Energy Economics 92 (2020) 104925

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneeco

# The impact of declining oil rents on tax revenues: Does the shadow economy matter?

Phoebe W. Ishak [a,*], Mohammad Reza Farzanegan [b,c,d]

[a] Universität Hamburg, Faculty of Business, Economics and Social Sciences, Hamburg, Germany
[b] Philipps-Universität Marburg, Center for Near and Middle Eastern Studies (CNMS), Economics of the Middle East Research Group, Marburg, Germany
[c] CESifo, Munich, Germany
[d] ERF, Cairo, Egypt

ARTICLE INFO

*Article history:*
Received 11 May 2020
Received in revised form 3 August 2020
Accepted 17 August 2020
Available online 29 August 2020

*Keywords:*
Shadow economy
Tax revenues
Oil rents
Resource curse

*JEL:*
Q32
Q35
H26
O17

ABSTRACT

We study the association between oil rents and tax revenues, highlighting the importance of the shadow economy (SE) as a moderating factor in this relationship. Declining oil rents may not lead to higher tax efforts in a state if the SE is sizable. Using a sample of 124 countries from 1991 to 2015, our panel data regression analysis illustrates the moderating role of the SE in the final effect of negative oil rent shocks on tax revenues. A decline in oil rents following negative oil price shocks ceases to have any significant positive impact on tax revenues in countries with an SE representing more than 35% of gross domestic product. The results are robust after controlling for country- and year-fixed effects, other determinants of tax revenues, and using a dynamic model.


## 1. Introduction

In the wake of the 2014 oil price crash, oil-producing countries suddenly faced a sharp decline in oil prices that left them in a serious fiscal situation, given that the bulk of their government revenues came from the proceeds of oil.[1] Concerns were raised about the ability of those countries, especially those with a high dependence on oil, to compensate for their fiscal losses and mobilize new revenue sources. Despite attempts by several countries to enact tax reforms (e.g., Kazakhstan, Angola, and Brazil), not all of them were successful in boosting their tax receipts. In this context, this study goes a step further in understanding the relationship between negative oil price shocks and tax revenues. Our goal is to show that the effect of a negative shock on a country's tax revenues depends on the size of the shadow economy (SE).[2] We show that a fall in oil rents does not lead to higher tax revenues in the presence of a sizable SE. Our study contributes to the resource curse literature by conditioning the effect of changes in oil rents on tax revenues to the existing SE.

We argue that "negative" changes in oil rents could increase the willingness of the state to initiate and implement tax reforms to increase tax revenues, but only conditionally. In particular, we emphasize the relevance of the size of the SE as a key determinant of the impact of declining oil rents on tax revenues. Our suggestive evidence and simple theoretical framework (see Appendix A) demonstrate that negative shocks in oil rents promote the tax revenues of the state when the

* Corresponding author.
*E-mail addresses:* pwishak@gmail.com (P.W. Ishak), farzanegan@uni-marburg.de (M.R. Farzanegan).

[1] https://blogs.worldbank.org/developmenttalk/what-triggered-oil-price-plunge-2014-2016-and-why-it-failed-deliver-economic-impetus-eight-charts

[2] We follow the definition of an SE presented by Schneider (2005) and Buehn and Schneider (2012 a,b). Their definition of the SE (i.e., an informal economy) covers the production and transactions of "legal" goods and services that are not reported for tax purposes. This definition excludes illegal activities, such as the drug trade and human trafficking. According to Schneider, there are four reasons for economic agents moving from the formal to the SE: (1) evading income-, value-added, and other tax payments; (2) evading payment of social contributions; (3) evading implementation of special labor standards, such as minimum wages and safety and environmental standards in the production process; (4) evading compliance with standard administrative processes, such as completing statistical questionnaires.

https://doi.org/10.1016/j.eneco.2020.104925
0140-9883/

size of the SE is sufficiently moderate, whereas they have no significant positive impact on tax revenues when the SE is extensive. The existence of the SE offers a safe haven for businesses and people to conceal their economic activities from tax authorities. It follows that a rise in tax rates will have a limited effect in compensating for a decline in government revenues from oil receipts in the presence of large informal economies and the respective low tax bases.

We examine our main hypothesis on the oil rents-tax revenues-SE nexus using panel data from 1991 to 2015 for a sample of 124 countries. We suggest that an expected increase in tax revenues in response to negative changes in oil rents is not happening automatically. The final effect of negative changes in oil rents on tax revenues depends on the size of the SE. In countries with moderately sized SEs, we may expect to observe an increase in government tax revenues following negative oil price shocks. However, if the size of the SE is significant, then we should not experience an increase in tax revenues. For example, the case of Kazakhstan, an oil-based economy, is informative. Between 2014 and 2016, the average crude oil price declined from $96 to $50 and then to $42 per barrel. This significant fall in oil prices led to a decline in oil rents (as a share of gross domestic product (GDP)) in Kazakhstan from 13% in 2014 to 7% in 2016 (WDI, 2020). Such a significant negative shock in oil rents was not associated with an increase in tax revenues, despite the implementation of tax reforms. Tax revenues as a share of GDP, which were 14% in 2014, declined to 10% in 2016. One possible reason for the failure of the Kazakhstan government to increase its tax efforts in response to falling oil rents was the sizable SE. According to Medina and Schneider (2019), the size of the SE (% of GDP) increased from 32% to 37% during the mentioned period.[3]

To the best of our knowledge, the moderating role of the SE in the nexus between tax revenues and negative oil shocks is neglected in the resource curse literature.[4] The resource curse hypothesis implies that resource-based economies, on average and in the long run, have slower rates of economic growth compared to resource-poor countries (Sachs and Warner, 1995, 2001). To date, much of this literature has studied the effect of an increase in oil rents on growth in developing countries and has shown different transmission mechanisms for the negative growth impacts of higher rents (e.g., Alexeev and Conrad, 2009).[5] Our study particularly relates to the fiscal transmission channel, which stipulates the negative effects of resource rents' dependency on the taxation capacity of the state and the willingness to reform the tax system. However, most of this literature relates to positive oil rent changes and usually reports a negative relationship between tax revenues and resource rents, neglecting the existence of contextual conditional effects. For example, using the U.S. case study, James (2015) argues that, in response to higher resource revenues, the government decreases non-resource tax rates and shows that a $1 increase in resource revenues results in a $0.25 decrease in non-resource revenues. Using a sample of resource-rich economies, Crivelli and Gupta (2014) show a significant negative impact from positive changes in resource rents on the taxation of goods and services. We extend this literature by analyzing the impact of negative changes in oil rents on government taxation performance. We further examine the conditional role of the SE in the final effect of negative changes of oil rents on government tax efforts, an aspect that is neglected in the literature. In this regard, we partly relate to recent studies reporting a negative association between SE and tax revenues (e.g., Mazhar and Méon, 2016; Awasthi and Engelschalk, 2018), albeit shedding more lights on the final association between oil rents and tax revenues under different sizes of the SE.

Another strand of literature investigates the long-term negative effects of rent dependency on tax administration. Besley and Persson (2011, p.21) argue that a higher dependence on resource rents (or aid) that flow directly to the government budget may mean that market incomes are smaller. This leads to a smaller tax base, which then diminishes the incentive to invest in a market-supporting legal capacity. This lack of development of state administrations, especially with reference to raising tax revenues, is also related to the rentier state hypothesis introduced initially by Mahdavy (1970) in his case study of Iran and developed in later studies, such as Beblawi and Luciani (1987) (for further discussion, see Besley and Persson, 2013, 2014).[6] We relate to this strand by documenting that the presence of a large SE, and subsequent low tax base, reduces government incentives and/or constrains efforts to develop strong fiscal systems.

Other scholars, such as Ross (2001, 2012), use the fiscal channel to explain democracy deficits in oil-rich economies. The negative effect of rents on political institutions is due to the response of tax revenues to positive changes in oil rents. Higher oil rents may reduce the willingness of the state to tax citizens and cause the postponement of tax reforms. The lower fiscal dependency of the state on citizens may reduce the demand for accountability of the state to the people, as well as the political participation of the people. In a panel of 30 hydrocarbon-producing countries, Bornhorst et al. (2009) empirically examine whether there is evidence of an offset between government revenues from oil and gas-related activities and revenues from other domestic sources. They show that countries that receive large revenues from the exploitation of natural resource endowments reduce their domestic tax effort. They conclude that "there might be significant adjustment costs in moving to a higher level of domestic taxation once resources are depleted." We add to this literature by showing that the adjustment of tax efforts in response to declining resource rents is significantly constrained by the initial size of the SE.

To set the scene, Section 2 presents a conceptual framework and some suggestive evidence on the moderating role of the SE on the impact of declining oil rents on tax revenues. In Section 3, we discuss our empirical strategy and data. We then proceed to present and discuss the empirical evidence and perform robustness analysis in Section 4. We conclude the article in Section 5.

## 2. Conceptual framework and descriptive analysis

Our main argument is that the effect of declines in oil rents following negative oil price shocks on a country's tax revenues depends on the size of the SE. To obtain an initial snapshot of the relationship between negative oil price shocks and tax revenues, taking into account the initial size of the SE, Figs. 1 and 2 plot changes in (log) tax revenues to GDP against negative oil price shocks in high- and low-SE countries. We define countries as high (low)-SE countries if the size of the SE is greater (lower) than the median (i.e., the sample median is 32%). Indeed, Fig. 1 shows hardly any relationship between (log) changes in tax revenues to GDP and negative price shocks in high-SE countries. The slope of the coefficient is equal to 0.69 and is statistically insignificant. Fig. 2 shows, in contrast, a positive and statistically significant relationship in low-SE countries. The slope of the coefficient is equal to 1.20 and is statistically significant at the 1% significance level.[7] In other

[3] The importance of dealing with the SE to improve the rate of tax collection in Kazakhstan is discussed here: https://www.worldbank.org/en/news/feature/2020/03/10/towards-a-more-dynamic-economy-revenue-reform-in-kazakhstan

[4] In unreported results, we also checked the effect of positive oil price shocks on tax revenues controlling for GDP per capita (i.e., tax base) and found no statistically significant effect. This could be due to the fact that tax rates in these countries (most of which are developing countries) are already low. Therefore, a rise in oil revenues following positive price shocks will have no significant effect on tax rates but may instead increase public expenditure (as is partly shown by Farzanegan, 2011 for case of Iran). However, future research may examine this issue in more detail.

