value of Oil Discoveries) × Colony (Dummy=1)</td>
<td>-63.87***</td>
<td>-37.99**</td>
</tr>
<tr>
<td></td>
<td>(16.64)</td>
<td>(16.99)</td>
</tr>
<tr>
<td>F-test</td>
<td>20.57</td>
<td>12.55</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: Table 3 is the First stage of the IV Fixed Effect regression results for Models V-VIII in Table 2.

^a Model V: The first stage for Model V. The endogenous variable is log GDP per capita.
^b Model VI: The first stage for Model VI in Table 2. The endogenous variable is Log GDP per capita.
^c Model VII: The first stage for Model VII in Table 2. The endogenous variables are income and income per capita (squared). The income per capita (squared) is re-centered to reduce multicollinearity and allow for easy interpretation.
^d Model VIII: The first stage for Model VIII in Table 2, where only African countries are included. The endogenous variable is Log GDP per capita. Because all the African countries that are in our sample were colonised, the interaction effect drops out.
^e Model IX: The first stage for Model IX in Table 2 is only for countries who are already producing oil and gas and are earning rents. The endogenous variable is Log GDP per capita.

All models control for Country and time FE and the other controls in the main model. The robust standard errors are in parenthesis and are clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.

As shown in the first-stage results (Table 3), colonial heritage matters for how the expected oil wealth transmits to income and effectively reduces the impact income has reducing child mortality in the second stage regression (Table 2). Several studies have identified the underlying cause of the resource curse to corruption that encourages the diversion of expected earnings for personal use (Leite and Weidmann 2002, Kolstad and Søreide 2009, Bhattacharyya and Hodler 2010, Brollo et al. 2013). However, a major problem is how to identify corruption. One major source of corruption in many developing countries is the deep historical legacies of colonial experience (Mulinge and Lesetedi 1998, Angeles and Neanidis 2015).
Colonialism introduced the abuse of office and power which might get magnified if such colonised states have access to resource wealth. The resultant colonial political structure that favoured extractive institutions was an ideal breeding ground for corruption and how post-colonial elites manage oil wealth for economic growth in terms of income per capita (Mulinge and Lesetedi 1998, Angeles and Neanidis 2015).

As we show in our First-stage results in Table 3, the colonial experience dummy significantly reduces the estimate from the value of oil discoveries on income. The ability of oil price and discovery shocks in oil rich countries to translate into an improvement in GDP and the subsequent consequence on child mortality rests on corruption identified with the enduring impact of colonialism. In relation to previous studies which have found establish the link between colonial heritage and corruption, e.g. Mulinge and Lesetedi 1998, Treisman 2000, Angeles and Neanidis 2015), we also find that given the same oil wealth, colonised oil-rich countries have less income per capita than non-colonised countries.

4.2.1 Test of the Validity of the Instruments

The validity of our results and conclusion reached rest primarily on how reliable our identification strategy uncovers the true effect of income using oil-price shocks and colonial experience on child mortality. Valid instrumental variables must meet at least two essential criteria (French and Popovici 2011). First, it must be statistically correlated with the endogenous variable(s) of interest and the correlation must reflect a deep and convincing theoretical understanding of real-life situations. The second condition is that it must be exogenous to all other important and unobserved heterogeneities. That is, they must be uncorrelated with the disturbance error term in the structural or outcome equation. This implies that the instrumental variables must not directly cause child mortality and they must also be uncorrelated with the residual effects, e.g., efficient use of technologies and other residual effect of income that could influence infant mortality.

The first assumption is relatively straightforward; implementing the first stage regression establishes a correlation between the instrumental variables and the endogenous regressors. Indeed as shown in Table 3, we find that across the five Models we presented the instruments are strongly correlated with the endogenous regressors. Also, the diagnostic tests in Tables 2 and 3 show that our instruments are not weak; the statistical threshold for a strong instrument when multiple variables are used to instrument for one endogenous regressor is that the F-statistic to be above 10 (Staiger and stock 1997, Stock et al., 2002).

