Int. Journal of Economics and Management 17 (3): 305-319 (2023)

IJEM
International Journal of Economics and Management
Journal homepage: http://www.ijem.upm.edu.my

The Determinants of Okun's Coefficients in Oil-Producing Countries: New Evidence from Quantile Regression

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ABSTRACT

Oil dependence, as a main factor in driving economic growth, undoubtedly plays a crucial role in determining labour market outcomes. This paper utilises the quantile regression approach and the dynamic system GMM methods to investigate the role of oil dependence in determining Okun's coefficient differences. This study uses the difference version of Okun's law to estimate Okun's coefficients for each country through the "rolling window technique" from 1991 to 2019 for panel data from 29 oil-producing countries. Okun's coefficients, estimated in the previous step, became the dependent variable in the second step. The results indicated that the differences in oil dependence prove relevant when accounting for Okun's law differences in oil-producing countries. In other words, oil dependency is found to be the key determinant of Okun's coefficient. Particularly as oil production per capita increases, unemployment becomes less sensitive to output growth. Additionally, this study has found that better institution quality and a higher level of unemployment strengthen Okun's coefficient. Finally, our results confirm the effect of the financial crisis on Okun's coefficients. The findings of this paper conclude with clear evidence for policymakers about the role of oil dependency in economic performance. Economic policy improvements enable a country's oil income to be used more effectively by strengthening its economic sectors, achieving higher economic growth, and thus lowering unemployment rates. The governments of these countries should pay attention to the structural reforms that enhance the development of the non-oil sector and improve the incentives for workers to promote employment in other economic sectors.

JEL Classification: C23, E24, E32, J64

Keywords: Oil countries; Okun's coefficient; Output growth; Quantile regression; Unemployment

Article history:
Received: 19 December 2022
Accepted: 26 November 2023

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DOI: http://doi.org/10.47836/ijeam.17.3.02

INTRODUCTION

The Okun's association between output growth and the unemployment rate, introduced in 1962, has become one of the most robust historical relationships in macroeconomics (see Freeman, 2001). This relationship suggests an adverse connection between unemployment and output, indicating that a 1 percent rise in output growth results in a 0.3 percentage point decrease in unemployment. Since the initial paper of Okun in 1962, numerous previous studies have indicated that Okun's law holds (Kim et al., 2015; Noor et al., 2007), but its coefficient varies and differs across countries and regions (Ball et al., 2017; Furceri et al., 2019). The attainment of high GDP growth and lower unemployment rates are top priorities for emerging and advanced countries. Unfortunately, many oil-producing countries have yet to be on sustained high growth paths and are dealing with high unemployment rates (Hassan et al., 2019). Even though it is commonly assumed in the field of economics that higher GDP growth in a country will boost employment and reduce unemployment, there is evidence that the influence of GDP growth on unemployment reduction is very small (Bartolucci et al., 2018). The GDP growth rate could not help to decrease the unemployment rate due to other factors in that specific economy, such as oil dependence. In other words, the oil income in many countries is often used to finance a large public sector. The mismanagement of this revenue may be a reason for the differences in Okun's coefficient across countries. Similarly, weak governance and corruption influence oil revenue management and governance expenditure (Al-Kasim et al., 2013; Damette and Seghir, 2018). Oil rents provide a major percentage of the GDP and government income of many oil-producing economies. Thus, oil price fluctuations may have contributed more to the high growth rates without eliminating the unemployment issue. It is known that oil is an extremely tradeable commodity, and its price is directly related to production, hence, it can have a substantial impact on inflation, employment, and output (Majumder et al., 2020). Accordingly, this paper investigates if oil production can influence the linkage between the unemployment rate and output growth. Specifically, this paper re-investigates Okun's law validation and determines Okun's coefficient differences in oil-producing countries. We analysed the panel data from, Algeria, Angola, Argentina, Azerbaijan, Brazil, Canada, China, Colombia, Ecuador, Egypt, India, Indonesia, Iran, Iraq, Kazakhstan, Kuwait, Libya, Malaysia, Mexico, Nigeria, Norway, Oman, Qatar, Russia, Saudi Arabia, United Arab Emirates, United Kingdom, United States, and Venezuela.

This paper introduces various contributions to the previous literature. Firstly, we added a new aspect to the prior studies on Okun's law. By applying the quantile regression technique, this study further constructs numerous regression curves at different percentage points of the distribution, providing a more comprehensive view of Okun's coefficient determinants than previous studies. Secondly, our paper extends Ball et al. (2017); de Mendonça and de Oliveira (2019) by examining the determinants of Okun's coefficient differences in a panel of 29 oil-producing countries. This is done by highlighting how oil dependence may influence the relationship between unemployment and output growth in the context of oil-producing countries. While many previous works of literature have focused on global countries in general, this study concentrates on a group of nations that are financially dependent on the same source of revenue. These countries are selected based on the following criteria: Oil production should be at least 500 thousand barrels per day, which is in the top twenty-nine countries based on the 2019 ranking of the USA. Energy Information Administration (EIA).

Oil-producing countries' total output is highly dependent on oil production. As a result, any decline in oil output will have a negative effect on the country's GDP and, consequently, on the unemployment rate. This was confirmed by several studies, such as Arezki et al. (2017); Rafindadi and Ozturk (2015). Thus, our results promote a better understanding of how over-dependence on oil could affect labour market outcomes and provide significant policy implications. Secondly, although considerable studies have investigated the validity of Okun's law, there is a scarcity of research investigating the factors that affect this relationship. Identifying the potential factors that determine Okun's coefficient differences significantly contributes to the current literature. In this regard, we extend the studies by Ball et al. (2019); Furceri et al. (2019) by investigating the role of oil production per capita on Okun's coefficient estimated in oil-producing countries. Additionally, this article adds to the existing studies by considering the influence of institutional quality on the determination of Okun's coefficient differences. Since our case study involves oil-producing countries, controlling for institutional quality is essential. For example, a study by Colgan (2014) has linked the high rate of unemployment to the resource curse phenomenon, or oil dependence. Thus, controlling for the political institution quality is critical when considering the resource curse hypothesis. Previous studies by Ball et al.