[5] For various investigations of the transmission channels of oil curse see Farzanegan and Thum, 2020; Ishak, 2019; Bjorvatn and Farzanegan, 2015; Farzanegan, 2014; Ross, 2012; Bjorvatn et al., 2012; van der Ploeg, 2011; Tsui, 2011; Aslaksen, 2010; Frankel, 2010; Venables, 2010; Mehlum et al., 2006; Hodler, 2006; and Gylfason, 2001, among others.

[6] In a theoretical and empirical investigation, Jensen (2011) also shows that "resource intensification weakens state-building by impeding the state's fiscal capacity." Fiscal capacity is defined as the state's ability to tax.

[7] Note, the clustering of some observations around zero is due to the inclusion of low-oil exporters (i.e., low oil export weight). In the robustness checks section (Table 4), we check the results after excluding low-oil exporters and results remain robust.

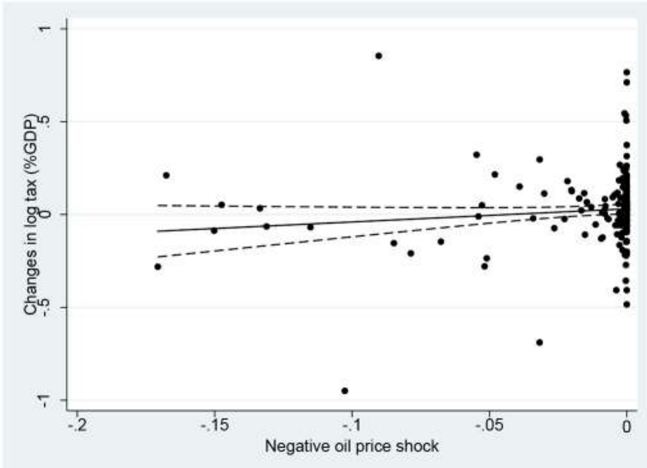


**Fig. 1.** Changes in (log) tax revenues to GDP and negative oil price shocks in high-SE countries. A country is considered a high-SE country if the size of the SE is greater than the median. The dashed lines are the 90% confidence interval.

words, negative oil price shocks cease to have an impact on tax revenues in high-SE countries, whereas tax revenues respond positively to negative oil price shocks in countries with low SEs.

Looking at countries' tax performance following drops in oil rents offers support for our argument. For illustration, we focused on the two years of 2014 and 2015, when global crude oil prices dropped from $96 to $50 per barrel. What was the trend of development of tax revenues in oil-producing countries in which the size of the SE as a proportion of GDP was more than the median level of 32% during 2014 and 2015? We find three main cases: Angola shows a decline in oil rents (% of GDP) from 23% to 10% from 2014 to 2015 and, at the same time, a drop in tax revenues as a proportion of GDP from 15% to 12%. In Brazil, we observe a drop in oil rents from 1.8% to 1%. No change was observed in tax revenues as a proportion of GDP (it remained constant at 12. 8%). In Egypt, we observe a reduction in oil rents from 6.7% to 2.9%. Likewise, no significant change in tax revenues can be observed (it remained almost constant at 12.5%). The SE in these countries amounts to around 35% of GDP.

Another episode involving a significant drop in oil prices is related to the global financial crisis of 2008–2009, the so-called "Great Recession."

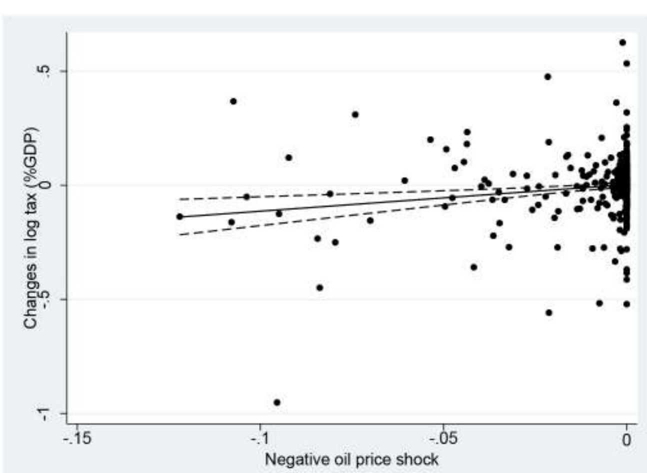


**Fig. 2.** Changes in (log) tax revenues to GDP and negative oil price shocks in low-SE countries. A country is considered a low-SE country if the size of the SE is lower than the median. The dashed lines are the 90% confidence interval.

The crude oil price decreased from $97 in 2008 to $67 in 2009. We look at countries in which the SE is more than 32% of GDP (i.e., the median in our sample). Is it possible to identify a meaningful increase in the tax efforts of oil-producing countries with a sizable SE during 2008–2009? In Angola, oil rent share of GDP dropped from 56% to 31% during this period, but the tax revenue share experienced a decline from 27% to 17%. Azerbaijan is another oil-rich economy that experienced a decline in the share of oil rents from 37% to 24% of GDP. However, this country experienced difficulty in increasing its tax efforts, mainly due to its sizable SE (which also expanded from about 44% to 45%). The share of tax revenues as a proportion of the GDP of Azerbaijan also declined from 16.4% to 14.1% in the mentioned period despite implementing tax reforms. Nigeria is another relevant example of an oil-rich economy in which the size of the SE equaled approximately 54% of GDP in 2008–2009. While the share of oil rents in Nigeria dropped from 17% to 9% of GDP, the tax efforts of the state were limited, and tax revenues declined, as a proportion of GDP, from 5.5% in 2008 to 5.1% in 2009. There are further similar examples for the period of 2008–2009, such as Russia, Cote d'Ivoire, and Thailand, among others.

In contrast, tax revenues in oil-producing countries with relatively lower levels of SE (less than the median of 32%) have responded significantly to negative developments in oil prices during different periods owing to their implemented tax reforms. For instance, considering the drop in oil price during 2014–2015, we can observe that Kuwait, which has experienced a drop in oil rents as a share of GDP from 54% to 37%, was able to raise its tax revenue share of GDP from 0.8% to 1.38%. The size of the SE in Kuwait was approximately 22%. Another example is Mexico, which has an SE size of 29%. Mexico faced a decline in its oil rents as a share of GDP from 4% to 1.6%. However, we can observe an increase in its tax revenues from 10.6% in 2014 to 13% in 2015.

There are other similar examples when considering the negative movement of oil price during the financial crisis of 2008–2009. Oil producing countries with a smaller SE were more able to increase their tax revenues in the short term in response to a drop in oil rents. For example, Qatar, with an SE size of 16%, experienced a decline in oil rents from 31% of GDP in 2008 to 21% in 2009. Tax revenues, as a share of GDP, in this country increased from 16% to 20% for the same period. Iran, with its estimated SE size of approximately 16% of GDP, is another example. The share of oil rents decreased from 31% of GDP to 17% during 2008–2009. We can observe an increase in tax revenues in Iran from 6% to 7.3%. A similar situation can be observed in Oman, with an SE size of 17% in 2009. Its oil rents, as a share of GDP, declined from 38% to 30%, while its tax revenue share increased from 2.4% to 3.4%.

In short, our argument can be summarized in the following two testable hypotheses:

**Hypothesis 1.** *An exogenous decline in international oil price increases tax revenues,* ceteris paribus.

**Hypothesis 2.** *An exogenous decline in international oil price has a smaller impact on tax revenues, where the initial size of the SE is higher,* ceteris paribus.

We provide a simple theoretical illustration of the association between tax revenues and negative changes in oil rents in the presence of an SE, as well as a formal representation of the hypotheses in Appendix A. Next, we present the empirical specifications for testing the hypotheses.

## 3. Research design

### 3.1. Empirical methodology

Our conceptual framework hypothesizes that the effect of negative oil price shocks on tax revenues depends on the initial size of the SE, ceteris paribus. Specifically, a negative exogenous decline in oil rents will increase tax revenues, but the effect is lower for a larger SE.

To test these two hypotheses, we estimate the following model:

$$ln\,TaxRev_{it} = \alpha_i + \gamma_t + \beta_1 NegPriceShock_{it} + \beta_2 SE_{it-1} + \beta_3 NegPriceShock_{it} \times SE_{it-1} + \beta_4 lnGDP_{it} + \varepsilon_{it} \quad (1)$$

where $\alpha_i$ is country-fixed effects and $\gamma_t$ is year-fixed effects. $lnTaxRev_{it}$ is (log) tax revenues (% of GDP) in country $i$ and year $t$; *NegPriceShock* measures negative oil rent shock; $lnGDP_{it}$ is (log) GDP per capita and $\varepsilon_{it}$ is a disturbance term. $SE_{it-1}$ is the initial size of the SE (% of GDP) lagged by one period to address reverse feedback concerns, since it is less likely that tax revenues and price shocks at year $t$ will affect the size of the SE in year $t-1$.[8] This suggests that a lagged level of the SE can be treated as a predetermined variable, whose lagged values are uncorrelated with the current error term.[9] In this specification, $\beta_1$ captures the linear effect of negative oil price shocks on tax revenues in countries more dependent on oil, and $\beta_3$ measures the effect of negative oil price shocks on tax revenues conditional on the initial size of the SE. According to our theoretical prediction, the sign of the linear effect should be positive ($\beta_1 > 0$) and the sign of the interaction effect should be negative ($\beta_3 < 0$). Hence, the higher the initial size of the SE, the lower the effect of oil price shocks on tax revenues. In this approach, the time variation stems from movements in international oil prices, while allowing the effect to change based on the degree of oil dependency. Country- and year-fixed effects control for all time-invariant country characteristics and common global trends, and we cluster the standard errors at the country level.

