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Oil Rents and Income Inequality: The Moderating Role of Institutional Quality in Oil-Rich Developing Countries

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Abstract

The purpose of this study is to analyze the impact of oil rent on income inequalities. To this end, we selected a sample of 22 oil-rich developing countries and Norway as a benchmark country. The methodology employed in this work involves the use of a dynamic panel data specification over the period 2000-2022. The econometric results show the existence of a non-linear (inverted U-shaped) relationship between oil rent and inequality. Specifically, oil rent increases inequality in the short term. This effect diminishes as oil revenues increase. Another important finding is that the reduction of income inequality due to the increase in oil rent is closely related to the quality of the institutional framework.

Keywords: oil rent, income inequality, institutional quality, panel data

JEL Classification: Q35, D63, O43, C23

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1 Introduction

The management of revenues from hydrocarbon exploitation and their impacts on economic growth have been the subject of abundant literature. Since the theory of the Dutch disease theory (Corden & Neary, 1982), research on natural resources has focused on rent and the resource curse (Gelb, 1988; Sid- Ahmed, 1989; Auty, 1994; Ross, 2001; Stevens, 2003). However, the effects of oil rent are not limited solely to the economic sphere. Various aspects of social life, particularly population well-being, are also affected through fluctuations in the oil market (Ekomie, Assoumou-Ella, & Moussavou-Batemi, 2019). Additionally, the dependence of economies on oil resources is one of the factors that exacerbates household vulnerability, as oil revenues are not evenly distributed (Rosellini, 2005).
Studies on the impact of oil revenues on inequalities have shown that oil rent exacerbates disparities between the rich and the poor (Farzanegan and Krieger, 2019; Ganguly & Das, 2016). According to Mehlum et al. (2012), the inequalities caused by rising oil prices are due to an unfair distribution of oil resources among households. One of the factors advanced to explain this inequitable redistribution is the quality of the institutional framework. Thus, Howie and Atakhanova (2014) demonstrate that revenues from natural resources contribute to reducing inequalities only when the quality of institutions is taken into account.
The objective of this study is therefore to highlight the impact of oil rent on certain areas of social life, particularly income inequalities. To this end, we selected a sample of 22 oil-rich countries (Algeria, Angola, Saudi Arabia, Azerbaijan, Bahrain, Colombia, the United Arab Emirates, the Republic of Congo, Gabon, Ghana, Equatorial Guinea, Iran, Iraq, Kazakhstan, Kuwait, Libya, Nigeria, Oman, Qatar, Sudan, Chad, and Venezuela). In this study, we opted for an institutional approach, and the methodology employed involves the use of a dynamic panel data specification over the period 2000-2022. To ensure consistent and unbiased results, we utilize the system GMM model. Additionally, in this paper, we estimate the non-linear relationship between oil rents and income inequality, on the one hand, and on the other hand, we evaluate the interactive effect between institutional quality and oil rents to determine how institutional quality can moderate or amplify the impact of oil rents on income inequality. In other words, we seek to understand whether stronger institutions can mitigate the potential negative effects of oil rents on income distribution, or whether weaker institutions exacerbate these effects.
This work provides an original contribution to the literature by combining three dimensions rarely analyzed together: a dynamic GMM approach, a nonlinear specification with an institutional threshold, and social variables such as female labor force participation. Unlike Nikoloski (2009), who uses production data, our model focuses on oil rents as a share of GDP, which better reflects redistributable resources. We also incorporate institutional quality as an interactive factor, which he omits. While Parcero and Papyrakis (2016) highlight the mitigating role of social spending,

our analysis identifies a critical institutional threshold (-0.02 WGI) beyond which oil rents worsen inequality. Compared to Berisha and al. (2021), who find a U-curve based on production in U.S. states, our study shows that in developing countries, institutional capacity determines whether oil rents reduce or exacerbate inequality. Our results echo Mallaye and al. (2023) on the non-linearity of this relationship, but go further by specifying the governance condition behind the curve's inflection.
This article is structured into three sections. In the second section, we will present a literature review on the relationship between oil rent and income inequalities as well as the institutional framework. The third section consists of a descriptive analysis of this relationship, and the last section will be devoted to estimating the dynamic panel data model and interpreting the results.