(2019); Furceri et al. (2019) indicated an inverse association between the average level of unemployment and Okun's coefficient estimated. Besides, Nugroho (2018) found that the appreciation of the real effective exchange rate negatively influences employment through the revenue channel. Therefore, this paper improves the model by studying the impact of the average level of unemployment and the real effectiveness exchange rate on the estimated Okun's coefficient. Moreover, we improve our model by including other factors such as the labour force rate, and labour productivity growth, which may impact the determinants of Okun's coefficient.

Finally, this study digs deep into a debate about the variation of Okun's coefficient, using the global financial crisis as an important factor that affect the unemployment rate's responsiveness to output growth. According to de Mendonça and de Oliveira (2019); Furceri et al. (2019); Van Ours (2015), the economic crisis has a significant effect on Okun's coefficient.

Our findings revealed a positive relationship between oil dependence (measured by oil production per capita) and the estimated "Okun's coefficients". Therefore, higher degrees of oil dependency influence the effect of output growth on the unemployment rate (Okun's law). In brief, a rise in oil production per capita is associated with reducing the sensitivity of unemployment to output growth. Besides, an inverse correlation between institution quality, the average level of unemployment, and Okun's coefficients were confirmed. Additionally, our paper has provided a significant effect of the real effective exchange rate and labour productivity growth on the unemployment/output relationship. As indicated by the quantile regression results, the real effective exchange rate is statistically significant for the 0.25 and 0.95 quantiles, and labour productivity growth is only statistically significant for the 0.25 quantile. In contrast, both variables were found to be statistically insignificant in the system (GMM) estimation. Furthermore, the quantile regression and two-step GMM results reported that the effect of labour force rate is significantly negative in affecting Okun's coefficient. Lastly, the financial crisis (CR) is found to influence Okun's coefficients only in the lower quantile, indicating that the impact of the crisis on the estimated Okun's coefficient is reduced by the lower responsiveness of the unemployment rate to output growth at the higher quantiles. On the other hand, the system GMM results disprove any influence of the crisis on the estimated Okun's coefficient.

The remainder of this study is organised as follows. Section 2 describes the relative studies in the field. Section 3 discusses the research methodology, including the theoretical framework of Okun's law, estimation steps, and the data applied in the current paper. Section 4 presents the estimation results. Finally, the main conclusions are provided in Section 5.

LITERATURE REVIEW

The validity of Okun's law

Numerous economists investigated the validity of Okun's relationship and identified the determining elements that affected Okun's coefficient differences using a sample of advanced and emerging countries. For example, Bod'a and Považanová, (2021) investigate the validity of Okun's law for a sample of 21 OECD countries from 1989 to 2019. The study confirms a higher magnitude of Okun's coefficient in periods when output decreases than in those when it rises. Based on the study findings, Okun's law appears to be stronger when unemployment decreases and weaker when unemployment rises.

Gil-Alana et al. (2019) scrutinized the stability of "Okun's coefficient" for 24 specified countries utilizing fractionally integrated techniques. The result confirmed the substantial variation of "Okun's coefficient" across nations. The findings of this study also indicated that the long-run memory behaviour of unemployment/GDP associations was confirmed. A recent study by Obst (2022) applied three different forms of "Okun's law" to the EU15 countries. This study estimated Okun's coefficient for the period from 1980 to 2018 and confirmed the adverse influence of output growth on unemployment. The result of this work indicated that the estimated Okun's coefficient differs among countries. Nevertheless, the estimated coefficients based on Okun's law appear to be small or sometimes not significant.

In a study by Benos and Stavrakoudis, (2022), there is strong validity to Okun's law in the United States, France, Canada, the United Kingdom, and Germany without invalidating it in Italy and Japan, where there is still a negative relationship. Widarjono (2020) examined the response of unemployment to output changes in three ASEAN countries (Malaysia, Philippines, and Singapore). Applying the nonlinear ARDL model and the asymmetric and symmetric "Pooled Mean Group" (PMG) technique, this study confirmed the validity and robustness of Okun's law in all selected countries but found that Okun's coefficient varied across countries with different economic development conditions.

The determinants of Okun's coefficients

There is no specific theoretical aspect of the determinants of Okun's coefficient, however, Wachter (1970) introduces examples of situations in which the findings of previous regression analyses became the focal point of a second analysis. Empirically, very few studies have done a subsequent econometric analysis to ascertain which factors are the most important explanatory variables for cross-country differences in Okun's coefficients. For instance, Ball et al. (2019) have pointed out the heterogeneity of Okun's law across countries. According to this study, Okun's coefficient is about half as large in emerging countries as in advanced countries. In terms of the factors that determine Okun's coefficients, they found that the share of services and the average level of unemployment are statistically significant in affecting Okun's coefficients. Another study by de Mendonça and de Oliveira (2019) addressed the influence of the firms' confidence updates on Okun's coefficients in fifteen OECD countries. As a result of the study, the firms' confidence updates significantly affected the estimated Okun's coefficients. Also, Porras-Arena and Martín-Román, (2017) investigated the impact of the weight of self-employment and labour productivity on Okun's coefficients. Using FMOLS and DOLS models, this research found that the weight of self-employment and labour productivity per worker play a role in determining Okun's law variation among Spanish regions. Also, Furceri et al. (2019) have determined various factors affecting the differences in Okun's coefficient across a sample of 85 advanced and developing countries. This empirical study applied time series as well as panel data analyses from 1978 to 2014. The result of this study confirmed that higher average unemployment, a smaller share of agricultural sectors, lower informality, and a higher share of public employment are associated with a greater ratio of unemployment to output growth.

In the context of oil-producing countries, certain scholars have studied the relationship between unemployment and output growth. For example, Beaton (2010) confirmed the instability of Okun's law in Canada and the United States. Additionally, Huang et al. (2019), examined the effect of international oil prices on Okun's coefficients and found that Okun's law continues to be valid. Also, Abu (2017) reported the presence of Okun's law in Nigeria. The results of this study indicated that oil prices positively affect economic growth.