The inclusion of (log) GDP per capita has two advantages. First, it controls for the effect of oil price shocks on GDP (i.e., the denominator in $\frac{Tax\ Revenues}{GDP}$), ensuring that we only capture the effect of negative oil prices on the size of tax revenues (i.e., the numerator) and not on GDP. Second, as tax revenues can change with changes in either the tax rate or tax base (i.e., output or consumption), controlling for GDP also captures the changes in tax base. Hence, $\beta_1$ and $\beta_3$ measure the unconditional and conditional effects, respectively, of negative oil price shocks on the changes in government efforts to increase tax revenues by increasing tax rates (for a similar approach, see Bhattacharyya and Hodler, 2014; Bhattacharyya and Collier, 2014).

One potential concern regarding our measure for an SE is that its estimated size is based on the multiple indicators multiple causes (MIMIC) approach, which treats tax revenues as a percentage of GDP as one of the drivers of the SE. However, it should be noted that even though our measure for SE could be endogenous, the interaction term between negative oil price shocks (i.e., the exogenous variable) and the SE remains consistent (Bun and Harrison, 2019).[10]

The usage of (non-) differenced specifications is motivated by the time series properties of international oil prices, tax revenues, SE, and GDP. In Table C1 in Appendix C, we provide formal unit root tests for these variables using both annual data and three-year averages. The tests cannot reject the null hypothesis of the presence of a unit root in the time series of oil price in levels, but they reject it for their first differences. For tax revenue, SE, and GDP, formal tests reject the null hypothesis of the presence of unit roots in levels and first difference.

### 3.2. Data

We use a panel dataset covering 124 countries over the period 1991–2015. Our main specification uses three-year averages of our measures of tax revenues, oil price shocks, SE, and per capita income. This allows us to overcome instances of missing data for some countries, especially tax revenues, and have a more balanced dataset. Nevertheless, our results do not depend on the use of three-year averages.[11] Appendix B presents the list of countries included in the sample. Our measure for oil price shock for country $i$ at time $t$ takes the following form (Eq. (2)):

$$OilPriceShock_{it} = \delta_i(\ln OilPrice_t - \ln OilPrice_{t-3}) \quad (2)$$

where $\delta_i$ represents the whole-period average of the country's $i$ share of oil exports to GDP multiplied by the three-year change in (log) international real oil prices ($\ln OilPrice_t$). The construction of the measure captures that oil price shocks will have a greater impact in countries with higher oil dependency.[12] It also allows us to circumvent problems associated with using conventional measures of oil wealth, such as export or production levels (typically normalized by GDP or population), which could be spuriously correlated with our outcome of interest. The oil export data are from the United Nations' Comtrade dataset, reported according to the Standard International Trade Classification 1 system (UN Comtrade, 2018). Data on international real oil prices are taken from the British Petroleum database (BP, 2018). To differentiate negative oil price shocks from positive shocks, we construct a variable that takes the value of three-year growth of logarithm oil price if the generated growth rate value is strictly negative and zero otherwise (see Farzanegan and Markwardt, 2009 for a similar approach). Negative oil price shocks are first calculated per year for each country and then collapsed to the three-year average. Formally,

$$NegPriceShock_{it} = min(0, OilPriceShock_{it}) \quad (3)$$

Tax revenues are measured by the ratio of tax revenues to GDP, taken from the World Bank's World Development Indicators (WDI, 2018). As we show in the next section, controlling for GDP per capita captures any variations in tax base, so that what remains in this measure is only the variation in tax rate, which is our variable of interest. GDP per capita is taken from the World Development Indicators (WDI, 2018). The share of SE to GDP is taken from Medina and Schneider (2018). The estimates for the size of the SE are based on the MIMIC model. This empirical approach first treats the SE as an unobserved (latent) variable, identifying multiple causes and multiple indicators for estimating its size. Second, it uses a structural equation model to estimate the relationships between the unobserved variable and the observed indicators. A key advantage of this dataset is that it uses a light intensity approach instead of GDP as an indicator variable and, hence, it captures a wider range of economic activities that are not reported by official GDP figures (Farzanegan and Hayo, 2019). A second advantage of this dataset is the inclusion of a longer time span and wider coverage of countries. Table 1 provides the summary statistics for our main variables of interest.

## 4. Empirical results

### 4.1. Main results

Table 2 contains our main empirical results. Column 1 looks at the average impact of negative oil price shocks on (log) tax revenues (% of GDP) without controlling for the initial size of the SE. This shows that negative oil price shocks have a positive but statistically insignificant

[8] As we will show below, our main specification uses three-year averages of our variables of interest; hence, the SE measured at year $t-1$ is the average of years $t-3$, $t-4$, and $t-5$, which further rules out any reverse feedback concerns.

[9] Results remain robust when we use the second lag of the SE, despite the drop in sample size. See Ishak (2019) for their findings on the insignificant response of the lagged SE to oil price shocks. We include the SE in levels rather than in logs to address multicollinearity concerns (i.e., the variance inflation factor (VIF) is, on average, 17.37 when using the (log) SE, whereas it drops to only 6.75 when using the SE in levels. Conventionally, the VIF should not exceed 10, otherwise the model would suffer from multicollinearity).

[10] We address concerns about the exogeneity of oil price shocks by dropping Organization of the Petroleum Exporting Countries (OPEC) and oil producers with 1% or 3% of world oil production (see section 4.2).

[11] Our results remain robust when using annual data or five-year averages.

[12] See Bazzi and Blattman (2014), Brückner and Ciccone (2010), and Brückner et al. (2012) for similar methodology. We also check whether there are significant differences between net oil importers and exports (see Table 5).

**Table 1**
Summary statistics.

| Variable | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| Tax revenue (% of GDP) (log) | 799 | 2.69 | 0.65 | −1.34 | 4.06 |
| Negative oil price shock (3-year growth) | 799 | −0.01 | 0.02 | −0.17 | 0 |
| SE (% of GDP) | 799 | 28.81 | 13.38 | 6.52 | 70.93 |
| GDP per capita (log) | 799 | 8.86 | 1.45 | 5.15 | 11.58 |

**Table 2**
Negative oil price shocks, taxation, and the shadow economy.

| Model | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | lnTax | lnTax | lnTax | lnTax |
| | OLS | OLS | OLS | OLS |
| | | High SE | Low SE | Baseline |
| Negative price shock, *t* | 0.777 | 0.754 | 4.053** | 6.389** |
| | (0.803) | (1.365) | (1.571) | (2.520) |
| Shadow economy, *t-1* | | | | 0.002 |
| | | | | (0.005) |
| Negative price shock, *t* × Shadow economy, *t-1* | | | | −0.124* |
| | | | | (0.068) |
| GDP per capita (log), *t* | 0.309** | 0.156 | 0.324 | 0.327** |
| | (0.130) | (0.143) | (0.200) | (0.139) |
| Number of observations | 799 | 276 | 523 | 799 |
| Number of countries | 124 | 63 | 96 | 124 |
| R-squared | 0.074 | 0.123 | 0.119 | 0.095 |
| Country FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |

Notes: The dependent variable is (log) tax revenues (% of GDP). Negative oil price shock is the three-year growth of the log oil price multiplied by the whole-period average oil exports share to GDP. Columns 2 and 3 differentiate between high- and low-SE countries if the SE is greater (lower) than the median. The method of estimation in the columns is ordinary least squares with Huber-robust standard errors (reported in parentheses) clustered at the country level. Country-fixed effects and year-fixed effects have not been reported. Significantly different from zero at *90% confidence, **95% confidence, ***99% confidence.

impact on tax revenues. In Columns 2 and 3, we split our sample into high-and low-SE countries, if the lagged size of the SE (% of GDP) is greater or lower than the median, respectively. Column 2 shows a positive but statistically insignificant effect of negative oil price shocks on taxes in high-SE countries. In contrast, the effect is positive and statistically significant in low-SE countries, as reported in Column 3.

In Column 4, instead of sample split, we add the lagged level of the SE, both by itself and interacting with negative oil price shocks. The coefficient of negative oil price shocks is positive and statistically significant at the 5% significance level, while the coefficient of the interaction term is negative and statistically significant at the 10% significance level. This suggests that negative oil price shocks lead to an increase in the tax revenue share of GDP, but the positive effect is reduced at the higher initial levels of the SE (as % of GDP) in line with our hypotheses.