2 Literature review

The role of natural resources in economic growth continues to fuel debates in economic literature. Many authors argue that an abundance of natural resources can hinder economic growth, considering these resources as a curse. Thus, Corden and Neary (1982) developed the theory of Dutch disease to characterize this natural resource curse. However, it is interesting to note that the term "Dutch disease" was initially proposed by *The Economist* magazine in 1977 rather than by Corden and Neary. This theory states that high oil revenues reduce the competitiveness of all sectors other than oil, displacing vital sectors such as agriculture and industry. Other studies have attempted to establish a negative relationship between natural resource abundance and low growth performance (Ranis, 1991; Auty, 1993; Lal & Myint, 1996; Sachs & Warner, 1995; Sachs & Warner, 1999; Auty, 2001). These authors show that resource-rich countries tend to grow more slowly than countries with fewer natural resources. Another dimension of the resource curse lies in its effects on various aspects of social life, including population well-being, poverty rates, and income disparities. Ekomie, Assoumou-Ella, & Moussavou-Batemi (2019) demonstrate that oil rent influences population well-being through fluctuations in the oil market. Additionally, the dependence of economies on oil resources is one of the factors that exacerbates household vulnerability, as oil revenues are not evenly distributed (Rosellini, 2005).
The literature on the effect of oil rent on inequalities supports the idea that an abundance of natural resources could lead to high inequalities. In this perspective Leamer, Maul, Rodrigue and Schott (1999) argue that resource exploitation does not require much specialized skills, meaning that the workforce in resource- rich countries is not ready to adapt to sectors requiring advanced skills. Consequently, this can lead to more pronounced and persistent income inequality in these countries compared to those less endowed with natural resources. Other authors have confirmed the existence of a positive correlation between income from natural resources and inequalities (Stevens, 2003; Sarraf & Jiwanji, 2001). Bourguignon and Morrisson (1998) advocate for including resource endowments as arguments in income distribution equations.

According to Gylfason and Zoega (2002), resource dependence leads to both lower growth and increased inequality, thus explaining the inverse relationship between growth and inequality. In a more recent empirical study covering 71 countries over the period 1980-2015, Kim and al. (2020) confirm the positive effect of oil rents on income inequality. Their panel GMM analysis also demonstrates that this effect is moderated by the quality of institutions and the level of human capital, suggesting that a critical threshold of 7.5 average years of schooling can mitigate the inequality-increasing impact of oil resources. They further observe that these effects are particularly pronounced in Sub-Saharan Africa, where the impact on inequality is 40% higher than the global average. These findings are supported by country-specific studies. Farzanegan and Krieger (2019) have shown that the oil boom did not reduce inequalities in Iraq. These results are confirmed by Gadom, Fondo, and Totouom (2018) for the case of Chad. These authors studied the impact of oil revenues on income disparities measured by the GINI index over the period 2003-2011.
Contrary to the notion that the resource curse is primarily a phenomenon of developing countries, a recent study on all 50 U.S. states over the period 1997-2015 reveals persistent oil-inequality dynamics even in developed economies, showing a U-shaped relationship where moderate production reduces inequality but high production increases it (Berisha et al., 2021). While Berisha et al. demonstrate that petroleum-related inequality dynamics persist even in developed economies through this production-volume-based U-curve, our analysis reveals a fundamentally different mechanism in developing countries: the impact of oil rents on inequality is conditioned by a critical institutional quality threshold (-0.2 WGI). This distinction underscores how analytical frameworks designed for developed economies cannot fully explain dynamics in producer developing countries, where state redistributive capacity plays a central role. Complementing this, Mallaye and al. (2023) find an inverted U-curve in developing countries, with oil rents below 7% of GDP reducing inequality through job creation, while higher rents worsen disparities. Their work highlights education (8.2+ schooling years) as a key moderator.
Recent literature nuances the deterministic vision of an oil inequality curse. Parcero and Papyrakis (2016), in a study covering 52 oil-producing countries over the period 1980-2010 confirm that oil rents increase inequality (a 10% increase in rents leading to a 2.1% increase in the GINI coefficient), this effect can be fully offset by education spending exceeding 4.5% of GDP or reduced by ~18% through social transfers. Their findings further reveal that the inequality-worsening impact is stronger in autocracies than democracies, highlighting how targeted redistribution policies can transform oil wealth into an inequality-reducing tool. In this regard, Farzanegan and Thum (2017) find that the effect of oil rent on education quality is significantly positive. These results are confirmed in the case of the United States by James (2017). The latter, by analyzing the impact of natural resources on education spending, shows that it is significantly positive and asserts that the salaries of teachers in oil-rich American states are relatively higher than those in neighboring oil-poor states.