It is, however, more challenging to ascertain the second condition of the instruments being exogenous to all other important and unobserved heterogeneities. There is no fairly straightforward and well-accepted test to confirm this condition. Ascertaining this condition is important to validate our instruments. For instance, colonialism can have heterogeneous effects by operating through many mechanisms that can encourage development that may be linked with child mortality. For example, the long-term impact of colonial investment in the human capital (Eynde 2015, Ayesu et al. 2016), the industrial expansion of local processing facilities (Cappelli and Baten 2017, Dell and Olken 2017), and the provision of transportation (railroad, roads) infrastructures (Michalopoulos and Papaioannou, in press) could be useful for reducing child mortality through the non-income channel. Also, because richer countries may have more resources to drill better, richer countries can have a better cross-section variation in oil discoveries than poorer countries.
To disprove these possibilities, first, we argue, in the case of colonial investment, that because these investments were made a long time ago they are part of the fixed components of the residual term that explains child mortality, and with the introduction of the country fixed effect, these residuals have been effectively removed from the error term. That is they no longer serve as a channel with child mortality. Also, in the case of discoveries being correlated with non-income country capital that reduces child mortality, we argue that the main source of variation in the value of the log of oil discoveries instruments comes from the time series variation in the global oil price which is not correlated with country-level capital. Besides, although countries can choose efforts and investment on exploration, they cannot choose the amount of discoveries they get; that is mainly a function geography of oil formation which is independent of countries’ efforts and investment.

We validate these explanations in Table 4. First, we conduct a reduced-form regression of the instrumental variables on the log of child mortality (Model X). With this approach, we can see from the sign and/or magnitude of the reduced-form estimates the validity of the identification strategy (Angrist and Krueger 2001). The absence of statistical significance of the instruments in these reduced-form equations could mean that instrumental variables do not affect the outcome (Angrist and Krueger 2001, French and Popovici 2011). Also, the sign on the estimates should justify the direction of expected causality. For instance, in our results in Model X, the estimates on the reduced-form regression of value of oil discoveries and the interaction with colonial experience are intuitively valid as they support the positive, though not significant, the correlation between the instruments and the dependent variable.

Second, we conduct a reduced-form regression of the instruments on oil rents per 1000 population to establish the non-correlation between oil rents and the log of the new oil discoveries (Model XI). This test is to support our assumption that the instrumental variable of discoveries is driven by global oil price, and it is not correlated with the existing oil production per capita. Also, because oil production could be associated with air pollution, the insignificance of the instruments on oil rents suggests in Model XI suggests that the countries with discoveries are not necessarily ones with higher levels of pollution.

Third, we also estimate a reduced-form of the instrumental variables on the number of wildcat drilling to test the relationship between discoveries and investments in oil exploration (Model XII). Wildcat drilling is the measure the number of oil wells drilled in a particular year (Cotet and Tsui 2013). Because of the cost of drilling, wildcat drilling represents effort and investment for an exploration adventure. The non-significance of these estimates suggests that the values of discoveries are not significantly related to capital and efforts.