Our main results (based on Column 4) are illustrated in Fig. 3, which plots the estimated effect of negative oil price shocks on tax revenues conditional on the initial size of the SE, along with the 90% confidence bands. The plot shows that the increase in tax revenues following negative oil price shocks is lower at higher levels of initial size of SE. With no SE, a one-percentage-point weighted decline in international oil price implies an increase in tax revenues of 6.4%. In a low-SE country (SE around 7% of GDP), the effect of a one-percentage-point weighted decline in international oil price leads to an increase in tax revenues of 5.5%. In a mid-SE country (SE around 32% of GDP), the effect of a one-percentage-point weighted decline in international oil price implies an increase in tax revenues of 2.4%. Negative oil price shocks cease to have any significant impact on tax revenues in high-SE countries,

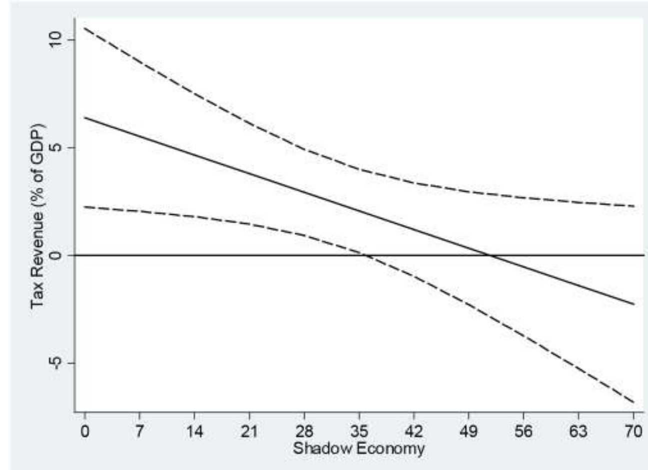


**Fig. 3.** Marginal effects of negative oil prices shocks on (log) tax revenues (% of GDP) at different levels of shadow economy (% of GDP). The dashed lines represent the 90% confidence intervals.

where an SE represents more than 35% of GDP. In Appendix B, we present a list of countries with SE representing more than 35% of GDP.

To put things differently, let us consider Iran, Oman, Kazakhstan, and the Republic of Congo as examples of oil-dependent countries with SEs representing, on average, 18%, 19%, 39%, and 50% of GDP, respectively. A one-percentage-point decline in international oil prices increases tax revenues in Iran and Oman by 4% each, but has no significant impact on tax revenues in Kazakhstan and the Republic of Congo.

### 4.2. Robustness checks

Our baseline results from the previous section are based on a static model. To allow for dynamics, Columns 1 and 2 of Table 3 add the lagged dependent variable as an additional explanatory variable and estimate a dynamic panel model. Column 1 shows the result using ordinary least squares estimation, while Column 2 reports the results using system-generalized method of moments (GMM) estimation.[13] Note that the number of countries has dropped slightly to 119 countries due to the non-availability of data on tax revenues for some countries before 1991. The estimates are close between the two models. Based on Column 1, the coefficient of the dynamic factor is 0.371 (=1–0.629), which indicates that tax revenues adjust very slowly over time, so that the long-run effect of a negative oil price shock on tax revenues is approximately 37% higher than the short-run effect. The estimated coefficients from Column 1 imply that, on average, a one-percentage-point weighted decline in international oil price, unconditionally, leads to an increase in tax revenues of 13.9% in the long run.[14] However, conditional on the size of the SE, a one-percentage-point weighted decline in international oil price leads to an increase in tax revenues of 11.3% in low-SE countries in the long run (SE around 7% of GDP) and by two percentage points in mid-SE countries (SE around 32% of GDP) in the long run.

In Column 3, we estimate the model in first differences by employing the one-period change in (log) tax revenues as our dependent variable.

[13] System-GMM is implemented in a two-step procedure, where the tax revenues variable is instrumented by its second lag in level equation and its first lag in differenced equation, following convention. We do not collapse instruments because the number of instruments (i.e., 39 instruments) is lower than the number of groups (i.e., 119 countries). The overidentifying restriction is not a concern in our case, with the *p*-value of the Hansen test being 0.41, meaning that we fail to reject the null hypothesis of no overidentifying restriction. We also estimated the first-differences GMM model. The results did not change.

[14] We calculate the long-run effect by dividing the oil shock estimated coefficient by (1-the coefficient of the lag of the dependent variable), which is (5.16/1–0.629).

**Table 3**
Negative oil price shocks, taxation, and the shadow economy - robustness checks.

| Model | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | lnTax | lnTax | Δ lnTax | Δ lnTax | lnTax | lnTax |
| | OLS | SYS-GMM | OLS | FE-ARDL | OLS | OLS |
| | Lagged Taxes | Lagged Taxes | 1st-difference | Long-run estimates | Correct for CSD | Correct for CSD |
| Negative price shock, *t* | 5.165*** | 7.586** | 2.689** | 13.992*** | 6.389*** | 5.165** |
| | (1.017) | (3.577) | (1.071) | (4.246) | (1.399) | (1.673) |
| Shadow economy, *t-1* | −0.001 | 0.001 | −0.004 | −0.009 | 0.002 | −0.001 |
| | (0.002) | (0.001) | (0.003) | (0.008) | (0.003) | (0.002) |
| Negative price shock, *t* × Shadow economy, *t-1* | −0.138*** | −0.139* | −0.074* | −0.360*** | −0.124** | −0.138** |
| | (0.024) | (0.073) | (0.043) | (0.101) | (0.043) | (0.049) |
| GDP per capita (log), *t* | 0.151** | 0.025* | | 0.356*** | 0.327*** | 0.151** |
| | (0.069) | (0.013) | | (0.128) | (0.067) | (0.051) |
| lnTax, *t-1* | 0.629*** | 0.785*** | | | | 0.629*** |
| | (0.064) | (0.088) | | | | (0.055) |
| Δ GDP per capita (log), t | | | 0.325*** | | | |
| | | | (0.118) | | | |
| Error correction term (ECM) | | | | −0.420*** | | |
| | | | | (0.032) | | |
| Number of observations | 726 | 726 | 726 | 726 | 799 | 726 |
| Number of countries | 119 | 119 | 119 | 119 | 124 | 119 |
| R-squared | 0.500 | | 0.086 | | 0.1 | 0.500 |
| AR (1) | | 0.01 | | | | |
| AR (2) | | 0.10 | | | | |
| Hansen test, *p*-value | | 0.41 | | | | |
| Country FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |

Note: The dependent variable in Columns 1–2, 5, and 6 is (log) tax revenues (% of GDP); in Columns 3 and 4, it is the change in (log) tax revenues (% of GDP). Negative oil price shock is the three-year growth of the log oil price multiplied by the whole-period average oil exports share to GDP. Columns 1, 2, and 6 add the lagged tax revenues as an additional explanatory variable. The method of estimation in Columns 1, 3, 5, and 6 is ordinary least squares with Huber-robust standard errors (reported in parentheses) clustered at the country level; in Column 2, it is System-GMM; in Column 4, it is fixed effects-augmented distributed lag (ARDL). Country-fixed effects and year-fixed effects have not been reported. Significantly different from zero at *90% confidence, **95% confidence, ***99% confidence.

The (log) GDP per capita also enters the first difference. Recall, our unit root tests have confirmed the stationarity of the tax revenues series. Nevertheless, this approach has the advantage of controlling for all country-specific linear trends in tax revenues when combined with country-fixed effects. We continue to find a positive impact of negative oil price shocks on tax revenues, and the impact is higher at the lower levels of the initial size of a SE.

To obtain a stronger sense of the long-run effects and further rule out any stationarity concerns, we additionally estimate a dynamic fixed effect augmented distributed lag (ARDL) model. Column 4 reports the long-run ARDL estimated coefficients and the error correction term, both of which are very close in magnitude to the computed long-run estimates from Column 1 (see above text). In Columns 5 and 6, we address the concern of the presence of cross-sectional dependence among panels.[15] To this end, we estimated a regression with Driscoll-Kraay standard errors, which are robust to both cross-sectional and temporal dependence. Column 5 contains the results for the static model, while Column 6 reports the estimates for the dynamic model. In both cases, the coefficients of the variables of interest remain identical to the baseline estimates in sign, significance, and magnitude. The only difference is that the interaction term in Column 5 becomes significant at the 5% significance level.

In Table 4, we add additional control variables to our baseline model. In Column 1, we add the share of agriculture value added to GDP to control for the fact that economy-dominated agriculture sectors may be difficult to tax in the presence of a large number of subsistence farmers (Gupta, 2007). In Column 2, we add the share of imports and exports to GDP as a proxy for the degree of openness. Trade liberalization could either negatively affect government revenues by reducing tariff receipts or increase revenue mobilization through the elimination of exemptions and improvement in customs procedures (Keen and Simone, 2004). In Column 3, we control for the share of foreign aid receipts to gross national income (GNI). Aid could affect the domestic revenue mobilization efforts depending on the type of aid received and its domestic use (i.e., to finance investments or current consumption). Gupta et al. (2004) find that concessional loans increase domestically generated taxation, while grants exert the opposite impact. In Columns 4–7, we control for different measures of the quality of institutions and state effectiveness (Besley and Persson, 2014). Corruption could reduce tax revenues by facilitating tax evasion (Buehn and Farzanegan, 2012). Low contestability of power, measured by the Polity2 score[16] and executive constraints from the Polity IV database (Marshall et al., 2018), reduces the incentives of the ruling elite to impose progressive tax rates and deliver efficient public services. Political instability, measured by a durable variable from Polity IV, lowers the ability of the government to impose efficient tax systems and monitor compliance. All factors result in a low tax base and lower tax compliance rates. Finally, in Column 8, we control for social-cultural norms affecting tax morals. Ethnically fractionalized states have a weaker sense of national identity, which in turn weakens their moral obligations toward tax payments (Besley and Persson, 2014). We use a one-year lag of all additional control variables to avoid reverse feedback effects. Throughout all the columns, our main results remain robust in sign and statistical significance.[17]

[15] Tests for cross-section dependence reject the null hypothesis that errors are weakly cross-sectional dependent.

[16] Following Brückner and Ciccone (2010), we adjust Polity2 so that periods of interregnum, coded as 0, and transitional periods are treated as missing.