In conclusion, all the empirical research mentioned above leads to inconclusive findings. The instability in the relationship between unemployment and output changes among countries has been confirmed. Also, numerous literature reviews have confirmed the variances in "Okun's coefficient" among countries. The results of these studies have indicated that Okun's coefficient variation is dominated by output changes. However, limited studies have discussed other potential factors that may influence these variables. For instance, Rafindadi et al. (2022) link the energy supply to economic growth. In this regard, the output level of oil-producing countries is extremely sensitive to any fluctuations in oil prices or their production. Consequently, the motivation of this work is to evaluate whether oil dependence has been an important factor in determining Okun's coefficients in oil countries.

RESEARCH METHODOLOGY

Theoretical framework

In the early 1960s, economist Arthur Okun proposed the inverse relationship between output and unemployment, which became known as "Okun's law" in the macroeconomics foundations. There are two substitutional versions of Okun's law: the first difference version and the gap version.

The first difference form captures how changes in the unemployment rate from one quarter to the next move with the quarterly growth in real output, and it takes the following form:

$$\Delta U_t = \alpha + \beta_0 \Delta Y_t + \varepsilon_t \quad (1)$$

where Δ defines the change from the previous period, and β_0 is our interest parameter named Okun's coefficient. It is expected to be negative, given that an increase in output growth causes the unemployment rate to fall.

Secondly, the gap version of Okun's law correlates with the deviation of the unemployment rate from its natural rate and the deviation of output growth from its potential. The correlation is specified as follows:

$$U_t - U_t^* = \alpha + \beta_0(y_t - y_t^*) + \varepsilon_t \quad (2)$$

where U_t represents the unemployment rate; U_t^* is the natural rate of unemployment; y_t is the actual output, and y_t^* is the potential output. The variable α can be interpreted as the unemployment rate associated with full employment. The coefficient β_0 would be positive to conform to the intuition above (Knotek, 2007), as the potential output and the natural rate of unemployment are unobserved macroeconomic statistics. One method used in the literature to estimate U_t^* and y_t^* is the pre-filtering technique (Hodrick and Prescott, 1997), and this is subject to problems like spurious results. Thus, to avoid these issues, they can be assumed to be constant and straightforward estimates of the relationship in the difference version of Okun's law.

Empirical model

This paper utilizes a two-step approach to investigate Okun's coefficient determinants. We will estimate Okun's coefficients for each oil-producing country in the first step. Then, this paper uses the estimated coefficients as dependent variables to examine the role of potential factors in determining the differences in Okun's coefficients.

In this setup, the difference form of Okun's law was applied. As documented by Knotek (2007), the first-difference version of Okun's law allows the usage of macroeconomic data while avoiding assumptions about full employment and potential output. A study by Lee (2000) pointed out that utilising the first-difference version of Okun's law is a straightforward method for achieving the stationarity of data with a unit root. Besides, most of the literature that uses the gap version depends on de-trending techniques such as "linear and first-difference filters, Hodrick-Prescott filters, and the Beveridge-Nelson decomposition", which leads to spurious results (Hamilton, 2018; Lee, 2000). Therefore, to avoid the problem related to that gap version of Okun's law, this study applies the first-difference version of Okun's law in the analysis.

In the first stage, this study estimates Okun's coefficients for each country over the period 1991 to 2019 through the rolling window technique. The rolling window estimations assist to provide how Okun's law has varied significantly over time in certain countries. The significance of the time discrepancy in investigating Okun's law in the present study was supported by de Mendonça and de Oliveira, (2019); Porras-Arena and Martín-Román, (2017), proving a significant time variation in the estimated Okun's coefficient. Figure 1 illustrates the usage of the rolling window method. Accordingly, this technique allows us to measure "Okun's time-varying coefficient" and hence demonstrate the effects of other potential factors that may influence the nexus between output growth and the unemployment rate. The coefficients are initially estimated using sample years 1991–2005 in the first rolling window. The sample period is then forwarded by one year and re-estimated for the subsequent period, and the same stepwise rolling is repeated until the last window is used.

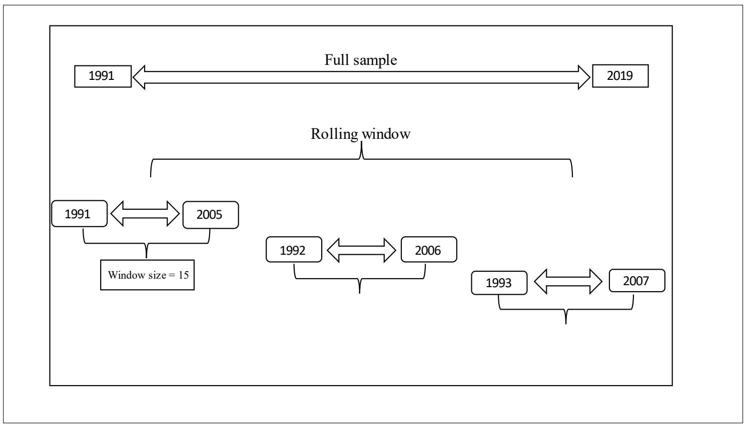


Figure 1 Rolling window method

In this second stage, Okun's coefficients estimated in the previous step become the dependent variable. Therefore, to investigate the role of oil dependence (oil production) on determining Okun's coefficient differences, the following empirical model is estimated:

$$OC_{it} = \alpha_i + \beta_1 OPPC_{it} + \beta_2 IQINDEX_{it} + \beta_3 UR_{it} + \beta_4 REEX_{it} + \beta_5 LFR_{it} + \beta_6 LPG_{it} + \beta_7 CR_{it} + \varepsilon_{it} \quad (3)$$

where i are twenty-nine countries, and t is equal to 15-time observations, corresponding to the 15-year windows. Also, (OC) is the Okun's coefficient and the vector of explanatory variables that consist of oil production per capita $(OPPC)$[1], the quality of institutions ($IQINDEX$), the average level of unemployment (UR), and the real effective exchange rate $(REEX)$. The set of control variables consists of the labour force rate (LFR), and labor productivity growth (LPG); α_i is the vector of country-specific factors, and ε_t represents the error term. Given that the sequential estimations of Okun's coefficient correspond to the information of 15-year periods, our initial idea was to employ the mean value of the explanatory variables in the same 15-year period, but the issue of endogeneity might be observed in some cases such as the average unemployment rate. In other words, the values of these explanatory variables may be related to the dependent variable Okun's coefficient. Thus, to narrow the endogeneity problem, the most satisfactory solution is to consider these variables at the beginning of the sample period, starting in 2005. The coefficients $(\beta_1, \dots \beta_n)$ measure the impact of each variable on the sensitivity of unemployment to output growth. Since the primary purpose of the current study is to examine the response of Okun's coefficient to oil dependence (oil production), the coefficient of interest is β_1, which would measure how much oil production explains Okun's coefficient differences across countries. A significant and positive coefficient is predicted, which would support the assumption that the higher oil dependence, the less responsive (more positive) the Okun's coefficient becomes.