Fourth, we regress the instruments on the polity score (Model XIII) and the likelihood of civil unrest (Model XIV). These two last cases are important because in the case of conflict, discoveries can generate civil conflict, and conflict may result in high mortality of the vulnerable groups, e.g. children. Our finding rejects this hypothesis, and it is supported by earlier studies suggesting that no evidence back the theory that oil and gas enable civil conflict (Cotet and Tsui 2013). Also, the rejection of correlation between the instrumental variables and the democracy score suggests that the residual effect of institutions that might be correlated with colonialism is plausibly demeaned out of the equation with the fixed effect. Results from Table 3.4 (Model X to XIV) and evidence from the first-stage results (Table 3) suggest that the validity of our identification strategy and the estimates plausibly support the validity of our instruments.
<table>
<thead>
<tr>
<th>Dependent Variables:</th>
<th>Model X</th>
<th>Model XI</th>
<th>Model XII</th>
<th>Model XIII</th>
<th>Model XIV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Log of child mortality per 1000 births (multiplied by a 100)</td>
<td>Oil barrel per 1000 population</td>
<td>Number of Wildcat drilling</td>
<td>Likelihood of civil Unrest</td>
<td>Democracy score (Polity IV)</td>
</tr>
<tr>
<td>Log (Value of Oil Discoveries per capita)</td>
<td>9.09</td>
<td>50.38</td>
<td>79.23</td>
<td>0.03</td>
<td>-0.11</td>
</tr>
<tr>
<td></td>
<td>(35.7)</td>
<td>(0.65)</td>
<td>(71.95)</td>
<td>(0.27)</td>
<td>(0.33)</td>
</tr>
<tr>
<td>Log (Value of Oil Discoveries) × Colony (Dummy=1)</td>
<td>8.75</td>
<td>-43.95</td>
<td>959.81</td>
<td>-0.32</td>
<td>-0.04</td>
</tr>
<tr>
<td></td>
<td>(38.9)</td>
<td>(36.43)</td>
<td>(925.38)</td>
<td>(0.39)</td>
<td>(0.42)</td>
</tr>
<tr>
<td>Percent of total population ages 15-64</td>
<td>-3.89***</td>
<td>-0.7</td>
<td>6.12</td>
<td>-0.003</td>
<td>-0.00002</td>
</tr>
<tr>
<td></td>
<td>(0.69)</td>
<td>(0.65)</td>
<td>(5.31)</td>
<td>(0.006)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>Female Labor force (% of total labor force)</td>
<td>-3.29***</td>
<td>0.09</td>
<td>-7.84</td>
<td>-0.012**</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>(0.69)</td>
<td>(0.65)</td>
<td>(5.31)</td>
<td>(0.006)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>Constant</td>
<td>684***</td>
<td>42.66</td>
<td>56.94</td>
<td>0.84**</td>
<td>0.34</td>
</tr>
<tr>
<td></td>
<td>(41.35)</td>
<td>(34.91)</td>
<td>(96.48)</td>
<td>(0.35)</td>
<td>(0.43)</td>
</tr>
<tr>
<td>F-test</td>
<td>29.35</td>
<td>11.98</td>
<td>3.65</td>
<td>3.73</td>
<td>2.08</td>
</tr>
<tr>
<td>Observations</td>
<td>3,820</td>
<td>4,083</td>
<td>4,083</td>
<td>3,600</td>
<td>3,840</td>
</tr>
<tr>
<td>Number of countries</td>
<td>99</td>
<td>100</td>
<td>100</td>
<td>97</td>
<td>99</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.86</td>
<td>0.07</td>
<td>0.04</td>
<td>0.03</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Notes: Table 4 is a Reduced-form estimation of the test of the validity of the instrumental variables. Model X: The dependent variable is the Log of Child Mortality Model XI: The dependent variable is Oil million barrel per 1000 population Model XII: The dependent variable is the Number of Wildcat drilling Model XIII: The dependent variable is the Likelihood of civil Unrest Model XIV: The dependent variable is the Democracy score (Polity IV) All models test for the correlation between the Instrumental variables and the dependent variable. We aim to establish an insignificant correlation and to justify the validity of the instruments. All models control for Country and time FE and the other controls in the main model. The robust standard errors are in parenthesis and are clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.


4.3 Heterogeneous Impact of Income Shocks and Child Mortality

Up to this point, we have implicitly assumed that aggregate income shocks from oil price and oil discoveries affect all countries irrespective of ecological zones. However, this need not be so for a host of reasons. According to Sachs (2001), the burden of disease and infant mortality are considerably higher in the tropics and ecology affects the spread of infectious diseases in many tropical countries. Countries located in the tropics have a higher burden of disease, which may make them better at utilising income shocks for reducing child mortality. Income shocks in the tropics may, therefore, have a higher impact on mortality rates among countries in this ecological zone. Although introducing the Fixed Effect estimator helps on partially out the country fixed unobservable heterogeneities, it, however, does not allow us to observe how tropical countries perform in respect of income shocks and child mortality. In Models XV and XVI, we restrict our sample to only countries in the tropical region.

Also, in our previous models, we pool both colonised and non-colonised countries together. This may introduce bias if there is any cofounding variable in the residual that might be correlated with the decision of colonisation. Although, as we argue and show in the previous analysis, none of such exists, nevertheless we restrict our sampled countries to countries that experienced European colonialism in Model (XVI). In Model (XVII), our sample includes countries that are in the tropics and were also colonised. In these Models, we instrument income per capita with the log of value of oil discoveries only; thereby, making the models to be exactly identified.

