Macroeconomic Determinants of Economic Growth of Major Oil and Natural Gas Countries

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Abstract
Today's economy cannot do without oil and gas, two commodities that two major crises have hit in particular in recent times. These energy commodities were and are in conflict of interest, and not only from that perspective. Therefore, it is legitimate to ask whether these commodities bring economic benefits and prosperity to the economies of the producing countries. A literature study reveals that the authors have focused mainly on the partial impact of individual determinants on economic growth. Therefore, the article's authors decided to examine the issue in full. This article deals with a study of the determinants of economic growth in the countries of the top ten oil and gas producers. This study uses panel data analysis and is a direct fixed-effects model. Two models are built, one for oil and one for natural gas. The period under study is the same for both models, between 1980 and 2021. The exchange rate, HDI, crude oil production, crude oil price, and oil consumption significantly positively affect GDP growth. Population growth, HDI, natural gas production, and the natural gas price have a significant positive effect on GDP growth.

Keywords
economic growth, top oil producer's countries, top gas producer's countries, panel analysis, determinants of economic growth.

Introduction

Oil and gas are increasingly discussed topics in terms of their exhaustibility, the development of the economies of the countries extracting these raw materials, the transition to alternative energy sources, and also, for example, the global crises affecting the price of the raw materials discussed.

Studies have already looked at the determinants of economic growth in developed and developing countries. Ademola and Badiru (2016) focused their research on the relationship between unemployment and inflation with real GDP in Nigeria. According to the results, inflation and unemployment positively affect economic growth in the long run. El-Joumayle (2016) investigated the effect of oil prices and oil production on GDP in Iraq. According to the results, oil production and oil prices have a positive effect on GDP, but in the case of oil prices, the effect is not statistically significant. Ur Rahman et al. (2020) examined the relationship between energy production, energy consumption, and GDP growth in China. The selected energy commodities are oil, natural gas, and coal. The consumption and production of all the energy commodities studied positively affect GDP growth.

The literature search did not find studies that directly addressed the determinants of economic growth of the top ten oil and gas producers. Only studies addressing the subdeterminants of the analysis presented in this article were found. Additionally, not many studies address the determinants of economic growth either. Articles dealing with energy raw materials as a whole were found. The topic examined is also interesting because the largest producers of both commodities include both developed and developing countries.

Oil and gas are commodities that influence economic and energy policy. Commodities formulate international relations and alliances and tend to be the focus of conflict and corruption. Oil and gas are traded on the world's commodity markets, but their price and quantity are influenced by the political agreements of oil and gas exporting countries. A case where oil and gas commodity markets have experienced considerable turbulence has been the ongoing war in Ukraine. In 2020, the COVID-19 pandemic also caused significant fluctuations in world markets. From this perspective, oil and gas are key drivers of policy decisions in many economies.

Research on the determinants of economic growth of oil and gas is an important topic to investigate because these two commodities play and will play a significant role in the world economy. In fact, oil and gas consumption is one of the key determinants of national development.

This paper identifies the determinants of economic growth for the top ten oil and gas producers separately for each commodity between 1980 and 2021. The determinants and their impact relative to economic growth are examined as a whole for the top ten producers of each commodity.

In the case of the oil model, the paper looked at the following determinants: exchange rate, inflation, population growth, unemployment, HDI, oil production, oil price, and oil consumption. In the case of natural gas, the last three determinants were replaced by natural gas production, natural gas price, and natural gas consumption. The whole analysis may be affected by the missing data and their volatility in the case of, for example, the UAE, Russia, or Iraq. This paper uses panel data analysis, namely, a direct fixed effects regression method.

The paper is further divided as follows: Section 2 - Literature review; Section 3 - Materials and Methods; Section 4 - Results and Discussion; Section 5 - Conclusion.

Literature review

Both theoretical and empirical studies examine the factors that can affect economic growth. Identifying the determinants of economic growth is essential for economic planning. This is because its objective is to achieve sustainable economic growth. All selected determinants in economic growth of this research are the main determinants of economic growth discussed.

Real exchange rate and economic growth

Zarei (2021) examined the relationship between real exchange rates and economic growth in Iran. He used the nonlinear autoregressive distributed lag method and applied it to monthly data from November 2009 to November 2019. The results show a negative relationship between the exchange rate and economic growth in the short and long run.

Khairul (2015) examined the relationship between exchange rate and economic growth in Bangladesh. He used time series analysis; the sample selected was data between 1985 and 2012. This study used the Johansen-Juselius cointegration test, multivariate Grander causality test, augmented Dickey-Fuller test, and Phillips-Perron test to conduct the analysis. A long-term relationship has been found between exchange rates and economic growth.

Ehikioya (2019) focused his research on the impact of exchange rate volatility on economic growth in Nigeria. He applied his research to time series data from January 1980 to December 2017. He employed the Generalised Autoregressive Conditional Heteroskedasticity model and the Generalized Method of Moments. In addition, the Augmented Dickey-Fuller and Philips-Perron tests were also used to establish the presence of a unit root. Johansen's cointegration test was also used to determine the relationship between the variables in the study. According to the results, the volatility of the exchange rate that persists throughout the period under study has a

significant and negative effect on economic growth in Nigeria. Excessive volatility caused by a low inflow of money is unfavourable to Nigeria's economic growth. Furthermore, the relationship between inflation and economic growth was also found to be significant and negative. Oil prices have a significant and positive relationship with economic growth.