Besides, we extended the empirical studies on determining Okun's coefficients by including institution quality as a potential explanatory factor in our model. It is important to use this index since our case study involves oil-producing countries and the occurrence of the resource curse implies that the increase in oil dependence will have a substantial influence on inflation, employment, and output (Colgan, 2014; Majumder et al., 2020). Also, studies by Ball et al. (2019); Furceri et al. (2019) confirmed the inverse association between the average level of unemployment and the estimated Okun's coefficient. Therefore, this paper improves the model by studying the impact of the average level of unemployment on the estimated Okun's coefficient. Additionally, a rise in resource dependency ends in a real exchange rate appreciation (Corden and Neary 1982). Hence, economic growth will slow down as manufacturing production and non-commodity exports fall because of increased labour costs in manufacturing and lower commodity exports. Thus, the industrial sector faces a labour shortage and higher input costs. Therefore, we included the real effective exchange rate as a potential factor in determining Okun's coefficient. The last two variables were incorporated in the model as control variables since previous literature has shown that they are essential in explaining the variations in Okun's coefficient[2].

Additionally, we examine the impact of the financial crisis on Okun's coefficients. As is well known, the financial crisis was enormously critical in terms of reduced output and employment. As a result, we present a revised estimate by including the global financial crisis into the analysis to verify if the crisis leads to different outcomes. In this respect, we include a dummy variable (CR) which takes a value of "1" for the crisis time and a value of "0" otherwise.

Estimation methods

Quantile regression technique

To achieve a deep understanding of the underlying link between Okun's coefficient and its determinant factors, we have applied a quantile regression approach. As our sample includes countries with varying degrees of oil dependence and economic development, for instance, there are three major income categories: high, mid, and low income. Consequently, the standard least-squares conditions of the normally distributed errors do not hold for our dataset because the values of the independent variables follow a skewed distribution. Thus, quantile regression results are characterised by their advantages and robustness in such

[1] We choose to retain the oil production per capita as proxy for oil dependence as in Eregha and Mesagan (2020); Ross (2019).

[2] For reference see, Bertinelli et al. (2020); de Mendonça and de Oliveira (2019); Porras-Arena and Martín-Román (2017).

instances. Another advantage of quantile regression is its capability of describing the dependent variable's whole conditional distribution, while conventional regression only concentrates on the mean (Coad and Rao, 2006; Uddin et al., 2017). Finally, the quantile regression technique eliminates the constraint that the error terms are equally distributed at all points of the conditional distribution (Coad and Rao, 2006). Thus, we can account for the heterogeneity issue by assuming the probability that the estimated slope parameters diverge at various quantiles of the dependent variable's conditional distribution. As a result, this research employs the quantile regression framework to examine the effects of the explanatory variables on the various degrees of unemployment's responsiveness to output growth.

Following the framework by Koenker and Bassett (1978); Tiwari (2013); Uddin et al. (2017), the quantile regression model is specified as follows:

$$OC_{it} = \acute{x}_{it}\beta_0 + \varepsilon\theta_{it}\ withQuant_{\theta}\ (OC_{it}\ x_{it}) = \acute{x}_{it}\beta_0 \qquad (4)$$

where i indicates country, t is time, OC_{it} is our dependent variable Okun's coefficient, $\acute{x}_{it}$ represents the vector of regressors, β is the parameters vector, and ε is a vector of residuals. $Quant_{\theta}\ (OC_{it}\ x_{it})$ represents θ^{th} conditional quantile of OC_{it} given x_{it}. Where, θ^{th} regression quantile, 0 < θ < 1, provides a solution to the following issue:

$$\min \mid \beta \frac{1}{n}\left\{\sum_{i,t:OC_{it} > \acute{x}_{it}\beta} \theta |\ OC_{it} - \acute{x}_{it}\beta| + \sum_{i,t:OC_{it} < \acute{x}_{it}\beta} (1-\theta)\ |OC_{it} - \acute{x}_{it}\beta|\right\} = \min \mid \beta \frac{1}{n}\sum_{i=1}^{n} \rho_{\theta}\ \varepsilon_{\theta it} \qquad (5)$$

Denoting the check function, $\rho_{\theta}(\bullet)$ as follows:

$$\rho_{\theta}(\varepsilon_{\theta it}) = \begin{Bmatrix} \theta\varepsilon_{\theta it}\ if\theta\varepsilon_{\theta it} \geq 0 \\ (\theta-1)\varepsilon_{\theta it}\ if\theta\varepsilon_{\theta it} \leq 0 \end{Bmatrix} \qquad (6)$$

Equation (6) is solved by linear programming methods. Based on Buchinsky, (1998), as one increases θ continuously from 0 to 1, one traces the entire conditional distribution of OC_{it}, conditional on x_{it}.