The institutional framework in resource-rich countries is often cited as a factor exacerbating inequalities. In this context, some authors argue that the link between oil and inequality could be shaped by various channels, including the level of corruption in the oil-rich country (Andres & Dobson, 2011; Arezki and Brückner, 2011). Thus, in these countries, oil rent does not promote economic development and inequality reduction but rather constitutes a powerful incentive for power struggles (Copinschi, 2007). In the same vein, Ndikumana and Boyce (2012) affirm the existence of a positive correlation between oil, poverty, inequality, and the institutional framework, notably corruption. In this perspective, Kolstad, Wiig and Williams (2008) show that corruption is a major problem in many resource-rich developing countries such as oil-producing countries and largely explains their poor performance in terms of socio-economic development. Similar findings emerge from the work of Arezki and Gylfason (2013), who, through an analysis of 29 sub-Saharan African countries between 1985 and 2007, demonstrate that higher revenues from resources lead to increased corruption. Omgba (2010), focusing on a sample of African countries, establishes a negative correlation between oil revenues and corruption control. Moreover, Arezki and Brückner (2011), based on their study of 30 oil-exporting countries over the period 1992-2005, conclude a significant increase in corruption associated with oil rent.

In a similar vein but with a distinct methodological approach, Nikoloski (2009) examines the economic and political determinants of inequality using a GMM panel model, highlighting the inequality-increasing effect of oil and gas production. However, unlike our approach – which employs oil rents as a percentage of GDP to capture actually redistributable resources – Nikoloski relies on production data, which is less directly tied to fiscal redistribution mechanisms. Our model extends beyond this by incorporating variables such as gender and analyzing interactions between natural resources and institutional quality, a dimension absent from his analysis.

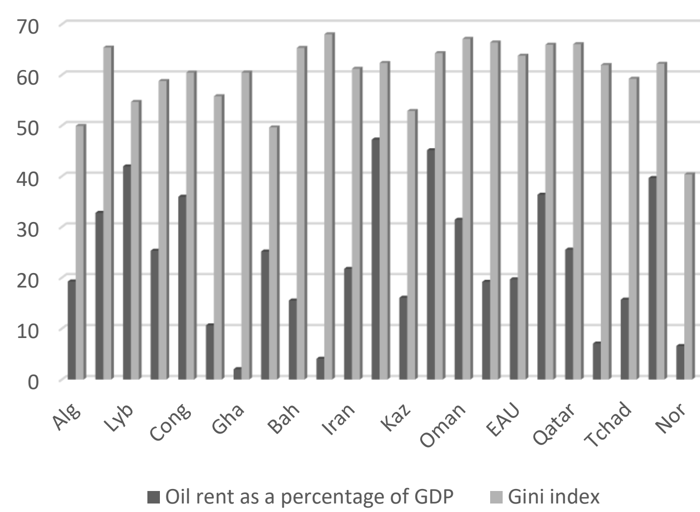
This review reveals three consensus points: (1) the overall inequality-widening effect of resources, (2) the moderating role of institutions, and (3) the importance of targeted policies. Specifically, improving institutional quality.

3 Descriptive analysis of the relationship between inequalities, oil rent, and institutions

The objective of this section is to provide a descriptive analysis of the relationship between oil rent, institutional quality, and income inequalities.

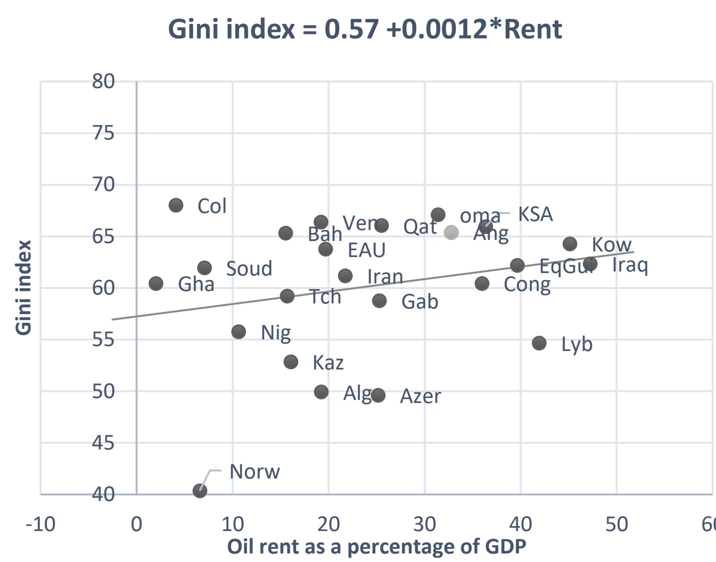
Figure 1 depicts the average distribution of the Gini coefficient and oil rent as a percentage of GDP over the period 2000-2021 for a sample of oil-exporting countries. The interpretation of the figure reveals that countries such as Angola, Congo, and Colombia exhibit the highest average Gini coefficients, with contrasting patterns in terms of the share of oil in GDP. Similarly, it is noticeable that Colombia, despite having one of the highest levels of inequality, does not display a high average level

Figure 1: Gini index and oil rent (2000-2021)



Source: Authors' results on the basis of World Bank data and World Inequality Database (2023).