Kogid et al. (2011) attempted to examine the effect of exchange rates on economic growth in Malaysia. They used time series data between 1971 and 2009. They conducted the analysis using an autoregressive model with distributed lag and a dynamic error correction model derived from this model. They made the assumption that nominal and real exchange rates have similar effects on economic growth. The results of the autoregressive model showed the existence of a long-run cointegration between the nominal exchange rate, the real exchange rate and economic growth. In the case of the real exchange rate, there is even long-term cointegration with a significant positive coefficient.

Inflation and economic growth

Mallik and Chowdhury (2001) focused their research on the relationship between inflation and economic growth in four South Asian countries: India, Pakistan, Sri Lanka, and Bangladesh. They used cointegration and error cointegration models. The results show a long-term positive relationship between economic growth and inflation for all the countries studied. A significant feedback relationship between inflation and economic growth was also found.

Bogdan (2016) focused on the determinants of economic growth in 28 EU countries between 2008 and 2013. The relationship between inflation, unemployment, and exports is particularly important for the research of this paper. According to Bogdan's results, inflation is positively and significantly correlated with economic growth, while unemployment is significantly correlated with economic growth but negatively. Exports have a positive effect on economic growth.

The results of Mahzalena and Juliansyah (2019) also confirm the positive effect of inflation on economic growth. They focused on the following determinants: inflation, government spending, and exports. These determinants were investigated using a sample of data from 1990 to 2016 in Indonesia. In this study, a Vector Autoregression Model was used. Inflation had a positive and insignificant effect on economic growth. Export is also an important determinant of this study, and export had a negative and insignificant effect on economic growth.

Gillman et al. (2004) used panel data analysis of OECD and APEC member economies between 1961 and 1997, directly using Pearson's correlation coefficient and fixed and random effects methods. It was found that inflation has a negative effect on economic growth, both in the OECD and APEC member economies.

Fischer (1993) used cross-sectional and panel regression in his research. According to his results, growth is negatively associated with inflation. Inflation reduces growth by reducing investment and productivity growth.

Salahuddin (2010) examined the relationship between economic growth and selected determinants in Pakistan between 1971 and 2006 using the Fully Modified Ordinary Least Squares and Autoregressive Distributed Lag Method for long periods and the Error Correction Model for short periods. According to the results, inflation has a negative effect on economic growth.

Adu (2013), in his study, sought robust evidence on the determinants of economic growth by complementing the usual parametric time series analysis with a nonparametric local linear kernel regression in Ghana. The two approaches were complementary in the analysis. According to the results, inflation is not a robust determinant of long-term economic growth.

In their analysis, Erbaykal and Okuyan (2008) also looked at the relationship between inflation and economic growth in Turkey. To conduct the analysis, they selected a sample of quarterly data ranging from 1987Q1 to 2006Q3. They used the bound test and autoregressive distributed lag method to investigate the said relationship. For both methods, no long-term relationship was found between growth and inflation.

Malla (1997) examined the impact of inflation on economic growth. The research focused on 11 countries in the OECD and Asia. He used panel data analysis and the following variables: GDP per capita, GDP growth rate, market openness, inflation, population growth, and terms of trade. The results did not show a relationship between inflation and growth in the OECD countries. On the contrary, a significant negative relationship was found for Asian countries.

Population growth and economic growth

Ogunleye et al. (2018) targeted their research on the relationship between population growth and economic growth in Nigeria between 1981 and 2015. In addition, the determinants examined were fertility rate, crude death rate, and exchange rate. They used the ordinary least squares regression method to perform the analysis. According to the results, population growth positively affects Nigeria's economic growth. The exchange rate is insignificant for economic growth.

Ali et al. (2013) tested the impact of population growth on economic development in Pakistan between 1975 and 2008. They used the autoregressive distributed lag method for their research. The effect of population growth is significant and positive on economic development.

Sibe et al. (2016) focused their study on the relationship between population growth and per capita income in a sample of 30 countries selected based on population size only. Panel data were constructed, and the world's most populous countries were included regardless of their level of development. The Augmented Dickey-Fuller test was used to examine stationarity. The results of the error correction model showed a long-term equilibrium relationship between population growth and economic growth. The larger causality test showed the existence of bidirectional causality between economic growth and population growth. Population growth and economic growth are positively related.

Ukpolo (2002) examined the causality between population growth and economic growth in Africa. He used the Johansen model and the Grander causality model to conduct the analysis. The results showed cointegration of the variables, implying the efficiency of the long-run relationship in Nigeria but not in the case of Côte d'Ivoire. Population growth negatively affects Nigeria's economic growth. In the case of Côte d'Ivoire, population growth affects economic growth only in the short run.