We first present the results for tropical countries without any instruments in Table 5 (Model XV). Specifically, we find a negative income shock on child mortality. In Model XVI, where we introduced an instrumental variable to identify income shocks in Tropical countries, we find that the effect is negative but weakly significant. In Model XVII where we only include colonised countries we find that income is not statistically significant and in Model XVIII, where are sample includes countries that were colonised and that belong in the tropical ecological zones, we find the similar result of a weak statistical impact of income shocks on child mortality. Our results confirm our findings in an earlier analysis that the conditional income shock does not significantly influence child mortality in oil-rich countries.

The results of the first-stages regression for the IV in Table 5 are presented in Table 6. In the first-stages of Models, XVI, XVII and XVIII, where we use the instrumental variable estimation, we only use the value of the log of value of discoveries per capita as the instrument for income per capita. The results in Table 3.6 and the diagnostic tests in Table 5 validate or results.
### Table 5: Heterogeneous impact of income shocks based on countries stratification

<table>
<thead>
<tr>
<th>Dependent variables: Log Child Mortality per 1,000 birth</th>
<th>Tropical Countries (No Instruments)</th>
<th>Tropical Countries with Instruments</th>
<th>Colonised Countries with Instruments</th>
<th>Colonised countries in tropical Zones with Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model XV</td>
<td>Model XVI</td>
<td>Model XVII</td>
<td>Model XVIII</td>
<td></td>
</tr>
<tr>
<td>Log GDP/capita</td>
<td>-0.211***</td>
<td>-0.34*</td>
<td>0.11</td>
<td>0.13</td>
</tr>
<tr>
<td>Percent of total population ages 15-64</td>
<td>-1.48</td>
<td>-0.84</td>
<td>-4.05**</td>
<td>-3.86**</td>
</tr>
<tr>
<td>Female Labour force (% of total labour force)</td>
<td>-3.34***</td>
<td>-4.59***</td>
<td>-3.0***</td>
<td>-2.84***</td>
</tr>
<tr>
<td>Number of endogenous regressors</td>
<td>No IV</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Number of instruments</td>
<td>No IV</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>F-stat</td>
<td>65.48</td>
<td>140</td>
<td>223.76</td>
<td>185.8</td>
</tr>
<tr>
<td>Kleibergen-Paap rk LM statistic</td>
<td>11.78</td>
<td>11.74</td>
<td>11.39</td>
<td></td>
</tr>
<tr>
<td>Cragg-Donald Wald F statistic</td>
<td>15.01</td>
<td>11.94</td>
<td>13.14</td>
<td></td>
</tr>
<tr>
<td>Kleibergen-Paap rk Wald F-stat</td>
<td>12.17</td>
<td>11.74</td>
<td>11.48</td>
<td></td>
</tr>
<tr>
<td>Number of Countries</td>
<td>62</td>
<td>49</td>
<td>63</td>
<td>44</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>2,308</td>
<td>1,828</td>
<td>2,337</td>
<td>1,649</td>
</tr>
</tbody>
</table>

**Notes:** The robust standard errors are in parenthesis and are clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.

### Table 6: First stage regression for Table 5

<table>
<thead>
<tr>
<th>First stage for Model XVI</th>
<th>First stage for Model XVII</th>
<th>First stage for Model XVIII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log (Value of Oil Discoveries per capita)</td>
<td>52.47***</td>
<td>34.28***</td>
</tr>
<tr>
<td>F-test</td>
<td>12.17</td>
<td>11.74</td>
</tr>
</tbody>
</table>

**Notes:** Table 6 is the First-stage regression for the estimates in Table 5 and columns represent the corresponding first stages for Models XVI, XVII, and XVIII respectively. The robust standard errors are in parenthesis and are clustered at the country level. *, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively.
4.3.1 Income shocks and other potential mechanisms of child mortality

So far, we have only focused on child mortality using the number of death per 1000 birth before the age five as the only possible outcome through which we can observe the impact of income shocks on health. In this section, we extend our analysis by considering other biological and demographic outcomes that are important for reducing improving health and child mortality. It is possible for the effect of income to not materialise on child mortality directly but to reduce the other causes that predispose a child to poor health and increased mortality.

For instance, while child mortality is often attributed to improvement in nutrition brought about by income, however, the usefulness of public sanitation and adoption of hygienic practices often contribute significantly to mortality reduction (Figure 6). Improvement in general hygiene and proper sanitation can help to prevent endemic diarrhoea and numerous other globally important infections that could contribute to a decline in the number of child mortality (Bartram and Cairncross 2010).