Figure 2: Gini index regression on oil rent (2000-2021)



Source: Authors' results on the basis of World Bank data and World Inequality Database (2023) using XLSTAT software.

of oil rent, whereas Norway, with the lowest level of inequality, shows a low average level of oil rent as a percentage of GDP.
This can be explained by the historical roots of inequalities in Colombia, which are linked to the private appropriation of land and the revenues it generates, contributing to significant economic and social disparities. Conversely, for Norway, this observation is explained by the long-term strategy of transferring most oil revenues to a sovereign wealth fund invested abroad, keeping the oil rent as a percentage of Norwegian GDP at a structurally low level over the 2000-2021 period.
Figure 2 illustrates the relationship between the Gini index and oil rents as a percentage of GDP for the period 2000-2021. The graph highlights a positive correlation between oil rents and inequality, suggesting that countries where oil rents represent a significant share of GDP, such as Nigeria (Nig) and Saudi Arabia (KSA), tend to have higher levels of inequality. In contrast, countries like Norway (Norw), despite high oil rents, exhibit a lower Gini index, likely due to effective redistribution policies. This relationship can be explained by the concentration of wealth generated by the oil sector in the hands of an elite, as well as insufficient redistribution of oil revenues to the broader population.

Figure 3: Regression of the Gini index on institutional quality (2000-2021)

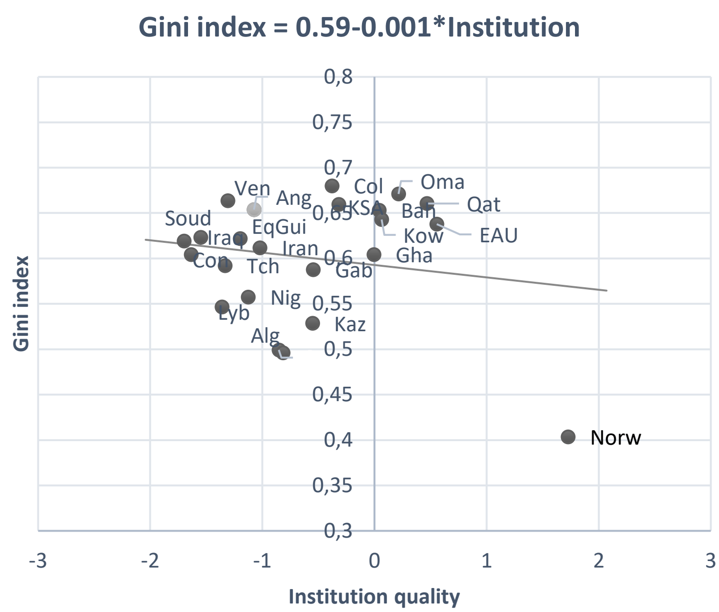


Figure 3 highlights the relationship between the Gini coefficient and the quality of the institutional framework, measured by the Kaufman global indicator for the period

2000-2021. The graph shows a negative correlation between institutional quality and inequality. According to the graph, countries with high levels of inequality are also characterized by lower-quality institutional frameworks. Additionally, it is interesting to note that Gulf countries, despite having relatively good institutional quality, exhibit quite high levels of inequality. This observation can be explained by the economic structure of these countries, where a focus on the oil sector can create economic imbalance. Economic opportunities may be heavily concentrated in this sector, leaving other sectors less developed, which can contribute to inequalities (Dutch Disease). Furthermore, the political systems of some Gulf countries are characterized by monarchies. In such systems, political and economic decisions are often centralized, and citizen participation is limited.

4 Data and methodology

In this section, we focus on the relationship between oil rents, the quality of the institutional framework, and income inequalities. To this end, we opt for an empirical analysis based on a panel composed of 22 oil-rich countries as defined earlier. Many studies have examined the impact of natural resource booms on income inequalities (Goderis & Malone, 2011). However, our study is distinguished by the use of oil rent as an important explanatory variable for inequalities. This specification is complemented by a set of control variables often used in macroeconomic inequality equations (Chong & Calderón, 2000; Andres & Dobson, 2011). In this regard, we consider the level of GDP, trade openness, demographic effects represented by population size, human capital, female labor force participation rate, and government efficiency, to control for the governance effect. Our reference dynamic panel data model takes the following form