Lastly, using the quantile regression technique, we examine the five quantiles (0.10, 0.25, 0.50, 0.75, 0.95), as given below:

$$Q_{0.10}(OC) = \alpha_{0.10} + \beta_{0.10,1}OPPC + \beta_{0.10,2}\ IQINDEX + \beta_{0.10,3}UR + \beta_{0.10,4}REEX + \beta_{0.10,5}LFR + \beta_{0.10,6}LPG + \beta_{0.10,7}CR + \varepsilon_{0.10,it} \qquad (7)$$

$$Q_{0.25}(OC) = \alpha_{0.25} + \beta_{0.25,1}OPPC + \beta_{0.25,2}\ IQINDEX + \beta_{0.25,3}UR + \beta_{0.25,4}REEX + \beta_{0.25,5}LFR + \beta_{0.25,6}LPG + \beta_{0.25,7}CR + \varepsilon_{0.25,it} \qquad (8)$$

$$Q_{0.50}(OC) = \alpha_{0.50} + \beta_{0.50,1}OPPC + \beta_{0.50,2}\ IQINDEX + \beta_{0.50,3}UR + \beta_{0.50,4}REEX + \beta_{0.50,5}LFR + \beta_{0.50,6}LPG + \beta_{0.50,7}CR + \varepsilon_{0.50,it} \qquad (9)$$

$$Q_{0.75}(OC) = \alpha_{0.75} + \beta_{0.75,1}OPPC + \beta_{0.75,2}\ IQINDEX + \beta_{0.75,3}UR + \beta_{0.75,4}REEX + \beta_{0.75,5}LFR + \beta_{0.75,6}LPG + \beta_{0.75,7}CR + \varepsilon_{0.75,it} \qquad (10)$$

$$Q_{0.95}(OC) = \alpha_{0.95} + \beta_{0.95,1}OPPC + \beta_{0.95,2}\ IQINDEX + \beta_{0.95,3}UR + \beta_{0.95,4}REEX + \beta_{0.95,5}LFR + \beta_{0.95,6}LPG + \beta_{0.95,7}CR + \varepsilon_{0.95,it} \qquad (11)$$

In this setup, we use a panel data set of 29 oil-producing countries from 2005 to 2019. We run a quantile regression estimation using Stat 16's *qrprocess* module.

Robustness analysis

In order to further enhance the robustness of our conclusions, we include another estimation as a robustness analysis. Besides, there are several significant econometric issues involved in estimating equation (3). They are the possibility of endogeneity, which occurs largely as a result of the omission of relevant variables, simultaneity bias induced by the probability that certain explanatory factors are endogenous, and bias caused by the correlation between the lagged dependent variable and the error term in a dynamic panel. Therefore, this paper empirically estimates equation (3) utilising the system-GMM (Blundell and Bond, 1998) to address these difficulties. This method is commonly used in panel data analysis (Adamu et al., 2018; Said and Bashir, 2018). Despite the suggestions by Arellano and Bond, (1991), who introduced the first difference GMM dynamic panel estimator, the first difference GMM leads to significant sample biases with the persistence of the independent variables (Blundell and Bond, 1998) and is widely known to suffer from the issue of the weak instrument. It does, however, serve as a useful evaluation in the more advanced system-GMM estimator.

We employed one and two-step systems of the GMM proposed by Blundell and Bond, (1998). This estimator allows the use of moment conditions that combine the first difference and the equations in levels, with the regressors' lagged levels instrumented for the equations in levels. Additionally, the system GMM assumes a constant correlation between the levels of the explanatory variables and the country-specific fixed effect. This assumption implies that the instruments used are valid and that the country-specific fixed effect and the explanatory variables' first differences are uncorrelated. As a result, a dynamic panel model is derived from equation (3) to enable the estimation using the dynamic panel GMM as follows:

$$OC_{it} = \alpha_i + \beta_0 OC_{it-1} + \beta_1 OPPC_{it} + \beta_2 IQINDEX_{it} + \beta_3 UR_{it} + \beta_4 REEX_{it} + \beta_5 LFR_{it} + \beta_6 LPG_{it} + \beta_7 CR_{it} + \varepsilon_{it} \tag{12}$$

where, OC_{it-1} is the lagged Okun's coefficient and μ_i is the country-specific effect, with the rest of the variables being defined earlier. However, the empirical analysis is based on 3-year averaged panel data for 29 oil-producing countries from 2005 to 2019. The three-year averaged panel data smooths the cyclical changes associated with yearly data, making inferences more accurate.

Lastly, the consistency of the GMM estimator is provided by two specification tests. The Hansen test of over-identifying restrictions will first be used to test the null hypothesis that the over-identifying restrictions are valid (Hansen, 1982). Failure to reject the null hypothesis shows that the instruments utilised are valid. Next, there is the Arellano and Bond serial correlation test. Acceptance of the null hypothesis indicates that the second-order serial correlation does not exist.

Data sources

We used the annual data from the World Bank's World Development Indicators (WDI) database to estimate Okun's law from 1991 to 2019 for panel data from 29 oil-producing countries. The unemployment rate reflects the share of the jobless labour force but available to seek work. Furthermore, the Gross Domestic Product (GDP) was employed as a measure of total output, which is the annual growth of the GDP. The second stage explanatory model was constructed using the "rolling windows" estimations of Okun's coefficients from the first stage as the dependent variable. Our main variable, oil production per capita was generated using the Energy Information Administration (EIA) data of the United States and the BP Statistical Review of World Energy (2020). The oil production per capita is the value of oil produced in a given year, calculated using international oil prices. The variable is believed to influence the country's economy. Increased oil output increases a country's gross domestic product, and the economy becomes extremely sensitive to oil production and price changes. As a result, we anticipate that this variable will influence the unemployment-output association. This study follows Eregha and Mesagan (2020); Mavisakalyan and Tarverdi (2019), by employing oil production per capita as a proxy for oil dependence. The rest of the variables were collected from the World Bank's World Development Indicators (WDI), The United Nations Industrial Development Organization (UNIDO) database, The International Labour Organization (ILO), The Worldwide Governance Indicators (WGI), and the BP Statistical Review of World Energy. Table 1 shows the expected signs of coefficient estimates based on theoretical considerations and previous research.