Befikadu and Tafa (2022) focus their analysis on the relationship between population growth and economic growth in Ethiopia. They used data between 1980 and 2020 and the autoregressive distributed lag method. The results of the study showed that the assessment of population growth and its implications is positive and significant. Furthermore, there are also long-term equilibrium relationships between gross domestic product, population growth rate, population size, inflation rate, foreign direct investment, personal remittances and gross capital formation. Based on the results, population growth has a significant and positive effect on economic growth.

Unemployment and economic growth

Okun's law showed that there is a negative relationship between unemployment and economic growth. However, this theory does not apply to all economies. In some countries, unemployment does not affect economic growth. This is due to structural unemployment, for example (Mujitapha et al. 2021; Jonathan 2006).

Ademola and Badiru (2016) examined the effect of unemployment and inflation on economic performance by establishing the relationship between unemployment and inflation and the actual gross domestic product in Nigeria. Annual data between 1981 and 2014 were used, and the ordinary least squares method was used to conduct the analysis. Unemployment and inflation positively affect economic growth in the long run.

Madito and Khumalo (2014) examined the context of unemployment in South Africa. They conducted the analysis of data between 1971Q1 and 2013Q4 using an error correction mechanism. The overall results showed the existence of a negative relationship between economic growth and unemployment in South Africa.

Adelowokan et al. (2019) used annual data from Nigeria between 1985 and 2015 to investigate the relationship between unemployment, poverty, and economic growth. The Augment Dickey Fuller test was used for the unit root test, Johansen cointegration test, Grander causality test and finally, the Error Correction Model. The cointegration test results showed no relationship between unemployment, poverty, and economic growth in the long run.

HDI and economic growth

Soleman et al. (2022) investigated how HDI, inflation, labour, and investment affect economic growth in Indonesia between 2015 and 2020. They used a panel regression with a common effect model, a random-effects model, and a fixed effects model. The results of the fixed effects model showed that HDI, inflation, and investment have a significant positive effect on economic growth. On the other hand, labour does not have an effect on economic growth.

Dewi and Sutrisna (2014) investigated how the HDI and its three main components, the health index, education index and strength index, are associated with the economic growth of Bali province. They used the regression analysis method and the associative panel data with the pooled least squares method. The total HDI has a significant effect on the economic growth of Bali province. The partial results of the individual components of HDI showed that the health index and the purchasing power index have a significant and positive effect on economic growth, while the health index does not significantly affect economic growth.

Suprapto et al. (2022) analysed the effect of HDI on economic growth, the effect of population consumption on social growth, the effect of inflation on economic growth, and the effect of population consumption, inflation, and human growth index (HDI) on economic growth in West Java. The quantitative method was used, and the data analysed were the data from 2015-2020. According to the results, HDI has an effect on economic growth, community consumption has an effect on community growth, and inflation has an effect on economic growth. Furthermore, the effect of HDI, municipality, and inflation on economic growth was also found.

Oil production, natural gas production and economic growth

Javed and Husain (2020) examined the relationship between oil production, oil revenue, oil price, oil exports, total income, gross capital formation, and economic growth in Oman. They used data between 1989 and 2018, the autoregressive distributed lag method and Grander's causality test. The results showed that oil production, oil price, and gross capital formation are significantly and positively correlated with economic growth. However, oil

exports have a significant but negative effect on economic growth. Total revenue and oil revenue do not affect Oman's economic growth.

Gunu and Kilishi (2010) concluded that Oman's economic development is positively and significantly supported by oil production in Oman. If Oman's production increases, economic development will also increase. Oil exports have a significant and detrimental effect on Oman's economic performance.

Kalyuzhnova and Patterson (2016) examined the development of Kazakhstan's oil sector after its separation from the USSR. In Kazakhstan, the key question is whether the exploitation of natural resources is beneficial to economic growth. Well-established institutions and policies are a prerequisite for long-term development. Econometric modelling of the relationship between domestic production, oil exports, and foreign production has been carried out. Oil exports have a persistent positive effect on GDP.

Diugwu et al. (2013) examined the relationship between the impact of extraction, flaring, gas use, and the GDP of Nigeria. They used the multiple linear regression analysis method. According to the results, gas production and flaring are negatively associated with economic growth. On the other hand, gas utilisation has a positive impact on GDP.

Oil price, natural gas price and economic growth

Ologbenla (2019) investigated the relationship between oil price, monetary policy and economic growth in African oil-producing countries, Algeria, Angola, Nigeria, Libya, Egypt, Sudan, Gabon, Equatorial Guinea and the Republic of Congo between 1980 and 2017. Panel data analysis was used. The fixed effects model showed that the oil price is an important exogenous factor affecting economic growth.

El-Joumayle (2016) examined the relationship between oil production, oil price, and gross domestic product in Iraq during 1971-2012. He also estimates the effects of the new institutional arrangement on the country's economic performance for the period 1998-2012. In this paper, the author tries to find out the impacts caused by the 2003 Iraq war. Rowat's model has been used for the analysis. According to the results, the 2003 war and the institutional arrangement had a negative and significant effect on GDP growth, while the effect of oil production and oil prices is positive, but the latter effect is not statistically significant.

Khan et al. (2019) focus their analysis on the impact of oil price shocks on economic activity in 13 selected Asian economies. From the perspective of our study, China is particularly important in this sample. They used a nonlinear autoregressive approach with a distributed lag for their analysis over the period 1980Q1-2014Q2. The results show no long-term relationship between oil price changes and economic activity. However, the impact of oil price shocks is greater in China than in Japan or Hong Kong.