$$\begin{aligned} LGini_{it} = {} & \alpha_i + \beta_1 LGini_{it-1} + \beta_2 LRent_{it} + \beta_3 Inst_{it} + \beta_4 LHk_{it} + \\ & + \beta_5 LGender_{it} + \beta_6 LTrade_{it} + \beta_7 LGDPc_{it} + \beta_8 LPop_{it} + \epsilon_{it} \end{aligned} \quad (1)$$

where i varies between 1 and 22 and t varies between 2000 and 2022.
Whereas α, $LGini$, $LGini_{t-1}$, $LRent$, $Inst$, LHk, $LGender$, $LTrande$, $LGDPc$, $LPop$, and ϵ represent, respectively, the constant, the logarithm of the Gini index of income inequality, the lagged logarithm of Gini index, the logarithm of oil rent expressed as a percentage of GDP, the quality of institutions, logarithm of human capital, logarithm of the female labor force participation rate, the logarithm of trade openness rate, GDP per capita, logarithm of population size, and the error term. The logarithmic transformation was applied to most variables to facilitate elasticity-based interpretation, reduce heteroscedasticity, and improve the normality of residuals. This approach ensures that estimated coefficients capture proportional changes rather than absolute changes. Additionally, the log transformation helps mitigate potential skewness in the data, making the estimation results more robust.

4.1 Data used

We have chosen the Gini index as the endogenous variable as a measure of income inequality. The data used are sourced from the World Income Distribution database (WID, 2023).
The other variables concern oil rent, which corresponds to oil profits as a share of GDP, and the quality of the institutional framework measured by the "Government Effectiveness" indicator from Kaufmann et al. These authors have developed six indicators, each covering a particular dimension of governance. Each indicator varies between -2.5 and 2.5, with higher values indicating better institutional quality. The data are extracted from the World Bank database (2023).
In addition to the two variables mentioned above, we consider other control variables as determinants of income inequalities. We include human capital measured by the average years of schooling from (Barro & Lee, 2013) and the rate of return to education based on estimates from the Mincer (1974) equation and subsequent studies (Murphy & O'Reilly, 2019; Bruns & Ioannidis, 2020). This choice is motivated by the lack of a clearly established consensus on the best way to measure education-related human capital. We also include the female labor force participation rate to estimate the influence of gender on income inequalities, the trade openness rate measured by the sum of imports and exports as a share of GDP, GDP per capita level, and population size. The data come from the World Bank database (2023) except for those related to human capital and population, which are sourced from the Penn World Table database (version 10.01). Annual data on the variables defined above cover the period from 2000 to 2022 for the entire sample. Table 1 reports the descriptive statistics of these variables.

Table 1: Descriptive statistics

Variable	Obs	Mean	Standard- deviation	Min	Max
Gini	484	0.6098718	0.553301	0.6456394	0.7058095
Rent	485	24.43908	16.30411	0	82.7769
Inst	506	-0.575843	0.8015046	-2.43996	1.500586
HK	407	2.193166	0.4648142	1.296941	3.301589
Gender	440	0.2033143	0.1069574	0.0474	0.4139
Trade	498	30.36847	42.53885	0	156.8618
Pop	506	2.85E+07	3.72E+07	592468	2.19E+08
GDPc	498	12657.66	15842.8	253.3802	73493.27

Source: Authors' results estimated using Stata 15.

Analysis of correlations Correlation analysis is essential due to the risk of multicollinearity, which can complicate econometric estimations and make interpreting results challenging (Erkel-Rousse, 1995). Table 2 provides the correlation coefficients between the explanatory variables of the model. We observe that there is no risk of correlation between the explanatory variables. To check for the presence of multicollinearity among the exogenous variables, we use the Variance Inflation Factor (VIF) test. Table 3 presents the results of the multicollinearity test between the different variables included in each model. The results indicate that the correlation between the variables is acceptable. Indeed, all variance inflation factors have values lower than 3, and the tolerance values all exceed 0.3. Therefore, we can include all explanatory variables in the growth model without the risk of multicollinearity. The dynamic model presented earlier cannot be estimated with OLS due to the introduction of the lagged dependent variable. Therefore, we use the Generalized Method of Moments (GMM) estimator. The equations in levels and first differences are combined into a system and estimated using an extended GMM system estimator,

Table 2: Correlation coefficients between explanatory variables

	Rent	Inst	KH	Gender	Trade	GDPc	POP
Rent	1.000						
Inst	-0.11	1.0000					
KH	-0.20	0.4767	1.0000				
Gender	-0.30	-0.351	-0.050	1.0000			
Trade	0.117	-0.389	-0.435	0.2725	1.000		
GDPc	0.108	0.739	0.420	-0.504	-0.39	1.000	
POP	-0.27	-0.366	-0.260	0.1605	0.025	-0.41	1.0000