![Child Mortality and Use of Basic Sanitation](image)

**Figure 6: Child mortality and percentage of the population who basic sanitation**

Also, because maternal health matters significantly for child health (Figure 7), e.g. access to breastmilk is a key child survival strategy and investment in mothers’ health that reduces maternal mortality could be important for reducing child mortality (Edmond et al. 2006).
Improving the quality of care for sick children in the form of investment in hospital facilities could also lead to reduced mortality (Nolan et al. 2001). Improving the quality of emergency care, diagnosis, and inpatient treatment in these hospitals are aspects that could be reflected in the investments in the number of beds (Figure 8).

Finally, low-birth-weight is a major determinant of child mortality and a worthy channel for exploring the income child mortality nexus (Figure 9). Also, low birth weight is associated with poor nutrition, especially in low-income households (McCormick 1985), a population
with a higher percentage of babies with low birth weight could suggest poor nourishment in the womb, and such population could have a higher risk of child mortality rate after birth.

Figure 9: Child mortality and Percent of babies with low birth weight

These are worthy channels that deserve exploring with respect to ascertain the impact of income on child mortality. If the conditional income shock, for instance, improves the number of people with access to sanitation or reduces maternal mortality, per cent of the population with low birth weight, then this might be a good justification for proposing policies for governments on how to direct program and investments that could help to reduce mortality.

In Table 7, we present the instrumental variable estimates of income conditional on log value of oil discoveries and colonial experience on these outcomes of public sanitation use, maternal death, number of hospital beds and birth weight at birth. Our results suggest that income has no significant influence on these possible channels that are linked to child mortality. These results confirm the previous analysis that the possible shocks from oil price do not translate into sufficient improvement in income that leads to a reduction in child mortality. Also, we find in the first-stage regression that the experience of colonialism reduces the positive impact of oil price shocks on income per capita (Table 8).
Table 7: IV Estimates of Income shocks on other mechanisms of health care

<table>
<thead>
<tr>
<th>Dependent variables:</th>
<th>Log % of Population using Basic Sanitation</th>
<th>Log Number of Maternal Deaths</th>
<th>Log Hospital beds per 1,000 people</th>
<th>Log Low birth weight (% of births)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model XIX</td>
<td>Model XX</td>
<td>Model XXI</td>
<td>Model XXII</td>
</tr>
<tr>
<td>Log GDP/capita</td>
<td>0.017* (0.009)</td>
<td>0.021 (0.013)</td>
<td>0.005 (0.02)</td>
<td>-0.01 (0.01)</td>
</tr>
<tr>
<td>Percent of total population ages 15-64</td>
<td>-0.065 (0.05)</td>
<td>-0.11 (0.07)</td>
<td>0.06 (0.08)</td>
<td>0.06 (0.04)</td>
</tr>
<tr>
<td>Female Labour force (% of total labour force)</td>
<td>0.02*** (0.006)</td>
<td>-0.14*** (0.01)</td>
<td>0.11*** (0.015)</td>
<td>-0.17* (0.009)</td>
</tr>
<tr>
<td>Number of endogenous regressors</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Number of instruments</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Country and Time FE?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>F-stat</td>
<td>522.7</td>
<td>698.5</td>
<td>35.66</td>
<td>3.89</td>
</tr>
<tr>
<td>Kleibergen-Paap rk LM statistic</td>
<td>24.23</td>
<td>24.22</td>
<td>24.22</td>
<td>24.23</td>
</tr>
<tr>
<td>Cragg-Donald Wald F statistic</td>
<td>12.82</td>
<td>12.82</td>
<td>12.82</td>
<td>12.82</td>
</tr>
<tr>
<td>Hansen test (over identification)</td>
<td>3.87</td>
<td>0.003</td>
<td>0.46</td>
<td>1.72</td>
</tr>
<tr>
<td>Number of Countries</td>
<td>98</td>
<td>98</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>3491</td>
<td>3491</td>
<td>3491</td>
<td>3491</td>
</tr>
</tbody>
</table>

Notes: Table 7 is the Second stage (IV) Fixed Effect regression of Log GDP per capita on other mechanisms of child mortality