Table 1 The expected sign of the coefficients

	Variable	Definitions	Source	Expected sign
▪ DV	▪ Okun's coefficients (OC)	▪ The responsiveness of unemployment to output changes.	▪ Authors' estimation	
▪ IV	▪ Oil production per capita (OPPC)	▪ The value of oil produced in a given year using international prices divided by population.	▪ U.S. Energy Information Administration (EIA) and the BP Statistical Review of World Energy (2020).	(+)
▪	▪ Institution quality (IQINDEX)	▪ Six measures of institutional quality are used: namely, Control of Corruption, Rule of Law, Voice and Accountability, Absence of Violence, Political Stability, Government Effectiveness, and Regulatory Quality.	▪ Worldwide Governance Indicators (WGI), World Bank (2020).	(-)
▪	▪ Unemployment (UR)	▪ The unemployment rate denotes the percentage of the labour force that is without work but seeking employment.	▪ World Development Indicators (WDI).	(-)
▪	▪ Real effective exchange rate (REEX)	▪ The index form of a currency's value in relation to the basket of other major currencies, adjusted for inflation/Consumer Price Index (CPI).	▪ www.bruegel.org	(+)
▪	▪ Labour force rate (LFR)	▪ The labour force rate represents the participation rate of the labour force for individuals aged (15-24) as a proportion of the population of the same age who are economically active.	▪ World Development Indicators (WDI).	(+)
▪	▪ Labour productivity growth (LPG)	▪ Labour productivity annual growth is measured by the total volume of output (GDP) produced per unit of labour (measured in terms of the number of employed people) in a given time period.	▪ International Labour Organisation database (ILO).	(-)
▪	▪ The financial crisis (CR)	▪ The financial crisis indicator is a "dummy variable" that assigns a value of "1" to years of crisis and a value equal to "0" otherwise.	▪ Laeven & Valencia (2020), IMF.	(-)

ESTIMATION RESULTS

Table 2 provides the summary statistics of the variables. In particular, it is revealed that the average Okun's coefficient in our sample of studies is -0.134, which is lower than the average obtained in earlier analyses that used a sample of emerging countries. This could be explained because this study uses a sample of developed and developing countries[3]. The skewness is -1.0066, which shows a skewed distribution. This shows that the data is not normal, or that the OLS assumption of a normal distribution of error terms is not guaranteed. Therefore, the quantile regression approach can solve these problems and provide more reliable results. Consequently, the empirical examination is conducted by estimating equation (3) at five quantiles (0.10, 0.25, 0.50, 0.75, 0.95), and the results are reported in Table 3.

Table 2 Descriptive Statistics

Variable	Obs	Mean	Std. Dev	Min	Max	Skewness	Kurtosis
OC	435	-.1346709	.1560328	-.668407	.1173484	-1.0066	3.268835
OPPC	435	7.054596	1.708354	2.168437	10.46082	-.338924	2.964019
IQ INDEX	435	43.4355	25.1633	2.753647	97.94629	.5699954	2.484319
UR	435	6.551954	3.80783	.091	19.063	1.18074	4.738804
REEX	435	4.68256	1.109245	3.559997	23.40342	13.72923	212.5063
LFR	435	42.88841	13.16808	15.85	70.05	-.149385	2.137353
LPG	435	1.291425	8.52578	-62.61	120.71	5.302035	98.1914

Source: Authors' calculations

Figure 2 displays the marginal effects of *OPPC*, *IQINDEX*, *UR*, *REEX*, *LFR*, *LPG*, and *CR* for all quantiles within the (0, 1) range of Okun's coefficient distribution. The bold dotted line indicates the OLS coefficient. The difference between the OLS and the marginal effects of oil production and the rest of the variables, including the crisis dummy at different percentage points of the quantiles in the Okun's coefficient

[3] It is important to note that Okun's coefficient (OC) might be various in developing countries (see Bartolucci et al., (2018); de Mendonça and de Oliveira, (2019)).

distribution, indicates the importance of considering the influence of our explanatory variables on the Okun's coefficient at different quantiles.

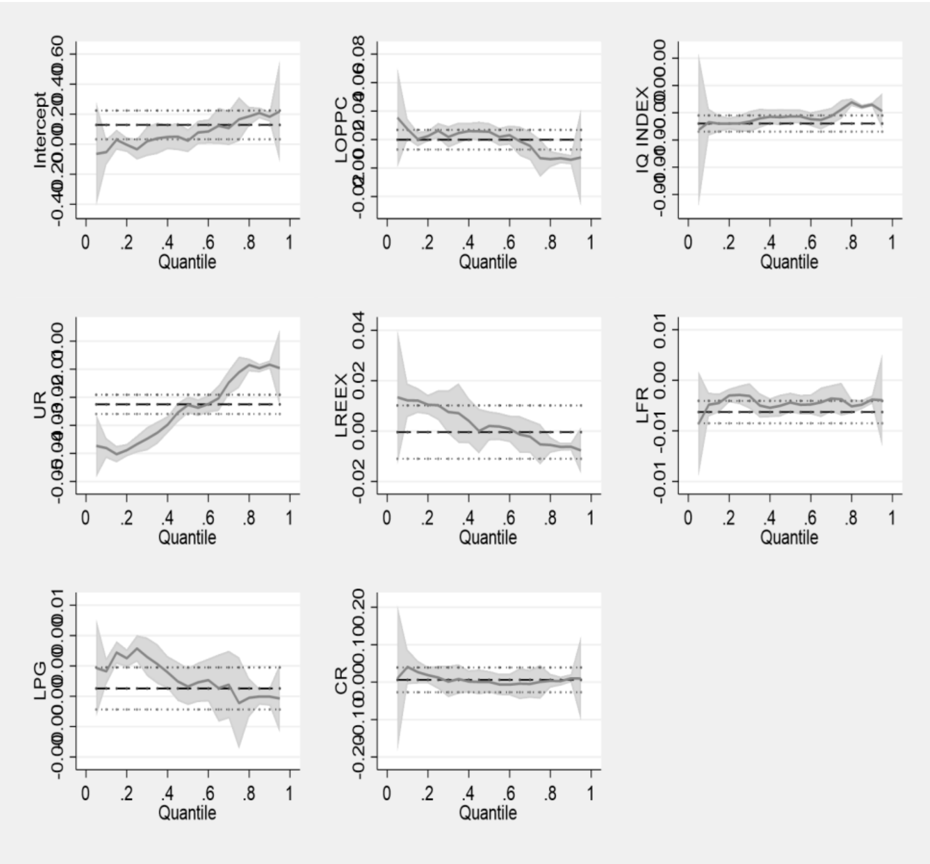
The results in Table 3 present the main empirical estimation of quantile regression. As the estimated Okun's coefficients are the dependent variable, the results will be interpreted in terms of the effect on the magnitude of Okun's coefficient, in which the negative value will magnify Okun's coefficient. Starting from Table 3 and focusing on our main variable, oil production per capita *OPPC*, the quantile regression indicates a significant positive correlation for all the quantiles between oil dependence and Okun's coefficient (the degree of unemployment responsiveness to output growth). In other words, an increase in oil production per capita is associated with a higher Okun's coefficient (less responsiveness of unemployment to output growth). Additionally, the estimated coefficients on oil production per capita show a decreasing trend from the 0.10 to 0.95 quantiles (Figure 2), which implies that the effect of oil production per capita (oil dependence) decreases for countries with less responsiveness of unemployment to output growth or a higher Okun's coefficient (higher quantile). Accordingly, we argue that the over-dependence on oil has a statistically significant inverse effect on the unemployment-output association. Okun's coefficient is less affected by oil dependence when unemployment is less responsive. The presence of such a link casts new light on the debate concerning the resource curse. The possible explanation for this finding might be that oil contributes highly to oil countries' total GDP and government incomes. As a result, oil prices and production changes may have given rise to high growth rates without resolving the unemployment issue to a greater extent. In this respect, this finding is consistent with that of Colgan (2014), who linked the high unemployment rate to the resource curse phenomenon, or oil dependence.