Takentsi et al. (2022) examined the causal relationship between energy prices and economic performance in South Africa in their study. They used the autoregressive distributed lag method and data between 1994 and 2019. The results showed that oil prices have a significant positive relationship with economic growth in the short and long term. Electricity prices significantly and negatively impact economic growth in the short and long term.

Oil consumption, natural gas consumption and economic growth

Lee (2006) examined energy consumption and GDP in the G-11 countries from 1960 to 2001. A bidirectional causality was found between energy consumption and GDP in the United States. In Canada, the Netherlands, Switzerland, and Belgium, only unidirectional causality was found between energy consumption and GDP. In Italy, Japan, and France, unidirectional causality was found but reversed. In the case of Germany, Sweden, and the United Kingdom, a neutral relationship was found between the variables examined.

Stern (2000) extended his previous analysis of the causal relationship between GDP and energy consumption in the postwar period in the US. The results showed that there is no cointegration between energy and GDP.

Ur Rahman et al. (2020) examined the relationship between energy consumption, energy production, and GDP growth in China between 1981 and 2016. Models were developed for each commodity: oil, natural gas, and coal. The results of the structural break test and the Hatemi-J cointegration test confirmed the long-term cointegration in the consumption and production of oil, natural gas, and coal. Furthermore, the results of the fully modified least squares method confirmed the presence of a long-term positive effect of oil, natural gas and coal consumption and production on GDP growth.

Ozturk and Al-Mulali (2015) examined the relationship between natural gas energy consumption, total labour force, gross fixed capital formation, and economic growth. They focused on Gulf Cooperation Council member countries (Kuwait, Saudi Arabia, Qatar, United Arab Emirates, Oman, and Bahrain). They used panel data from 1980 to 2012 and the dynamic ordinary least squares and modified ordinary least squares methods. Energy consumption is cointegrated with economic growth. Natural gas energy consumption positively affects economic growth in the long run of GCC member states. In addition, the test of the Grander causality showed a bidirectional causality between natural gas energy consumption and economic growth.

Shahbaz et al. (2013) examined the relationship between natural gas consumption and economic growth in Pakistan. They used a model with a multivariate framework that included capital, labour, and exports. An autoregressive distributed lag test and an innovative accounting approach were used to examine the dynamic causal

relationships between the variables to investigate cointegration. The existence of a long-term relationship between the variables was found. The results also showed that natural gas consumption, capital, labour and exports positively affect economic growth.

Materials and Methods

The study focuses on the determinants of economic growth of the top ten oil and gas producers. The sample of countries includes both developed and developing countries. Panel data analysis is used to perform the analysis. The largest oil producers include the United States, Russia, Saudi Arabia, Canada, Iraq, China, the United Arab Emirates, Brazil, Kuwait, and Iran (World Population Review, 2023a). The relationship between GDP growth and the following determinants is examined: exchange rate, inflation, population growth, unemployment, HDI, oil production, oil price, and oil consumption. The major gas producers include the United States, Russia, Saudi Arabia, Canada, China, Iran, Qatar, Australia, Norway and Algeria (World Population Review, 2023b). For these producers, the relationship between GDP growth and the following determinants is investigated: exchange rate, inflation, population growth, unemployment, HDI, natural gas production, natural gas price, and natural gas consumption.

The research is based on annual long-term data between 1980 and 2020 from the World Bank database (crude oil price, exchange rate, GDP, inflation, population growth, unemployment), The Global Economy (HDI), Energy Institute (oil consumption, natural gas production and natural gas consumption), and official data from OPEC (World crude oil production by country).

The STATA statistical software was used to perform the analysis.

Panel data analysis. Panel data, also referred to as longitudinal data, contains a time series of observations of several individuals. For this reason, there are two dimensions in these data. These are the cross-sectional dimension (denoted by index i) and the time series dimension (denoted by the index t). Panel data with a more complex hierarchical or clustered structure also occur (Hsiao, 2007).

The basic equation for panel data is based on the relationship:

$$Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_K X_{Kit} + \dots + u_{it} \qquad for \ i = 1, \dots, N; \ t = 1, \dots, T \qquad (1)$$

Y_{it} is the explained variable in time t and in cross-section i,
β_0- the level constant,
$\beta_1, \dots, \beta_K$- estimated regression parameters,
$X_{1it}, \dots, X_{Kit}$ - the value of the explanatory variable in time t and cross-section i,
u_{it}- random error (in time t and cross-section i) (Hsiao, 1985).

The analysis of this study is based on two-panel data analysis models. The general notation of the functional dependence of the eight variables in the case of both models is as follows:

$$Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \beta_4 X_{4it} + \beta_5 X_{5it} + \beta_6 X_{6it} + \beta_7 X_{7it} + \beta_8 X_{8it} + u_{it} \ (2)$$

where
Y_{it} - a dependent (explained) variable in time t and in cross-section i,
β_0 - level constant,
$\beta_1, \dots, \beta_8$ - estimated regression coefficients expressing the change in the explained variable Y_{it} for a change in the explanatory variable $X_{1t}, \dots, X_{8t}$ by 1%; other things equal independent variables.
u_{it} - random component (residue) in time t and cross-section i.