[17] We also checked with alternative controls for political institutions and trade openness in Table C3 in Appendix C. Specifically, we used the democracy index developed by Gründler and Krieger (2016) based on machine learning techniques. For trade openness, we employed the Konjunkturforschungsstelle (KOF) globalization index (de facto) and the KOF economic globalization index (de facto) (for more information on this index see Gygli et al., 2019 and Dreher, 2006). For a survey on tax revenues and globalization as measured by the KOF globalization index, see Potrafke (2015). In all cases, the results remain robust, except that the interaction term becomes insignificant when the democracy index is used. However, the estimated marginal effects, which take into account the estimations of both the main effect and the interaction effect, remain the same as in the baseline results (see Fig. C1).

**Table 4**
Adding additional control variables.

| Model | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | lnTax | lnTax | lnTax | lnTax | lnTax | lnTax | lnTax | lnTax |
| | OLS | OLS | OLS | OLS | OLS | OLS | OLS | OLS |
| Negative price shock, *t* | 7.078*** | 6.303** | 9.763*** | 7.432*** | 6.874*** | 7.071*** | 6.985*** | 6.425** |
| | (2.436) | (2.656) | (2.090) | (2.383) | (2.548) | (2.597) | (2.589) | (2.502) |
| Shadow economy, *t-1* | 0.003 | 0.000 | -0.001 | -0.001 | 0.002 | 0.002 | 0.002 | 0.002 |
| | (0.005) | (0.005) | (0.004) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) |
| Negative price shock, *t* × | -0.138** | -0.123* | -0.210*** | -0.173*** | -0.148* | -0.154* | -0.149* | -0.124* |
| Shadow economy , *t-1* | (0.069) | (0.072) | (0.048) | (0.057) | (0.078) | (0.081) | (0.079) | (0.067) |
| GDP per capita (log), *t* | 0.469*** | 0.306** | 0.362** | 0.295** | 0.340** | 0.326** | 0.326** | 0.327** |
| | (0.156) | (0.152) | (0.156) | (0.147) | (0.144) | (0.143) | (0.143) | (0.138) |
| **Additional Controls** | **Agriculture, value added (%GDP) (log)** | **Trade (%GDP)** | **Aid (%GNI) (log)** | **Corruption (log)** | **Polity2** | **Executive constraints** | **Political instability** | **Ethnicity** |
| | 0.125 | 0.0001 | 0.050** | -0.029 | 0.005 | 0.002*** | 0.002 | 0.004 |
| | (0.085) | (0.001) | (0.021) | (0.060) | (0.006) | (0.000) | (0.002) | (0.020) |
| Number of observations | 753 | 759 | 467 | 720 | 754 | 766 | 766 | 799 |
| Number of countries | 123 | 122 | 89 | 111 | 119 | 120 | 120 | 124 |
| R-squared | 0.153 | 0.086 | 0.193 | 0.099 | 0.103 | 0.108 | 0.104 | 0.095 |
| Country FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Note: The dependent variable in the columns is (log) tax revenues (% of GDP). Negative oil price shock is the three-year growth of the log oil price multiplied by the whole-period average oil exports share to GDP. The method of estimation is ordinary least squares with Huber-robust standard errors (reported in parentheses) clustered at the country level. Country-fixed effects and year-fixed effects have not been reported. Significantly different from zero at *90% confidence, **95% confidence, ***99% confidence.

Table 5 presents several robustness checks using alternative samples. To the extent that international oil prices are exogenous to specific countries' demands or supply shocks, we should obtain unbiased estimates for $\beta_1$ and $\beta_3$ in our baseline specification. Nevertheless, we cannot rule out the possibility of price manipulations triggered by major oil producers.[18] To address this, in Columns 1–3, we exclude major oil producers whose production exceeds 1% or 3% of global production and Organization of the Petroleum Exporting Countries.[19] In Columns 4 and 5, we check whether our results are driven by high-SE countries or by low-oil exporters. In Column 4, we exclude the top 1% of countries in size of SE as a percentage of GDP.[20] In Column 5, we drop low-oil exporters, whose average share of oil exports to GDP is lower than the median. In all instances, our coefficients of interest maintain their sign and statistical significance. In Columns 6 and 7, we weigh our measure for negative oil price changes (i.e., $\delta_i$) once with a country's whole-period average of oil production (% of GDP) and again with the country's whole-period average of oil rents (% of GDP). In both cases, the coefficient of negative oil price shocks remains positive and statistically significant. The conditioning term loses its statistical significance but retains its negative sign. Nevertheless, the estimated marginal effects of negative oil prices at different levels of SE remain the same as the baseline specification (see Figs. C2 and C3 in Appendix C).

In Table 6, we check whether our estimated effects differ with country characteristics. As low-oil exporters are net oil importers, a decline in international oil prices represents a reduction in their costs of production and, in turn, an increase in output and government revenues. This could reverse the relationship, so that net oil importers may lower tax rates in periods of low international oil prices. We have shown that the exclusion of low-oil exporters does not change the results, with our variables of interest remaining stable in magnitude, sign, and significance. To further address this, Column 1 in Table 6 includes an indicator for net oil importers interacting with our main variable of interest. Net oil importers are defined as those whose whole-period average oil exports are strictly negative. All interaction terms are statistically insignificant (not shown for brevity) and the reported Chow test fails to reject the null hypothesis of equality of estimated effect in both net oil importers and net oil exporters. In contrast, our baseline estimates remain robust. An alternative explanation for such an insignificant difference could be the fact that some net oil importers are financially dependent on net oil exporters in terms of remittances and aid, so that negative oil price shocks could also negatively affect government revenues, which balance out the positive effects of the decline in production costs.

As previously mentioned, low contestability of power reduces the incentives of the ruling elites to impose progressive tax rates and deliver efficient public services, which is the case in autocracies. In Column 2, we differentiate between democracies and autocracies by including an interaction dummy variable that takes the value of 1 if the lagged Polity2 score is strictly positive (negative) for democracies (autocracies). The dummy is included on its own and interacts with our variable of interest. The results reported in Column 2 show that our estimated coefficients preserved their signs and statistical significance. The included dummies and their interactions were statistically insignificant (not shown) and the reported Chow test failed to reject the null hypothesis of equality of estimated effect in both democracies and autocracies. We proceed in Columns 3 and 4 by showing that our results are not sensitive to the choice of data frequency. In Column 3, we use annual observations, and in Column 4, we employ five-year average observations. Our results remain robust.

Other robustness checks are reported in Table C2 in Appendix C, including the dropping of fixed effects and using alternative transformations for GDP per capita. First, as the SE size exhibits low variation over time, it could be the case that adding fixed effects drives down the estimated coefficients for the SE, especially in the presence of measurement error. This is not a major concern for the identification strategy because our main variable of interest is the interaction term between the initial level of SE and negative price shocks. Nevertheless,

[18] For a review of the literature on the market power of the different members of OPEC, see Farzanegan and Raeisian Parvari (2014).

[19] Data on world oil production are calculated using the Ross and Mahdavi (2015) oil and gas database. We also excluded the top 10 oil producers based on the CIA World Factbook and results remain unchanged.

[20] Exclusion of observations corresponding to the highest 1% and 5% of SE values does not change our results.

**Table 5**
Alternative samples and weights.

| Model | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | lnTax | lnTax | lnTax | lnTax | lnTax | lnTax | lnTax |
| | OLS | OLS | OLS | OLS | OLS | OLS | OLS |
| Negative price shock, *t* | 8.576*** | 8.813*** | 7.866*** | 6.248** | 6.345** | 3.824* | 4.844* |
| | (2.480) | (2.319) | (2.273) | (2.558) | (2.506) | (1.947) | (2.798) |
| Shadow economy, *t-1* | 0.004 | 0.002 | 0.002 | -0.001 | 0.000 | 0.004 | 0.005 |
| | (0.005) | (0.005) | (0.005) | (0.004) | (0.008) | (0.007) | (0.007) |
| Negative price shock, *t* × Shadow economy , *t-1* | -0.149** | -0.132* | -0.154** | -0.120* | -0.122* | -0.064 | -0.076 |
| | (0.072) | (0.074) | (0.063) | (0.068) | (0.067) | (0.054) | (0.090) |
| GDP per capita (log), *t* | 0.351** | 0.286** | 0.332** | 0.258** | 0.452** | 0.401** | 0.385** |
| | (0.140) | (0.137) | (0.143) | (0.126) | (0.181) | (0.169) | (0.164) |
| **Omitted observations/weights for shocks** | **OPEC** | **Oil producers with 1% of world production** | **Oil producers with 3% of world production** | **Top 1% high SE countries** | **Low oil exporters** | **Negative oil price shocks weighted by oil production (% GDP)** | **Negative oil price shocks weighted by oil rents (% GDP)** |
| Number of observations | 763 | 708 | 753 | 786 | 387 | 529 | 559 |
| Number of countries | 118 | 110 | 117 | 122 | 59 | 79 | 84 |
| R-squared | 0.109 | 0.098 | 0.105 | 0.079 | 0.158 | 0.122 | 0.121 |
| Country FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Note: The dependent variable is (log) tax revenues (% of GDP). The negative oil price shock is the three-year growth of log oil price multiplied by whole-period average oil exports share to GDP in Columns 1–5; by whole-period average oil production share to GDP in Column 6; and by whole-period average oil rents share to GDP in Column 7. Column 4 excludes the top 1% of SE countries averaged over the whole period; Column 5 excludes low-oil exporters with whole-period average oil exports share to GDP lower than the median. The method of estimation is ordinary least squares with Huber-robust standard errors (reported in parentheses) clustered at the country level. Country-fixed effects and year-fixed effects have not been reported. Significantly different from zero at *90% confidence, **95% confidence, ***99% confidence.