Furthermore, the quantile regression results show that the quality of institution *IQINDEX* is negatively significant for all quantiles, indicating that better institutional quality strengthens the validity of Okun's law. Specifically, better institutional quality will magnify the estimated Okun's coefficient. This finding raises the importance of the quality of institutions to promote growth and maximise the advantages of oil dependence in oil-producing countries. The average level of unemployment *UR* is also negatively significant for all quantiles, indicating that the higher the level of unemployment, the more negative Okun's coefficients become. The real effective exchange rate *REEX* effect is significantly positive for the 0.25 quantile, significantly negative for the 0.95 quantiles, and insignificant for the 0.10, 0.50, and 0.75 quantiles. While the labour force rate *LFR* is found to be negatively significant for all the quantiles, labour productivity growth *LPG* is only significant and positive for the 0.25 quantile. Finally, concentrating on the crisis dummy *CR* in Table 3, the results reveal that the crisis is associated with a lower unemployment response (less negative Okun's coefficient) only for the 0.10 quantile. The coefficient in the rest of the quantiles is insignificant, which indicates that Okun's coefficient was less affected by the crisis for countries with less unemployment responsiveness to output growth at higher quantiles. Based on these findings, a weak level of correlation between oil countries and economic crises, suggests that these countries may still achieve economic growth through oil price increases. The exact magnitude of the output growth/ unemployment nexus largely depends on country-specific circumstances.

Table 3 Quantile regression results

VARIABLES	Q0.10	Q0.25	Q0.50	Q0.75	Q0.95
OPPC	0.0273***	0.0262***	0.0255***	0.00696*	0.00747***
	(0.00913)	(0.00846)	(0.00744)	(0.00369)	(0.00202)
IQINDEX	-0.00269***	-0.00278***	-0.00227***	-0.00175***	-0.00188***
	(0.000428)	(0.000407)	(0.000381)	(0.000475)	(0.000369)
UR	-0.0381***	-0.0367***	-0.0227***	-0.0111***	-0.00958***
	(0.00401)	(0.00403)	(0.00427)	(0.00296)	(0.00192)
REEX	0.0122	0.0103*	0.00204	-0.00527	-0.00768***
	(0.00744)	(0.00539)	(0.00574)	(0.00435)	(0.00234)
LFR	-0.00241***	-0.00145*	-0.00220***	-0.00188***	-0.00197***
	(0.000792)	(0.000797)	(0.000626)	(0.000574)	(0.000404)
LPG	0.00165	0.00315*	0.000642	-0.000447	-0.000141
	(0.00355)	(0.00179)	(0.00218)	(0.000888)	(0.000294)
CR	0.0407**	0.0124	0.00291	0.000740	0.00961
	(0.0165)	(0.0192)	(0.0208)	(0.0219)	(0.0144)
Constant	-0.0526	-0.0339	0.0234	0.166***	0.219***
	(0.0998)	(0.0834)	(0.0842)	(0.0553)	(0.0356)
Observations	435	435	435	435	435

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.



Note: Confidence intervals extend to 95% confidence intervals in both directions. Horizontal lines represent OLS estimates with 95 % confidence intervals.

Figure 2 Variation in the OPPC, IQ INDEX, UR, REEX, LFR, LPG, and CR coefficients over the conditional quantiles

Robustness estimation

The estimates of the result in Table 4 are computed with the system-GMM dynamic panel estimators without time-specific effect. Using the robust system-GMM method as the preferred model specification, the regression results show that lagged Okun's coefficient *OC* influences contemporaneous *OC* positively and significantly for all model specifications.

Table 4 demonstrates that oil production per capita *OPPC* influences Okun's coefficient positively and significantly in both one-step and two-step system GMM estimators. In other words, an increase in oil dependence is associated with a smaller (less negative Okun's coefficient) unemployment response to output growth. Thus, the results further strengthen our results in the quantile regression estimation and confirm that oil dependence has an inverse impact on unemployment and the output growth relationship. Additionally, this model has been performed with the system GMM robust standard error, indicating that the empirical model has been specified correctly and been robustly. However, both one and two-step estimators are shown to be statistically significant. Besides, this finding is consistent with the "Dutch Disease" theory. According to that theory, with more government expenditure on the non-tradable sector, resources will be shifted from the tradable sector to the non-tradable one. As a result, the economy will de-industrialise, and the unemployment rate will rise.

Besides, the GMM estimates indicated a significant negative correlation between the quality of the institution *IQINDEX* and Okun's coefficient, and the quantile regression results also confirmed this. Similar results were obtained for the average level of unemployment *UR*. As shown in Table 4, the higher the level of unemployment, the Okun's coefficient becomes more sensitive (more negative). In particular, the average level of unemployment is statistically and negatively significant at a 1% significant level in both one-step system and two-step system estimators, implying that the average level of unemployment increases the estimated elasticities between unemployment and output. Similarly, the average level of unemployment remains negative and statistically significant with the robust system-GMM. However, the significant level in both one-step and two-step system GMM robust standard errors was at a 10%. This result is consistent with our quantile estimation results and with the previous work by Ball et al. (2019); Furceri et al. (2019).