Oil

For the oil-based model, GDP growth is utilised as the explained variable. The selected explanatory variables for this analysis are exchange rate, inflation, population growth, unemployment, HDI, oil production, oil price, and oil consumption. These are described in more detail in Table 1 below.

Tab. 1 Description of variables

Oil- Description of variables
Description of the explained variable
GDP = GDP change [%]
Description of explanatory variables

exchangerate = exchange rate of the local currency against USD
inflation = inflation [%]
populationgrowth = population growth [%]
unemployment = unemployment [%] (modelled ILO estimate)
HDI = Human Development Index [0-1]
crudeoilproduction = oil production [1000 b/d]
crudeoilprice = crude oil average price [$/bbl]
oilconsumption = oil consumption [Million tonnes]

The estimated regression model for oil has the following form:

$$gdpgrowth_t = \hat{\beta} + \hat{\beta}_1.exchangerate_t + \hat{\beta}_2.inflation_t + \hat{\beta}_3.populationgrowth_t + \hat{\beta}_4.unemployment_t + \hat{\beta}_5.HDI_t + \hat{\beta}_6.crudeoilproduction_t + \hat{\beta}_7.crudeoilprice_t + \hat{\beta}_8.oilconsumption_t + \hat{u}_t. \qquad (3)$$

We are assuming that we find statistical significance between the individual explanatory variables and the explained variable. If this relationship is found, then they may have a positive or negative effect on the explanatory variable.

Natural gas

In the case of the natural gas model, GDP growth is chosen as the explained variable. Explanatory variables for this model are exchange rate, inflation, population growth, unemployment, HDI, natural gas production, natural gas price, and natural gas consumption. The variables are also tabulated in Table 2 below.

Tab. 2 Description of variables

Natural gas- Description of variables
Description of the explained variable
GDP = GDP change (%)
Description of explanatory variables
exchangerate = exchange rate of the local currency against USD
inflation = inflation (%)
populationgrowth = population growth (%)
unemployment = unemployment (%) (modeled ILO estimate)
HDI = Human Development Index (0-1)
naturalgasproduction = natural gas production (Bcf/D)
naturalgasprice= natural gas price ($/mmbtu)
naturalgasconsumprion = natural gas consumption (Bcf/D)

The estimated regression model for natural gas has the following form:

$$gdpgrowth_t = \hat{\beta} + \hat{\beta}_1.exchangerate_t + \hat{\beta}_2.inflation_t + \hat{\beta}_3.populationgrowth_t + \hat{\beta}_4.unemployment_t + \hat{\beta}_5.HDI_t + \hat{\beta}_6.naturalgasproduction_t + \hat{\beta}_7.naturalgasprice_t + \hat{\beta}_8.naturalgasconsumption_t + \hat{u}_t \qquad (4)$$

The assumption of estimated results is the statistical significance of each explanatory variable with respect to the explained variable. If this relationship is found, then the answer is whether the explanatory variable has a positive or negative effect on the explained variable.

A similar analysis procedure was used for both models. The stationarity of the selected data is checked using the unit root test according to Harris and Tzavalis (1999) and Fischer (1970). For some variables, a transformation had to be performed. When this is necessary, the variables are transformed into growth rates or by using

differences. The fixed-effects panel regression model adds variables, and various model options are tested. The most robust model is then selected.

Results and Discussion

In this section, we present the results of the panel data analysis steps presented in the section above. For convenience, the results of the oil model will be described first, followed by the results from the natural gas model. Both models are built on data between 1980 and 2021 and processed in the STATA statistical software.

Oil
According to the results, the exchange rate, HDI, crude oil production, crude oil price, and oil consumption positively and significantly impact the GDP of the top ten oil producers. Inflation, population growth, and unemployment have no effect on the development of the GDP of the group of these countries.

Correlation matrix
Table 3 shows the correlation matrix. It represents the correlation coefficients between the variables and their statistical significance. The correlation between the explained variable and the explanatory variables is low and statistically insignificant in the case of exchange rate (0.0188) and population growth (0.0287). This is also true for inflation (0.1137) and unemployment (-0.1413), but the level of correlation coefficients is statistically significant. The value of the correlation coefficient is higher and statistically significant for HDI (0.3189), oil production (0.2171), oil price (0.3223), and oil consumption (0.1794).