Table 3: Multicollinearity test: tolerance and VIF values

	VIF	Tolérance
Inst	2.98	0.3360
GDPc	2.81	0.3561
HK	1.66	0.6088
Gender	1.60	0.6281
Rent	1.50	0.6648
Trade	1.49	0.6718
POP	1.42	0.7034
Mean VIF	1.92	

allowing for the use of lagged differences and lagged levels of explanatory variables as instruments (Blundell & Bond, 1998). GMM estimations account for the endogeneity of certain explanatory variables.

5 Empirical results and discussion

The results of estimating the model with the GMM estimator are presented in Table 4.

Table 4 presents the results of GMM estimations of the dynamic model exploring the relationship between oil rent and inequalities. The Arellano-Bond test statistics for first and second-order autocorrelation, as well as the Sargan over- identification test, are also provided. Regarding first and second- order autocorrelation, the tests do not reject the null hypothesis of no second-order autocorrelation. Similarly, the Sargan test does not reject the null hypothesis of the validity of instruments used in the regression.

Several specifications were adopted (four specifications). The first column of the table presents the linear model. We observe that the coefficient associated with oil rent is positive and significant at the 5% level. Specifically, a 1% increase in oil rent leads to a 0.014-point increase in inequalities. These results are consistent with those of Gylfason and Zoega (2002), which suggest that heavy reliance on natural resources leads to significant inequality associated with low growth. They also confirm the conclusions of Buccellato and Mickiewicz (2009), who argue that inequalities stem from the failure of oil rent distribution policies.

The results also show that improving the quality of the institutional framework leads to a decrease in income inequalities. These results support previous findings (Gupta, Davoodi, & Alonso-Terme, 2002; Dincer & Gunalp, 2008) suggesting that good-quality institutions lead to a reduction in income inequalities. These inequalities can be reduced through more efficient social spending and tax systems that favor the disadvantaged segments of society (Martini & Wickberg, 2014).

Another important result concerns the gender variable, which is negative and significant. The interpretation of the coefficient associated with this variable reveals a reduction in income inequalities of 0.08 percentage points. This result is explained by the work of Gonzales, Sonali, Kochhar, Newiak, and Zeinullayev (2015), who suggest that differences in activity rates between genders can result in wage inequalities between men and women. According to these authors, wage inequalities can also be generated by the high activity rate of women in the informal sector, where wages are lower. This characteristic is widespread in developing countries. The impact of the female labor force participation rate on income inequalities is also amplified by several other factors, including limited access to education and vocational training for women, as well as their family and social responsibilities, which often confine them to informal or part-time jobs that are less well-paid.

Our results also confirm that human capital measured by the average years of

Table 4: Estimation results

Dependent Variable	Linear model	Nonlinear model	Linear model with an interaction term institutions* oil rent	Nonlinear model with an interaction term institutions* oil
LogGini Index	-0.408 (0.067)***	-0.466 (0.044)**	-0.3362 (0.127)	-0.487 (0.050) **
LogOil Rent	0.014 (0.013)**	0.018 (0.006) *	0.0148 (0.015) **	0.0149 (0.026) **
Square of Oil Rent	/	-0.00014 (0.084)***	/	-0.000017 (0.11)
Quality of Institutions	-0.012 (0.096)***	-0.0558 (0.049) **	/	-0.067 (0.17)
Log Human Capital	-0.132 (0.02)**	-0.177 (0.005) *	-0.124 (0.043) **	-0.190 (0.01) *
LogGender	-0.178 (0.00) *	-0.189 (0.000) *	-0.182 (0.000) *	-0.202 (0.000) *
LogTrade Openness	-0.088 (0.005) *	-0.533 (0.154)	-0.109 (0.004) *	-0.066 (0.19)
LogPopulation	0.00038 (0.972)	-0.0074 (0.543)	0.004 (0.75)	0.003 (0.76)
LogGDP per Capita	-0.158 (0.003) *	-0.00019 (0.98)	-0.020 (0.004) *	-0.008 (0.50)
Oil Rent * Institution	/	/	-0.00038 (0.05) *	-0.00081 (0.019) **
Arellano-Bond test for AR(1) in first differences	0.322	0.202	0.523	0.368
Arellano-Bond test for AR(2) in first differences	0.079	0.448	0.050	0.444
Sargan test	0.52	0.643	0.47	0.681

Source: Authors' results estimated using Stata 15; * significant at 1%; ** significant at 5%; *** significant at 10%.

schooling and the rate of return to education could help reduce inequality. This result is consistent with the work of Yang and Qiu, (2016), Odusola, Dhliwayo, and Sabo (2017), and Yang & Gao (2018), who highlight an inverse relationship between education and inequality. According to these authors, inequalities will decrease following better integration of well- educated individuals into the income redistribution chain via access to employment.