**Table 6**
Country characteristics and alternative data frequency.

| Model | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | lnTax | lnTax | lnTax | lnTax |
| | OLS | OLS | OLS | OLS |
| Negative price shock, *t* | 6.243** | 7.211*** | 1.612** | 12.536* |
| | (2.556) | (2.407) | (0.708) | (7.212) |
| Shadow economy, *t-1* | -0.001 | 0.003 | 0.002 | 0.001 |
| | (0.007) | (0.007) | (0.004) | (0.005) |
| Negative price shock, *t* × Shadow economy , *t-1* | -0.121* | -0.128* | -0.041** | -0.272* |
| | (0.071) | (0.076) | (0.020) | (0.160) |
| GDP per capita (log), *t* | 0.313** | 0.339** | 0.330** | 0.391** |
| | (0.138) | (0.144) | (0.146) | (0.151) |
| | **Including a dummy for net importers + interactions** | **Including a dummy for democracies + interactions** | **Annual observations** | **5-year average** |
| Chow test *(P value)* | 0.11 | 0.14 | | |
| Number of observations | 799 | 799 | 2,114 | 530 |
| Number of countries | 124 | 124 | 124 | 124 |
| R-squared | 0.115 | 0.106 | 0.077 | 0.172 |
| Country FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |

Note: The dependent variable is (log) tax revenues (% of GDP. Negative oil price shock is the three-year growth of the log oil price multiplied by the whole-period average oil exports share to GDP. Columns 1 and 2 use the three-year average observations, Column 3 uses annual observations, and Column 4 uses five-year average observations. In Columns 1 and 2, the net importers and democracy dummies are included on their own and interacted with our variables of interest, respectively. The method of estimation is ordinary least squares with Huber-robust standard errors (reported in parentheses) clustered at the country level. Country-fixed effects and year-fixed effects have not been reported. Significantly different from zero at *90% confidence, **95% confidence, ***99% confidence

in Columns 1 and 2 of Table C2, we drop country-fixed effects and both country- and year-fixed effects, respectively. The estimated coefficients remain qualitatively similar but greater in magnitude. The latter is due to the exclusion of fixed effects, which control for time-invariant country characteristics and common time-varying shocks. Hence, their exclusion results in an upward bias in the estimates. Second, despite the importance of controlling for fluctuations in GDP as laid down in the empirical specification section, the downside is that it could create a linear relationship between the left side and the right side of the equation, since the GDP is also included in the denominator of the dependent variable. To tackle this, we follow two approaches. In Column 3 of Table C2, we replace log GDP per capita with its value in levels, and in Column 4, we employ the one-year lagged log GDP per capita. The results remain robust in both cases.

## 5. Conclusion and policy implications

We studied how the impact of falling oil rents on tax revenues may be contingent on the size of the SE. Employing a conceptual framework and presenting ample examples, in addition to a simple theoretical illustration, we demonstrate that declining oil rents are less likely to increase the tax receipts of governments under a sizable SE.

To test our main hypothesis on the moderating role of the SE in the final effect of negative oil shocks on tax receipts, we use panel data covering the period 1991–2015 and more than 120 countries. Our main hypothesis is supported by the data. In particular, the positive effects of falling oil rents on tax revenues decrease with higher levels of SE. Our main results hold when we control for the effects of income, agriculture value added to GDP, trade, aid, ethnicity, time-varying common shocks, country-fixed effects, and quality of institutions (corruption, democracy, and political stability). Moreover, our main results, based on country- and year-fixed effect regressions, are robust after addressing endogeneity and using different estimation methods, such as dynamic fixed effect ARDL and GMM models.

Our results contribute to the debate on ambiguity in the role of the SE in oil-dependent countries. On the one hand, the existence of an SE can correct market inefficiencies and allow workers to cope with economic volatility (Ishak and Fritsche, 2020), but on the other hand, our findings suggest that it may impede government taxation efforts during economic downturns. In this regard, policymakers are well-advised to analyze the SE and its drivers, as well as weigh the benefits and costs for its existence. Allowing for a limited role of the SE can be conditionally beneficial if its size is kept under control. At the same time, the government is recommended to embark on labor market reforms, in terms of increasing labor productivity, reducing obstacles for firm entry, offering a flexible regulatory environment, and employee social protection. This will allow for a reduction in the role of the SE without losing its benefits.

Future research may also investigate how a decline in oil revenues following the negative economic shocks from the coronavirus pandemic in 2020 or economic sanctions may affect the tax efforts of oil-based economies, considering the size of the SE.

## Acknowledgments

The authors are grateful for useful comments from the Editor (Russell Smyth), three anonymous referees, Marcel Thum, and Olaf Posch. The usual disclaimer applies.

## Appendix A

### A.1. Theoretical framework

We develop a simple model showing the moderating effect of the SE in the oil rent-taxation nexus. Specifically, the SE is incorporated as a determinant of the final impact of oil rents on taxation efforts. The intuition is that negative shocks to oil rents increase the government's incentive to invest in tax efforts to compensate for the decline in oil receipts. However, such an ability to raise tax revenues is constrained in the presence of large informal economies, which, in turn, implies low tax bases. It follows that a decline in oil rents will have a lower impact on tax efforts to raise tax rates and tax revenues, the greater the size of the SE.

To model these effects, let us consider that the government has the choice between using oil rents or taxation to finance public goods. The difference between both sources lies in the fact that taxation is distortive and creates welfare losses (Bornhorst et al., 2009). Hence, the government will depend on oil rents as a first option. If oil rents suddenly declined, the government would resort to taxing firms. We assume that a rational citizen will understand that using oil rents for financing public goods is also considered a tax. If the money were not used for this purpose, he/she could receive a transfer instead.[21] As such, the government's total received tax revenues encompass both oil rents and imposed corporate taxes.

Suppose that the individual's utility function takes the following form $U(Y,T)$, where $Y$ denotes private net income (i.e., consumption) and $G$ is a government transfer or the size of the received public good. The government receives an exogenous amount of oil rents of $pR$, where $p$ is the international oil price and $R$ is the amount of oil extraction. The government can tax firms, with each firm $n$ charged a tax rate of $\tau$. However, the government can only tax firms operating in the official economy. The share of firms in the SE is $SE$, with $0 < SE < 1$. The total tax revenues collected ($T$) is thus

$$T = [n - nSE]\tau \quad \text{(a1)}$$

We assume that the number of firms operating in the official and SEs (i.e., tax base) $[n - nSE]$ remain constant (i.e., fixed at their given initial level) to avoid leakages into the informal market or dropping out of business in response to tax rate increases and to allow for a proportional relationship between tax revenues, $T$, and tax rate, $\tau$. In other words, we assume that an increase in $\tau$ (say by 1%) will lead to an increase in $T$ by the same amount. It then follows that the size of the public good ($G$) is

$$G = pR + [1 - SE]\tau n \quad \text{(a2)}$$

and net income ($Y$) is:

$$Y = [(1 - SE)\,(1 - \tau) + SE]n = n[1 - \tau\,(1 - SE)] \quad \text{(a3)}$$

For simplicity, we assume a Cobb–Douglas utility function $U(Y,G) = Y^a T^{1-a}$. The individual's utility function then becomes

$$U = [n[1 - \tau\,(1 - SE)]]^a [pR + [1 - SE]\tau n]^{1-a} \quad \text{(a4)}$$

[21] We follow Jensen's (2011) line of reasoning in defining rational citizen's preferences for direct transfers or provision of public goods.

With $\tau$ and $SE \in [0,1]$, the first-order condition of the maximization problem, $dU/d\tau$, assuming an internal solution implies that

$$\frac{dU}{dY} - \frac{dU}{dT} = 0 \tag{a5}$$

This means that the marginal utility from private consumption and the marginal utility of public goods should be equal.[22] Under this condition, it yields

$$a[pR + [1-SE]\tau n] - [1-a][\, n[1-\tau\,(1-SE)]] = 0 \tag{a6}$$

By conducting comparative statistics to the above condition (5) using the implicit function theorem, we obtain

$$\frac{d\tau}{dp} = -aR\left[\frac{1}{n(1-SE)}\right] \tag{a7}$$

with SE < 1, which makes

$$d\tau/dp < 0 \tag{a8}$$

To see how the change in $SE$ affects $d\tau/dp$, we obtain.

$$\frac{d}{dSE}\left(\frac{d\tau}{dp}\right) = \frac{-aRn}{n^2(1-SE)^2} < 0 \tag{a9}$$

Thus, the final impact of a change in $p$ depends on $SE$, that is, the initial level of the SE. Based on Eq. (a8) and (a9), we can therefore formulate the following two hypotheses:

**Hypothesis 1.** *An exogenous decline in international oil price p increases tax rate $\tau$ and, consequently, tax revenues T,* ceteris paribus.

**Hypothesis 2.** *An exogenous decline in international oil price p has a smaller impact on tax rate $\tau$ and tax revenues T, the higher the size of the SE,*ceteris paribus.

Hypothesis 1 is based on equation (a8), while Hypothesis 2 is based on Eq. (a9).

## Appendix B

### *A.2. List of sampled countries*

Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Belarus, Belgium, Belize, Benin, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burundi, Canada, Chile, China, Colombia, Congo Rep., Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Egypt, El Salvador, Estonia, Ethiopia, Fiji, Finland, France, Georgia, Germany, Ghana, Greece, Guatemala, Honduras, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea Rep., Kuwait, Kyrgyzstan, Laos, Latvia, Lebanon, Lesotho, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Mali, Malta, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Netherlands, New Zealand, Nicaragua, Nigeria, Norway, Oman, Pakistan, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russia, Rwanda, Senegal, Singapore, Slovakia, Slovenia, Solomon Islands, South Africa, Spain, Sri Lanka, Suriname, Sweden, Switzerland, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Vietnam, Zambia, Zimbabwe.