On the other hand, Table 4 reports that the real effective exchange rate *REEX* and labour productivity growth *LPG* are not statistically significant in both one-step and two-step system estimations. The quantile regression also shows an insignificant impact of the real effective exchange rate and labour productivity growth, except for the 0.25 and 0.95 quantiles for the real effective exchange rate and the 0.25 quantile for labour productivity growth, which turns out to be statistically significant. Besides, the effect of the labour force rate *LFR* is significantly negative for all the quantiles in our quantile results, similar to the two-step robust GMM and contrary to the one-step robust system GMM, which is found insignificant at any significant level. Finally, introducing the financial crisis *CR* into all the specification models is statistically insignificant at any conventional significance level. However, these results are inconsistent with the quantile regression results and the previous studies by de Mendonça and de Oliveira (2019).

For the diagnostic tests, the results in Table 4 indicated that all Sys-GMM regressions do not reject the H-null hypothesis in the Hansen test of the overall validity of the instruments. Furthermore, the results of all specification tests of the second-order autocorrelation AR (2), fail to reject the null hypothesis of the absence of second-order serial correlation. Hence, considering all the diagnostic tests of these models, we are able to conclude that the estimated models are adequately specified.

Table 4 Regression Results (dependent variable: Okun's coefficient)

VARIABLES	One-step system GMM	Two-step system GMM	**One-step system GMM (robust)**	**Two-step system GMM (robust)**
L.OC	0.509***	0.501***	0.509**	0.501**
	(0.110)	(0.0923)	(0.226)	(0.199)
OPPC	0.0128***	0.0135***	0.0128**	0.0135**
	(0.00337)	(0.00298)	(0.00618)	(0.00594)
IQINDEX	-0.00150***	-0.00134***	-0.00150**	-0.00134**
	(0.000351)	(0.000377)	(0.000739)	(0.000640)
UR	-0.00954***	-0.00867***	-0.00954*	-0.00867*
	(0.00229)	(0.00286)	(0.00520)	(0.00522)
REEX	0.00307	0.00282	0.00307	0.00282
	(0.00246)	(0.00191)	(0.00264)	(0.00289)
LFR	-0.00100**	-0.00131**	-0.00100	-0.00131*
	(0.000470)	(0.000580)	(0.000773)	(0.000762)
LPG	-0.000399	0.000551	-0.000399	0.000551
	(0.00107)	(0.000945)	(0.00116)	(0.00127)
CR	0.00569	-0.000183	0.00569	-0.000183
	(0.00819)	(0.00753)	(0.0165)	(0.0115)
Observations	116	116	116	116
No of countries	29	29	29	29
No of instruments	16	16	16	16
AR(2)	0.456	0.196	0.250	0.257
Hansen test			0.464	0.464

Note: *** indicate significant at 1% level, ** Significant at 5% percent level, and * Significant at 10% percent level.

CONCLUSION AND POLICY IMPLICATIONS

This study revisits the regularity popularised by Okun's law using an annual panel data analysis for 29 oil-producing countries from 1991 to 2019. The determinants of Okun's coefficient differences among oil countries were then investigated in this paper. Specifically, this study focuses on the effect of oil dependence on Okun's coefficient. Moreover, this paper adds to the current relative literature by disputing the importance of oil dependence in determining the relationship between the unemployment rate and output growth in the context of oil-producing countries. Besides, we provide a new econometrics approach towards determining Okun's coefficient using the quantile regression technique.

The findings of the current paper indicate a positive association between oil dependence (oil production per capita) and Okun's coefficients, suggesting that higher levels of oil dependence have the potential to influence Okun's coefficients (unemployment and output growth relationship). In other words, an increase in oil production per capita causes unemployment to become less responsive to output growth. These results were confirmed by our quantile estimation and the robustness analysis of the dynamic GMM. Furthermore, our result reveals an inverse correlation between institution quality *IQINDEX* and the average level of unemployment *UR*. Enhancing the quality of institutions leads to higher unemployment responsiveness to output growth, while a higher level of unemployment results in more responsiveness. Additionally, the quantile regression results indicated a significant effect of the real effective exchange rate *REEX* for the 0.25 and 0.95 quantiles, while labour productivity growth *LPG* was only statistically significant for the 0.25 quantile. In our robustness analysis, both variables were found to be statistically insignificant. The quantile results indicated that the effect of the labour force rate *LFR* is significantly negative for all the quantiles, and similar results were obtained by the two-step robust GMM. The financial crisis (CR) affected Okun's coefficients in the lower quantile but not in the higher quantile.

In summary, the findings of this study conclude with clear evidence of the so-called "oil curse" and its symptoms, which are clearly observed in the relationship between unemployment and GDP growth. The findings suggest that overdependence on oil revenues can dampen the response of unemployment to GDP growth. Therefore, the governments of these countries should pay attention to the structural reforms that enhance the development of the non-oil sector and improve the incentives for workers to promote employment in other economic sectors. Furthermore, improving the quality of institutions may help to reduce unemployment by increasing output, because long-term economic growth is unlikely to be achieved in the absence of a strong political institution. Hence, weak institutions countries from oil-producing nations are more likely to have less responsiveness of unemployment to GDP growth, and these countries are at risk of the resource curse. Additionally, the study finds evidence that labour productivity magnifies Okun's coefficient in the quantile regression. Hence, governments should adopt a set of policies that aim to improve the quality of employment and minimize the possible adverse short-term effects. In this sense, improving labour productivity through the adoption and dissemination of new technologies is essential. This research indicated that labour force participation magnifies Okun's coefficient. Thus, employment protection might be implemented in such a way as not to impede job creation as well as labour reallocation. Policymakers in oil-producing countries should place more emphasis on the development of human capital through an increase in knowledge and technical proficiency among the labour force of these nations.

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