Regarding the trade openness variable, its coefficient is significantly negative, suggesting a major role in the evolution of inequalities within countries by influencing the prices of goods and factors, as mentioned by McCulloch, Winters and McKay (2001). These findings are consistent with those of Daumal (2010), who demonstrated, in a study covering the period from 1960 to 1995 and focusing on interdependent economies, that trade positively contributes to reducing income inequalities.

Column 2 reports the results of the nonlinear model. Two main observations emerge from the results. First, the coefficient of oil rent increases compared to the value obtained in the linear model (0.018 and 0.014 respectively). Secondly, the estimations support the hypothesis of a nonlinear relationship between oil rent and income inequality. This relationship shows that initially, the positive effect of oil rent persists until a certain threshold, beyond which a decrease in income inequality is observed. This threshold is estimated at 64.28% of GDP, affecting only 13% of the sample. These results contradict those obtained by Goderis and Malone (2011), who showed that in the short term or immediately after a natural resource boom, income inequality decreases, followed by a gradual increase as economic growth progresses, until the initial effect of the boom on inequality fades. Our results are consistent with the work of Arezki and Gylfason (2013), who demonstrated through a study on a panel of 29 sub-Saharan African countries over the period from 1985 to 2007 that the significance of natural resource rents leads to larger government spending in less democratic countries, thereby favoring inequality reduction. These findings suggest that the mechanisms by which resource revenues affect income disparities are closely linked to political systems.

Column 3 presents the results of the model with an interaction term between the quality of institutions and oil rent. The aim of this new estimation is to assess the impact of oil rent on income inequalities when it is associated with institutions. Subsequently, we attempt to identify the specific level of institutional quality at which the curve of the nonlinear effect of rent on inequalities reverses.

The estimation results provide a negative and significant sign for the coefficient of the interaction term (the interaction of oil rent with institutions), indicating that the reduction in income inequalities due to oil rent is conditioned by the quality of institutions.

Oil rent acts directly on income inequalities through the coefficient of the square of oil rent β_3 and indirectly and conditioned by the institutional level through the coefficient of the interaction term β_{10}.

Given the equation of the model, the total effect of oil rent can be represented as follows:

$$Total\ effect\ of\ oil\ rent = (\beta_3 + \beta_{10} I) Rent_{it} \quad (2)$$

where
I is the average of the institutional quality measure,
β_3 is the coefficient of the square of oil rent,
β_{10} is the coefficient of the interaction term between oil rent and institutional quality.
Through the interaction effects between oil revenues and institutional quality, we can calculate the threshold of institutional development, from which oil rent has a negative effect on income inequalities. This amounts to determining from what level of institutional quality the rent allows for inequality reduction in the countries of our sample.
To calculate the threshold effect, we assume that the total effect of oil rent is negative:

$$(\beta_3 + \beta_{10} I) Rent_{it} < 0 \quad (3)$$

$$(\beta_3 + \beta_{10} I) < 0 \quad (4)$$

$$Institutional\ quality\ threshold = \beta_3 / \beta_{10} = -0.02 \quad (5)$$

According to the results, oil rent contributes to reducing income inequalities from the threshold of institutional quality of -0.02. In other words, above an institutional quality level equivalent to -0.02, the nonlinear effect of oil rent on inequalities changes from positive to negative. Below this threshold, the nonlinear effect remains positive. Remember that institutional quality varies between [-2.5; +2.5].

6 Robustness analysis

The robustness analysis aims to assess the stability of the obtained results and verify whether the conclusions remain valid under different model specifications. This step is crucial to ensure that the findings are not driven by a particular estimation method. In this study, the main concern is whether the estimated effects of oil rent on income inequality remain robust when alternative estimation techniques are used. While the GMM method was employed in the main estimation to correct simultaneity bias and account for the dynamic nature of the Gini index, other approaches provide complementary insights by either controlling for country-specific characteristics or accounting for cross-sectional relationships between variables.
To ensure the robustness of our findings, we re-estimated the model using the following alternative methods available in Stata:
Pooled regression (POOL): Estimated via ordinary least squares (OLS), this approach assumes homogeneity of coefficients across countries and does not control for country-specific effects. It serves as a baseline to evaluate whether the results hold without accounting for individual heterogeneity.
Fixed-effects model (FE): This method controls for unobservable country-specific

factors that could influence the results. By eliminating time-invariant heterogeneity, it isolates the relationship between oil rent and inequality.