### *A.3. List of countries with a SE representing more than 35% of GDP*

Albania, Algeria, Angola, Armenia, Azerbaijan, Bahamas, Bangladesh, Belarus, Belize, Benin, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burundi, Colombia, Congo Rep., Cote d'Ivoire, Croatia, Cyprus, Dominican Republic, Egypt, El Salvador, Ethiopia, Georgia, Ghana, Guatemala, Honduras, Jamaica, Kazakhstan, Madagascar, Malawi, Malaysia, Mali, Mexico, Moldova, Morocco, Myanmar, Nicaragua, Nigeria, Pakistan, Papua New Guinea, Paraguay, Peru, Philippines, Romania, Russia, Rwanda, Senegal, Sri Lanka, Suriname, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Ukraine, Uruguay, Zambia, Zimbabwe.

### *A.4. Control variables*

- Agriculture value added (% of GDP): Agriculture corresponds to International Standard Industrial Classification divisions 1–5 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. Source: WDI (2018).
- Trade (% of GDP): The sum of exports and imports of goods and services measured as a share of GDP. Source: WDI (2018).
- Aid (% of GNI): The share of official development assistance (ODA) to GNI. It consists of disbursements of loans made on concessional terms (net of repayments of principal) and grants by official agencies of the members of the Development Assistance Committee (DAC), by multilateral institutions, and by non-DAC countries in the DAC list of ODA recipients. Source: OECD (2018).

[22] We also checked for internal solutions assuming U(Y,0) or U(0,T), but both solutions were rejected for having contradictory signs.

- Corruption: An index for corruption perceptions ranging from 1 to 6, with higher values indicating less corruption. Source: ICRG (2018).
- Polity2: An index measuring the quality of political institutions. It ranges from 1 to 10, with higher values indicating better institutional quality. Source: Marshall et al. (2018).
- Executive constraints: An index measuring constraints imposed on the powers of the executive. It ranges from 1 to 7, with higher values indicating more executive constraints. Source: Marshall et al. (2018).
- Political instability: measured by the "Durable" variable, counting the number of years since the most recent regime change that altered the essential characteristics of the authority, as defined by a three-point change in Polity2 over a three-year period or less. Source: Marshall et al. (2018).
- Ethnicity: A measure for ethnic fractionalization taken from Fearon (2003).

## Appendix C

**Table C1**
Unit root tests.

| Variable | Log Oil Prices (Time-Series Tests) | | Log Tax revenues (Panel Data Tests) | | Shadow economy (Panel Data Tests) | | Log GDP per capita (Panel Data Tests) | |
|---|---|---|---|---|---|---|---|---|
| Annual data | Level | Diff. | Level | Diff. | Level | Diff. | Level | Diff. |
| Dickey-Fuller | n.s. | ** | *** | *** | *** | *** | *** | *** |
| Dickey-Fuller-GLS | n.s. | ** | – | – | – | – | – | – |
| Philipps-Perron | n.s. | *** | *** | *** | *** | *** | *** | *** |
| 3-year Average | | | Level | Diff. | Level | Diff. | Level | Diff. |
| Dickey-Fuller | | | *** | *** | *** | *** | *** | *** |
| Philipps-Perron | | | *** | *** | *** | *** | *** | *** |

Note: All unit root tests contain trends. For panel data, we apply Fisher-type tests. Abbreviations: n.s., not significant at the 10% level. Significantly different from zero at *10% significance, **5% significance level, ***1% significance level.

**Table C2**
Further robustness checks.

| Model | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | lnTax | lnTax | lnTax | lnTax |
| | No country FE | No country & year FE | GDP per capita in Levels | lagged GDP per capita |
| | OLS | OLS | OLS | OLS |
| Negative price shock, *t* | 29.260*** | 28.878*** | 6.806** | 7.326*** |
| | (10.317) | (10.221) | (2.610) | (2.362) |
| Shadow economy, *t-1* | −0.002 | −0.003 | −0.008* | 0.003 |
| | (0.004) | (0.004) | (0.004) | (0.005) |
| Negative price shock, *t* × Shadow economy, *t-1* | −0.506* | −0.500* | −0.134* | −0.148** |
| | (0.278) | (0.276) | (0.068) | (0.059) |
| GDP per capita (log), *t* | 0.057 | 0.056 | | |
| | (0.044) | (0.043) | | |
| GDP per capita (level), *t* | | | 0.0001 | |
| | | | (0.000) | |
| GDP per capita (log), *t-1* | | | | 0.351** |
| | | | | (0.150) |
| Number of observations | 799 | 799 | 799 | 793 |
| Number of countries | 124 | 124 | 124 | 124 |
| R-squared | 0.173 | 0.170 | 0.051 | 0.093 |
| Country FE | No | No | Yes | Yes |
| Year FE | Yes | No | Yes | Yes |

Note: The dependent variable in the columns is (log) tax revenues (% of GDP). Negative oil price shock is the three-year growth of the log oil price multiplied by the whole-period average oil exports share to GDP. The method of estimation is ordinary least squares with Huber-robust standard errors (reported in parentheses) clustered at the country level. Country-fixed effects and year-fixed effects have not been reported. Significantly different from zero at *90% confidence, **95% confidence, ***99% confidence.

**Table C3**
Further robustness checks.

| Model | (1) | (2) | (3) |
|---|---|---|---|
| | lnTax | lnTax | lnTax |
| | Alternative political institutions index | Alternative measure for trade openness | Alternative measure for trade openness |
| | OLS | OLS | OLS |
| Negative price shock, *t* | 6.502** | 6.120** | 6.161** |
| | (2.721) | (2.479) | (2.535) |
| Shadow economy, *t-1* | 0.001 | 0.002 | 0.002 |
| | (0.005) | (0.005) | (0.005) |
| Negative price shock, *t* × Shadow economy, *t-1* | −0.131 | −0.117* | −0.115* |
| | (0.092) | (0.067) | (0.068) |
| GDP per capita (log), *t* | 0.313** | 0.284** | 0.311** |

(continued on next page)

**Table C3** (*continued*)

| Model | (1) | (2) | (3) |
|---|---|---|---|
| | lnTax | lnTax | lnTax |
| | Alternative political institutions index | Alternative measure for trade openness | Alternative measure for trade openness |
| | OLS | OLS | OLS |
| | (0.143) | (0.133) | (0.136) |
| Gründler and Krieger (2016), *t-1* | −0.058 | | |
| | (0.083) | | |
| KOF globalization index (de facto), *t-1* | | 0.005* | |
| | | (0.003) | |
| KOF economic globalization index (de facto), *t-1* | | | 0.002 |
| | | | (0.002) |
| Number of observations | 774 | 799 | 799 |
| Number of countries | 119 | 124 | 124 |
| R-squared | 0.092 | 0.104 | 0.102 |
| Country FE | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes |

Note: The dependent variable in the columns is (log) tax revenues (% of GDP). Negative oil price shock is the three-year growth of the log oil price multiplied by the whole-period average oil exports share to GDP. The method of estimation is ordinary least squares with Huber-robust standard errors (reported in parentheses) clustered at the country level. Country-fixed effects and year-fixed effects have not been reported. Significantly different from zero at *90% confidence, **95% confidence, ***99% confidence.

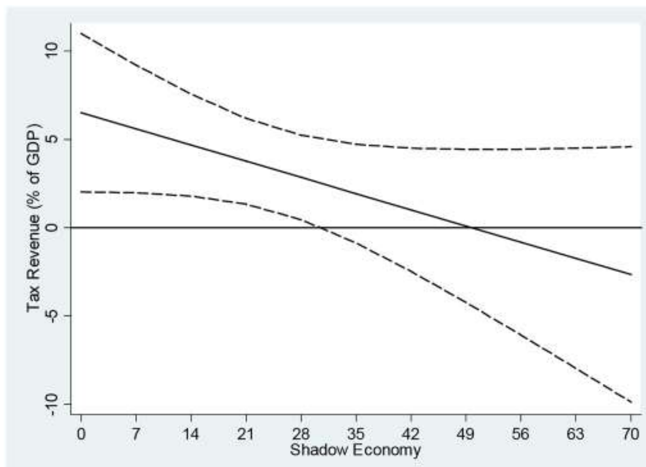


**Fig. C1.** Marginal estimates of Model 1 in Table C3.

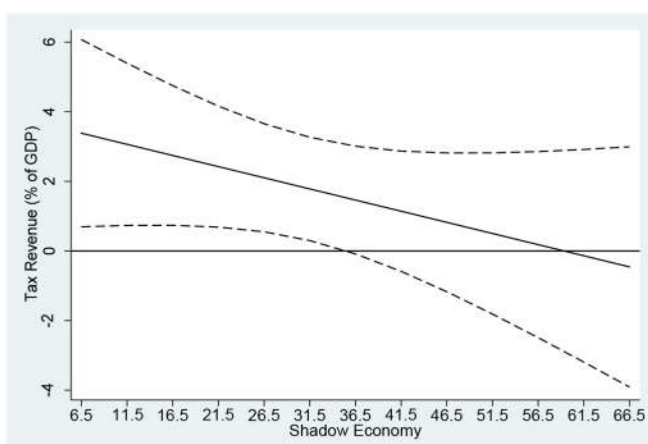


**Fig. C2.** Marginal estimates of Model 6 in Table 5.

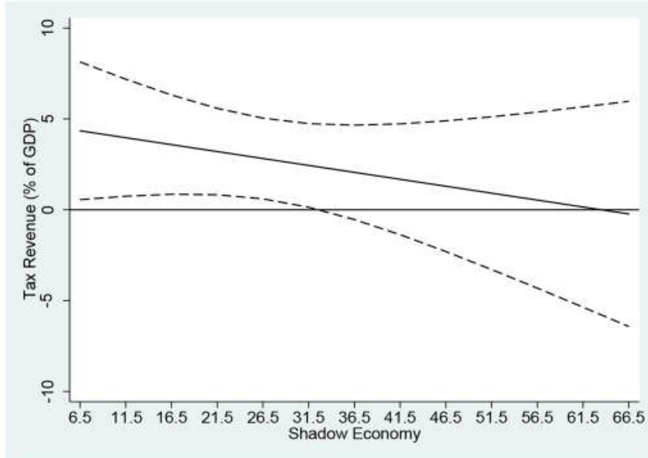


**Fig. C3.** Marginal estimates of Model 7 in Table 5.

## References


Alexeev, M., Conrad, R., 2009. The elusive curse of oil. Rev. Econ. Stat. 91 (3), 586–598.