Tab. 3 Correlation matrix

	g_GDP	g_exchangerate	inflation	Population growth	g_uneployment	g_HDI	g_crudeoil production	g_crudeoil price	g_oilconsumption
g_GDP	1.0000								
g_exchangerate	0.0188	1.0000							
	0.7122								
inflation	0.1137*	0.0626	1.0000						
	0.0335	0.2444							
populationgrowth	0.0287	-0.0283	-0.1802*	1.0000					
	0.5687	0.5761	0.0006						
g_uneployment	-0.1413*	-0.0254	-0.1414*	-0.0325	1.0000				
	0.0148	0.6648	0.0175	0.5745					
g_HDI	0.3189*	0.0850	0.0424	0.1218*	-0.1363*	1.0000			
	0.0000	0.1528	0.4858	0.0375	0.0220				
g_crudeoilproduction	0.2171*	0.0030	-0.0846	0.3417*	-0.0831	0.1826*	1.0000		
	0.0000	0.9531	0.1119	0.0000	0.1511	0.0017			
g_crudeoilprice	0.3223*	-0,0309	0.1716*	-0.0367	-0.2640*	0.1079	-0.0083	1.0000	
	0.0000	0.5416	0.0012	0.4587	0.0000	0.0655	0.8674		
g_oilconsumption	0.1794*	0.0022	0.0107	0.3227*	-0.2007*	0.3656*	0.2791*	0.0763	1.0000
	0.0003	0.9649	0.8412	0.0000	0.0005	0.0000	0.0000	0.1253	

Multicollinearity test

The results of the multicollinearity test are interpreted in Table 4. In the table, for the purpose of this analysis, the most important indicator is the Variance Inflation Factor (VIF), which is presented here, both for individual variables and as an average (Mean VIF). Multicollinearity is not present in the model. The value of mean VIF (1.16) and the values of individual VIFs g_crudeoilproduction (1.37), populationgrowth (1.36), g_oilconsumption (1.18), g_HDI (1.12), g_unemployment (1.11), g_crudeoilprice (1.10), inflation (1.06), and g_exchangerate (1.02) are low. Thus, multicollinearity is not present in the model.

Tab. 4 Multicollinearity test

Variable	VIF	1/VIF
g_crudeoilproduction	1.37	0.727649
populationgrowth	1.36	0.734275
g_oilconsumption	1.18	0.844995
g_HDI	1.12	0.895512
g_uneployment	1.11	0.899797
g_crudeoilprice	1.10	0.912286
inflation	1.06	0.943951
g_exchangerate	1.02	0.985115
Mean VIF	1.16	

Stationarity tests

Then, stationarity tests were performed. The test results showed a p-value of 0.0000 for all variables. The null hypothesis was rejected. Inflation and population growth are stationary. The other variables are also stationary after transformation to growth.

Resulting model with fixed effects

The resulting fixed effect model (Table 5) shows the different model options. They are indicated numerically from one to five. Explanatory variables were added in sequence.

Model 5 was selected. According to R-squared (18.7 %), the best model is model 4, but in variant 5, the exchange rate was added, which is statistically significant; therefore, the last model was selected for evaluation. In this model, the R-squared is 17.8%. According to the results of this model, five of the eight explanatory variables are statistically significant. Inflation, population growth, and unemployment do not have a statistically significant effect on the economic growth of the top ten producing countries.

The results of the regression analysis can be interpreted as follows:

If g_exchangerate increases by one, GDP growth decreases by 0.009.
If g_HDI increases by one, GDP growth increases by 3.544.
When g_crudeoilproduction increases by one, GDP growth increases by 0.150.
When g_crudeoilprice increases by one, GDP growth increases by 0.311.
If g_oilconsumption increases by one, GDP growth increases by 0.133.

Tab. 5 Final model

VARIABLES	1	2	3	4	5
g_exchangerate					**0.009****
					(0.004)
inflation				0.000	0.000
				(0.000)	(0.000)
populationgrowth			0.000	0.000	-0.000
			(0.007)	(0.008)	(0.007)
g_unemployment		-0.008	-0.008	0.017	0.016
		(0.054)	(0.053)	(0.057)	(0.056)
g_HDI	6.030**	4.865***	4.867***	4.733***	**3.544*****

	(2.072)	(1.028)	(1.173)	(1.111)	(0.948)
g_crudeoilproduction	0.149***	0.144***	0.144***	0.153***	**0.150***
	(0.041)	(0.033)	(0.032)	(0.035)	(0.028)
g_crudeoilprice	0.308***	0.309***	0.309***	0.300***	**0.311***
	(0.057)	(0.059)	(0.059)	(0.066)	(0.066)
g_oilconsumption	0.189**	0.176**	0.176**	0.166**	**0.133*
	(0.063)	(0.065)	(0.064)	(0.065)	(0.064)
Constant	0.006	0.016*	0.016	-0.029	-0.028
	(0.015)	(0.008)	(0.020)	(0.064)	(0.064)
Observations	289	280	280	263	257
R-squared	0.236	0.183	0.183	0.187	0.178
Number of id	10	10	10	10	10

The exchange rate positively affects the GDP. The results of Kogid et al. (2011) showed that the real exchange rate positively and significantly affects economic growth in the long run. The results are consistent with the results of our study. In his study, Khairul (2015) found a long-term relationship between exchange rate and economic growth, so the results are partially consistent with our study. However, the results of our study were not confirmed by Zarei's research of Zarei (2021) because the study showed a negative relationship between exchange rate and economic growth in the long and short term.

HDI positively affects GDP. This result found in our study was confirmed by the study of Arifin et al. (2023). Based on their results, HDI has a significant positive impact on economic growth. The result has been confirmed, but only partially, by studies. 10 ASEAN member states have a strong and statistically significant correlation between HDI and GDP (Elista and Syahzuni, 2018). The human development index is a critical factor in the economic growth of Asian countries (Zhang and Danish, 2019). In contrast, our results were not confirmed by the research of Damanik et al. (2021). These researchers did not find a significant effect of HDI on economic growth.