Model XIX: The dependent variable is the Log of People using at least basic sanitation services (% of the population)
Model XX: The dependent variable is the log number of maternal deaths
Model XXI: The dependent variable is the log number of Hospital beds (per 1,000 people)
Model XXII: The dependent variable is the log of Low-birthweight babies (% of births)
The robust standard errors are in parenthesis and are clustered at the country level.
*, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively

Table 8: First stage regression for Table 7

<table>
<thead>
<tr>
<th>First stage for Model XIX</th>
<th>First stage for Model XX</th>
<th>First stage for Model XXI</th>
<th>First stage for Model XXII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log (Value of Oil Discoveries per capita)</td>
<td>66.30*** (13.55)</td>
<td>66.30*** (13.55)</td>
<td>66.30*** (13.55)</td>
</tr>
</tbody>
</table>

Notes: Table 8 is the First-stage regression for the estimates in Table 7 and columns represent the corresponding first stages for Models XIX, XX, XXI and XXII respectively
The robust standard errors are in parenthesis and are clustered at the country level.
*, ** and *** represent significance level of estimates at p-values of <0.1, 0.05 and 0.01 respectively
5 Conclusion

This paper explores how changes in income per capita, conditional on oil-price shocks and enduring impact of European colonialism, affect the risk of child mortality in oil-rich countries. We hypothesise that if oil-rich countries with oil discoveries cannot efficiently translate the oil-price shocks into an improvement in economic development; then, the expected positive shocks to income per capita will fail to lead to a reduction in child mortality in oil rich countries. A finding the role of shocks to income per capita, on child mortality has important implications for the design of socially efficient rents allocation, the development of specific policies that promotes transparency in oil-rich countries, and for the understanding of the multi-faceted channels of the resource curse.

We use a 2-stage Instrumental variable (IV) strategy to estimate the causal effect of aggregate GDP per capita on child mortality per 1,000 births. We instrument aggregate national income per capita with time series variation in global oil prices interacted with cross-sectional variation in the log of new oil discoveries and a dummy to capture if a country was a former colony under European colonisation. This strategy helps to isolate a potentially exogenous source of variation in incomes. It also helps us to understand the enduring implication of colonial legacy at fostering institutional barriers that complicate the translation positive income shocks on the observed child mortality. Our strategy also controls for the country and time fixed effects to account for the unobservable heterogeneities that are possible correlates on income and the instrumental variables.

Conditional on the positive oil price shocks given oil discoveries and colonial legacy, our findings document a weak and statistically insignificant relationship between income per capita and child mortality. Specifically, in the first stage, we find that while oil discoveries and oil-price shocks are positively correlated to income, however, there is a negative gap which reduces the magnitude of this estimate given that a country was colonised. A limited analysis where we restrict our analysis to tropical and colonised countries also find similar results. Also, we find that income per capita does not appear to reduce other potential child mortality mechanisms like the reduction of maternal mortality, investment in hospital facilities, basic sanitation and low birth weights.

Nevertheless, an important finding across all our specifications suggests that improving female labour participation helps in reducing child mortality. Overall women’s participation in wage-paid jobs remains low especially in many petroleum-rich countries, and resource wealth has often been linked to lower levels of female labour, economic and political participation (Ross 2008, Simmons 2016). Women empowerment and economic development are closely related (Duflo 2012), and empowering women may bring development benefits that have significant implications for maternal health, birth weights and overall child mortality (Brenner 1979, McAvinchey 1984, Becker et al. 1990, Eswaran 2002).

These findings have practical implication for formulating a policy to reduce child mortality in oil-endowed and colonised countries. First, given the tendency for colonised countries to have less income from oil shocks, we suggest that targeted policies that ensure the accountability of the government in countries that were former European colonies. Second, given that child mortality reduces with female labour market participation, we suggest that policies that economically empower women could have a beneficial effect on child and infant mortality. Also, we recommend the provision of institutional instruments that make the oil-rich government more accountable in the disbursement of oil revenue and by increasing
budgetary provision for medical care during an oil-price boom. This can be through the creation of a specially dedicated child-welfare fund from oil-wealth that assures free medical coverage for pregnant mothers and children for current and future generation, and ensuring insurance coverage for a child and mother welfare from oil wealth.

References


Sterck, O. (2016). Natural resources and the spread of HIV/AIDS: Curse or blessing?. Social Science & Medicine, 150, 271-278