Aslaksen, S., 2010. Oil and democracy: more than a cross-country correlation? J. Peace Res. 47 (4), 421–431.

Awasthi, R., Engelschalk, M., 2018. Taxation and the shadow economy: how the tax system can stimulate and enforce the formalization of business activities. Policy Research Working Paper No. 8391, World Bank, Washington, DC.

Bazzi, S., Blattman, C., 2014. Economic shocks and conflict: evidence from commodity prices. Am. Econ. J. Macroecon. 6, 1–38.

Beblawi, H., Luciani, G., 1987. The Rentier State. Taylor and Francis Group, Routledge, London.

Besley, T., Persson, T., 2011. Pillars of Prosperity: The Political Economics of Development Clusters. Princeton University Press, Princeton, NJ.

Besley, T., Persson, T., 2013. Taxation and development. In: Auerbach, A., Chetty, R., Feldstein, M., Saez, E. (Eds.), Handbook of Public Economics. Elsevier, Amsterdam.

Besley, T., Persson, T., 2014. Why do developing countries tax so little? J. Econ. Perspect. 28 (4), 99–120.

Bhattacharyya, S., Collier, P., 2014. Public capital in resource rich economies: is there a curse? Oxf. Econ. Pap. 66 (1), 1–24.

Bhattacharyya, S., Hodler, R., 2014. Do natural resource revenues hinder financial development? The role of political institutions. World Dev. 57, 101–113.

Bjorvatn, K., Farzanegan, M.R., 2015. Resource rents, balance of power, and political stability. J. Peace Res. 52, 758–773.

Bjorvatn, K., Farzanegan, M.R., Schneider, F., 2012. Resource curse and power balance: evidence from oil rich countries. World Dev. 40, 1308–1316.

Bornhorst, F., Gupta, S., Thornton, J., 2009. Natural resource endowments and the domestic revenue effort. Eur. J. Polit. Econ. 25 (4), 439–446.

BP, 2018. Statistical Review of World Energy. BP P.L.c. Available at:. https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

Brückner, M., Ciccone, A., 2010. International commodity prices, growth and the outbreak of civil war in sub-Saharan Africa. Econ. J. 120 (544), 519–534.

Brückner, M., Ciccone, A., Tesei, A., 2012. Oil price shocks, income, and democracy. Rev. Econ. Stat. 94 (2), 389–399.

Buehn, A., Farzanegan, M.R., 2012. Smuggling around the world: evidence from a structural equation model. Appl. Econ. 44 (23), 3047–3064.

Buehn, A., Schneider, F., 2012a. Shadow economies around the world: novel insights, accepted knowledge, and new estimates. Int. Tax Public Financ. 19 (1), 139–171.

Buehn, A., Schneider, F., 2012b. Corruption and the shadow economy: like oil and vinegar, like water and fire? Int. Tax Public Financ. 19, 172–194.

Bun, M.J., Harrison, T.D., 2019. OLS and IV estimation of regression models including endogenous interaction terms. Econ. Rev. 38 (7), 814–827.

Crivelli, E., Gupta, S., 2014. Resource blessing, revenue curse? Domestic revenue effort in resource-rich countries. Eur. J. Polit. Econ. 35, 88–101.

Dreher, Axel, 2006. Does Globalization Affect Growth? Evidence from a new Index of Globalization. Applied Economics 38 (10), 1091–1110. https://doi.org/10.1080/00036840500392078.

Farzanegan, M.R., 2011. Oil revenues shocks and government spending behavior in Iran. Energy Econ. 33 (6), 1055–1069.

Farzanegan, M.R., 2014. Can oil-rich countries encourage entrepreneurship? Entrepreneurship Reg. Dev. 26, 706–725.

Farzanegan, M.R., Hayo, B., 2019. Sanctions and the shadow economy: empirical evidence from Iranian provinces. Appl. Econ. Lett. 26, 501–505.

Farzanegan, M.R., Markwardt, G., 2009. The effects of oil price shocks on the Iranian economy. Energy Econ. 31 (1), 134–151.

Farzanegan, M.R., Thum, M., 2020. Does oil rents dependency reduce the quality of education? Empir. Econ. 58, 1863–1911.

Fearon, J., 2003. Ethnic structure and cultural diversity by country. J. Econ. Growth 8 (2), 195–222.

Frankel, J.F., 2010. The Natural Resource Curse: A Survey. NBER working paper, no. 15836.

Gründler, K., Krieger, T., 2016. Democracy and growth: evidence from a machine learning indicator. Eur. J. Polit. Econ. 45, 85–107.

Gupta, A.S., 2007. Determinants of tax revenue efforts in developing countries. IMF Working Paper No. 07/184, Washington, DC.

Gupta, S., Clements, B., Pivovarsky, A., Tiongson, E.R., 2004. Foreign aid and revenue response: does the composition of aid matter? Helping Countries Develop: The Role of Fiscal Policy, ed. by Gupta, Clements, and Gabriela Inchauste. International Monetary Fund, Washington, DC

Gygli, Savina, Haelg, Florian, Potrafke, Niklas, Sturm, Jan-Egbert, 2019. The KOF Globalisation Index – Revisited. Review of International Organizations 14 (3), 543–574. https://doi.org/10.1007/s11558-019-09344-2.

Gylfason, T., 2001. Natural resources, education, and economic development. Eur. Econ. Rev. 45, 847–859.

Hodler, R., 2006. The curse of natural resources in fractionalized countries. Eur. Econ. Rev. 50, 1367–1386.

ICRG, 2018. The International Country Risk Guide. The PRS Group.

Ishak, P.W., 2019. Autocratic survival strategies: does oil make a difference? Peace economics. Peace Sci. Public Policy 25 (2), 1–22.

Ishak, P.W., Fritsche, U., 2020. Oil price shocks, protest and the shadow economy: Is there a mitigation effect? WiSo-HH Working Paper No. 52. University of Hamburg, Hamburg.

James, A., 2015. US state fiscal policy and natural resources. Am. Econ. J. Econ. Pol. 7 (3), 238–257.

Jensen, A., 2011. State-building in resource-rich economies. Atl. Econ. J. 39 (2), 171–193.

Keen, M., Simone, A., 2004. Tax policy in developing countries: some lessons from the 1990s and some challenges ahead. Helping Countries Develop: the role of Fiscal Policy, ed. by Sanjeev Gupta, Benedict Clements, and Gabriela Inchauste. International Monetary Fund, Washington, DC.

Mahdavy, H., 1970. The patterns and problems of economic development in rentier states: the case of Iran. In: Cook, M.A. (Ed.), Studies in the Economic History of the Middle East. Oxford University Press.

Marshall, M.G., Gurr, T.R., Jaggers, K., 2018. POLITY IV PROJECT. Center for Systemic Peace.

Mazhar, U., Méon, P.-G., 2016. Taxing the unobservable: the impact of the shadow economy on inflation and taxation. World Dev. 90, 89–103.

Medina, L., Schneider, F., 2018. Shadow economies around the world: what did we learn over the last 20 years? IMF Working Paper No. 18/17, Washington, DC.

Medina, L., Schneider, F., 2019. Shedding light on the shadow economy: a global database and the interaction with the official one. CESifo Working Paper No. 7981, Munich.

Mehlum, H., Moene, K., Torvik, R., 2006. Institutions and the resource course. Econ. J. 116, 1–20.

OECD, 2018. Net Official Development Assistance (ODA) (Indicator). OECD, Paris.

Potrafke, N., 2015. The evidence on globalisation. World Econ. 38 (3), 509–552.

Farzanegan, M.R., Raeisian Parvari, M., 2014. Iranian-oil-free zone and international oil prices. Energy Econ. 45, 364–372.

Ross, M.L., 2001. Does oil hinder democracy? World Polit. 53, 325–361.

Ross, M., 2012. The Oil Curse: How Petroleum Wealth Shapes the Development of Nations. Princeton University Press, Princeton.

Ross, M., Mahdavi, P., 2015. Oil and gas data, 1932-2014. Harvard Dataverse https://doi.org/10.7910/DVN/ZTPW0Y Available at.

Sachs, J.D., Warner, A.W., 1995. Natural resource abundance and economic growth. Harvard Institute for International Development, Development Discussion Paper no. 517a.

Sachs, J.D., Warner, A.W., 2001. The curse of natural resources. Eur. Econ. Rev. 45, 827–838.
Schneider, F., 2005. Shadow economies around the world: what do we really know? Eur. J. Polit. Econ. 21, 598–642.
Tsui, K., 2011. More oil, less democracy: evidence from worldwide crude oil discoveries. Econ. J. 121, 89–115.
UN Comtrade Database, 2018. International Trade Statistics Database. United Nations. Available at:. https://comtrade.un.org/.
Van der Ploeg, R., 2011. Challenges and opportunities for resource rich economies. J. Econ. Lit. 49 (2), 366–420.
Venables, A.J., 2010. Resource rents; when to spend and how to save. Int. Tax Public Financ. 17, 340–356.
WDI, 2018. World Development Indicators. The World Bank, Washington DC.
WDI, 2020. World Development Indicators. The World Bank, Washington DC.