Oil production positively affects GDP. The results of the study by Javed and Husain (2020) are consistent with the results arising from this analysis because the results also showed a positive and significant relationship between oil production and economic growth.

The oil price positively affects the GDP. This relationship was confirmed by Takentsi et al. (2022) and partially by Ologbenla (2019). Takentsi et al. (2022) found a positive and significant relationship between oil prices and economic growth in the long and short term in their study. On the contrary, Khan et al. (2019) found no long-term relationship between oil price changes and economic activity.

Oil consumption positively affects GDP. The results of the study by Ur Rahman et al. (2020) agree with the results of the present study. Based on their results, the consumption and production of oil, natural gas, and coal positively affect GDP growth in the long run. In contrast, the results of our study were inconsistent with the analysis of Stern (2000), who found no cointegration between energy consumption and GDP. A study by Lee (2006) revealed the results of this study in part. He found bidirectional causality between energy consumption and GDP in the United States. In Switzerland, Belgium, the Netherlands, and Canada, he found only unidirectional causality between energy consumption and GDP. In Japan, Italy, and France, causality is unidirectional but reversed. In the case of Sweden, the UK and Germany, a neutral relationship between energy consumption and GDP was found.

Natural gas
According to the result of the analysis, population growth, HDI, natural gas production, and natural gas prices have a significant positive impact on the GDP development of the top ten oil producers. Exchange rate, inflation, unemployment, and natural gas consumption have no effect on the GDP development of the group of these countries.

Correlation matrix
The correlation matrix presented in Table 6 presents the correlation coefficients between the variables and their statistical significance. The correlation between the explained variable and the explanatory variables is low and statistically insignificant in the case of population growth (0.0768) and natural gas consumption (0.0841). A higher correlation, which is also statistically significant, was found for inflation (0.1509), HDI (0.3851), natural gas production (0.1133), and natural gas price (0.3955). The exchange rate (-0.3016) and unemployment (-0.2304) show a higher and statistically significant correlation, but the value of the correlation coefficient is negative.

Tab. 6 Correlation matrix

	g_GDP	g_exchange rate	inflation	d_population growth	g_uneploy ment	g_HDI	g_naturalgas production	g_natural gasprice	g_naturalgas consumption
g_GDP	1.0000								
g_exchange rate	-0,3016*	1.0000							
	0.0000								
inflation	0.1509*	0.0275	1.0000						
	0.0028	0.5885							
d_population growth	0.0768	-0.1124*	0.1108*	1.0000					
	0.1256	0.0257	0.0283						
g_uneplo yment	-0.2304*	-0.0004	-0.1537*	-0.1265*	1.0000				
	0.0001	0.9946	0.0077	0.0285					
g_HDI	0.3851*	0.1012	0.0990	0.0053	-0.1003	1.0000			
	0.0000	0.0865	0.0911	0.9276	0.0916				
g_naturalgas production	0.1133*	-0.2648*	-0.0129	0.0396	-0.0678	0.1291*	1.0000		
	0.0236	0.0000	0.7992	0.4267	0.2415	0.0269			
g_natural gasprice	0.3955*	0.0017	0.0776	-0.0113	-0.1996*	0.0860	0.0209	1.0000	
	0.0000	0.9733	0.1252	0.8196	0.0005	0.1411	0.6751		
g_naturalgas consumption	0.0841	-0.2621*	0.0185	0.0526	-0.0852	0.1853*	0.6572*	-0.0014	1.0000
	0.0933	0.0000	0.7155	0.2914	0.1409	0.0014	0.0000	0.9776	

Multicollinearity test

Table 7 shows the results of the multicollinearity test. For the purpose of the analysis, the Variance Inflation Factor (VIF) is an important indicator here, both for individual variables and as an average (Mean VIF). The value of mean VIF (1.14) and the values of individual VIFs g_naturalgasconsumption (1.41), g_naturalgasproduction (1.38), g_unemployment (1.09), inflation (1.08), g_HDI (1.07), g_naturalgasprice (1.06), d_populationgrowth (1.04) and g_exchangerate (1.03) are low. Therefore, multicollinearity is not present in the model.

Tab. 7 Multicollinearity tests

Variable	VIF	1/VIF
g_naturalgasconsumption	1.41	0.710586
g_naturalgasproduction	1.38	0.726977
g_unemployment	1.09	0.915626
inflation	1.08	0.923076
g_HDI	1.07	0.932083
g_naturalgasprice	1.06	0.947481
d_populationgrowth	1.04	0.964272
g_exchangerate	1.03	0.973991
Mean VIF	1.14	

Stationarity Tests

The next step was to perform stationarity tests. The results showed a p-value of 0.0000 for all variables. Thus, the null hypothesis was rejected. Inflation is stationary. The exchange rate, unemployment, HDI, natural gas production, natural gas price, and natural gas consumption are also stationary after transformation to growth. Population growth had to be transformed by differencing into growth rates. Population growth is stationary after transformation.