Random-effects model (RE): Unlike the fixed-effects model, this approach assumes that country-specific differences are random and uncorrelated with the explanatory variables. To validate this assumption, we conducted a Hausman test to compare the FE and RE models.

Bias-corrected fixed-effects model (FE2): To mitigate the bias of FE estimators in panels with a limited time dimension, a bias correction was applied, ensuring more reliable estimates.

These additional estimations allow us to verify whether the relationship between oil rent and income inequality remains consistent across different modeling assumptions. The results of these robustness checks are presented in Table 5.

The results of the different estimations confirm the main conclusions of the GMM estimation, thereby strengthening the validity of our analysis.

First, the effect of oil rent on income inequality remains positive and significant across all estimations, indicating that an increase in oil revenues tends to exacerbate inequality. However, the presence of a negative and significant quadratic term in all estimation methods (GMM, POOL, FE, RE, FE2) suggests an inverted U-shaped relationship: while an initial increase in oil rent intensifies inequality, beyond a certain threshold, this trend reverses, and oil revenues contribute to reducing income disparities.

Second, institutional quality plays a key role in reducing inequality, as evidenced by its negative and significant coefficient across all estimations. Moreover, the interaction effect between oil rent and institutional quality is negative and significant, confirming that strong institutions mitigate the inequality-inducing effects of oil revenues. This finding aligns with existing literature, which highlights the role of institutions in resource redistribution and in counteracting the negative consequences of resource dependence.

Finally, while some variations appear across estimation methods, the main results remain robust to different specifications. The sign and significance of the key coefficients are preserved, indicating that the conclusions are not merely a product of a specific methodology but rather reflect structural relationships between oil rent, institutions, and income inequality.

7 Conclusions

The purpose of this study is to analyze the impact of rent on income inequality in a sample of oil-rich countries. These countries are often characterized by income disparity and poor institutional quality. Using the GMM system estimator to address endogeneity issues, the results indicate a nonlinear relationship between oil rent and inequalities. Thus, oil rent increases inequalities in the short term. This effect then decreases with increasing oil revenues. Our additional finding is that the reduction

Table 5: Robustness checks; alternative estimations

Variables	Pool	FE	RE	FE2
LogOil Rent	0.0006 (0.531)	0.012 (0.004)***	0.012 (0.005)**	0.003 (0.000)***
Square of Oil Rent	-0.014 (0.094) *	-0.001 (0.076)*	-0.001 (0.095)*	-0.012 (0.000)***
Quality of Institutions	-0.077 (0.019) **	-0.023 (0.000)***	-0.021 (0.000)***	-0.017 (0.000)***
Log Human Capital	-0.24 (0.005) ***	-0.122 (0.000)***	-0.12 (0.000)***	-0.22 (0.000)***
LogGender	0.011 (0.683)	-0.098 (0.000)***	-0.094 (0.000)***	-0.001 (0.61)
LogTrade Openness	-0.027 (0.004)***	-0.0001 (0.059)**	-0.0001 (0.038)**	-0.02 (0.000)***
LogPopulation	0.013 (0.175)	0.003 (0.086)*	0.003 (0.103)	0.017 (0.004)***
LogGDP per Capita	-0.002 (0.816)	-0.011 (0.000)***	-0.010 (0.000)***	-0.012 (000)***
Oil Rent * Institution	-0.019 (0.084)*	*0.0002 (0.086)*	-0.0002 (0.082)*	-0.013 (0.000)***
R-sq Hausman Test	0.5314	0.4742	0.4740	0.4684

Source: Authors' results estimated using Stata 15; * significant at 1%; ** significant at 5%; *** significant at 10%.

in income inequalities due to increased oil rent is closely linked to the institutional framework.
Next, we estimated the interactive effect between oil revenues and institutional quality by calculating the threshold from which oil rent reduces income disparities. The estimation results provide a negative and significant sign for the coefficient of the interaction term (the interaction of oil rent with institutions), indicating that oil revenue can reduce income inequalities, but only when a threshold level of institutional development is reached. Furthermore, a robustness analysis was conducted using alternative estimation methods (POOL, FE, RE, FE2) to verify the stability of our findings. The results confirm the main conclusions of the GMM estimation, reinforcing the reliability of the identified relationships between oil rent, institutional quality, and income inequality.

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