Resulting model with fixed effects

In Table 8, different variants of the resulting fixed-effects model are presented. They are also labelled from one to five, and explanatory variables have also been added sequentially. According to R-squared (40.0%), the best model is Model 5. From this model, four explanatory variables of eight are statistically significant. The exchange rate, inflation, unemployment, and natural gas consumption do not statistically affect the economic growth of the top ten natural gas countries.

The results of the analysis can be interpreted as follows:

When d_populationgrowth increases by one, GDP growth increases by 0.006.
If g_HDI increases by one, GDP growth increases by 5.683.
When g_naturalgasproduction increases by one, GDP growth increases by 0.354.
If g_naturalgasprice increases by one, GDP growth will increase by 0.121.

Tab. 8 Final model

VARIABLES	1	2	3	4	5
g_exchangerate					-0.180
					(0.114)
inflation				0.000	0.000
				(0.000)	(0.000)
d_populationgrowth			0.009**	0.008*	**0.006****
			(0.003)	(0.003)	(0.002)
g_unemployment		-0.104	-0.097	-0.092	-0.077
		(0.059)	(0.061)	(0.063)	(0.054)
g_HDI	6.651***	6.272***	6.238***	6.046***	**5.683****
	(1.306)	(1.275)	(1.287)	(1.234)	(1.174)
g_naturalgasproduction	0.299	0.319*	0.321*	0.325*	**0.354****
	(0.167)	(0.167)	(0.167)	(0.161)	(0.155)
g_naturalgasprice	0.139***	0.128***	0.128***	0.127***	**0.121****
	(0.025)	(0.026)	(0.026)	(0.027)	(0.027)
g_naturalgasconsumption	0.107	0.077	0.077	0.062	0.081
	(0.085)	(0.062)	(0.062)	(0.059)	(0.058)
Constant	-0.019	-0.014	-0.014	-0.028*	-0.020
	(0.012)	(0.012)	(0.012)	(0.015)	(0.015)
Observations	291	282	282	281	277
R-squared	0.294	0.312	0.316	0.317	0.400
Number of id	10	10	10	10	10

Population growth positively affects GDP. The results of the study by Befikadu and Tafa (2022) are consistent with the results found in the analysis of this article. The impact of population growth is positive and significant. This was also confirmed in the study by Ogunleye et al. (2018); according to the results, population growth has a positive and significant effect on economic growth. However, the study by Ukpolo (2002) refutes the results in the analysis of this paper. This is because population growth has a negative effect on Nigeria's economic growth.

HDI positively affects GDP. The analysis by Soleman et al. (2022) showed a positive significant relationship between HDI, inflation, investment, and economic growth. Therefore, these results are consistent with the positive effect of HDI and GDP in the analysis of this article. The results were also partially confirmed by Dewi and Sutrisna (2014) and Suprapto et al. (2022). According to Dewi and Sutrisna (2014), total HDI significantly impacts economic growth. Suprapto et al. (2022) found the existence of an effect between HDI and economic growth.

Natural gas production positively affects GDP. The results of the study by Diugwu et al. (2013) are inconsistent with the results of this analysis. According to their results, gas extraction is negatively associated with GDP.

The price of natural gas positively affects GDP. The results of the study by Heidari et al. (2013) are partly consistent with the results of this analysis. The price of natural gas has a significant impact on economic growth.

Conclusion

The study examines the determinants of the long-term economic growth of the top ten oil and gas producers. The analysis of this paper aims to find out which of the following determinants of economic growth affect economic growth, positively or negatively. No effect was found for some of the selected determinants concerning economic growth. The analysis is also interesting because the leading oil and gas producers include developed and developing countries.

Panel data analyses were used. The analysis uses a fixed-effects model for each commodity, so two models were built, one for oil and one for natural gas. The analysis was applied to data between 1980 and 2021. The data used are affected by volatility and missing variables for, for instance, Russia, Iraq, and UAE. The analysis may be influenced by these facts.

The established assumptions were confirmed for five explanatory variables. Therefore, the exchange rate, HDI, oil production, oil price, and oil consumption are statistically significant relative to GDP growth. The second assumption was to establish the relationship of these variables with GDP growth. All these variables have a positive effect on GDP growth. Inflation, population growth, and unemployment have no effect on GDP growth.

The stated assumptions were confirmed for the four explanatory variables. Population growth, HDI, natural gas production, and natural gas price are statistically significant relative to GDP. The second established assumption implies that these variables are positively related to GDP growth. Exchange rate, inflation, unemployment, and natural gas consumption have no effect on GDP growth.

The study conducted in this paper can be a resource for future decision-making of the economies under study. The economies under study should consider all the determinants that came out statistically significant. The results of both models suggest that raw material production and price play an important role and will continue to play an important role in the future for both commodities. Production of both energy commodities may be affected by the transition to clean energy and, thus, the impossibility of building new oil and gas production. The price of oil and gas is volatile. It is due, for example, to the two recent global crises. Therefore, countries should look to create a system in the future that is resilient primarily to these pitfalls.

Given the current relevance of the oil and gas issue under study, this topic will be explored in the future, for example, by expanding to other key determinants of economic growth or other commodities.

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